Enhancement of Municipal Wastewater Management System with Polluter Pays Principle (PPP): a Case Study of Cities in Thailand

Miss Kwanmanas Meethavorn

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy in Environmental Engineering
Department of Environmental Engineering
FACULTY OF ENGINEERING
Chulalongkorn University
Academic Year 2019

การเพิ่มคุณภาพระบบการจัดการน้ำเสียชุมชนด้วยหลักการผู้ก่อมลพิษเป็นผู้จ่าย กรณีศึกษาเมืองในประเทศไทย

น.ส.ขวัญมนัส มีถาวร

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรดุษฎีบัณฑิต
สาขาวิชาวิศวกรรมสิ่งแวดล้อม ภาควิชาวิศวกรรมสิ่งแวดล้อม
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2562

Thesis Title	Enhancement of Municipal Wastewater Management System with Polluter Pays Principle (PPP): a Case Study of Cities in Thailand
By	Miss Kwanmanas Meethavorn
Field of Study	Environmental Engineering
Thesis Advisor	Associate Professor Chanathip Pharino, Ph.D.

Accepted by the FACULTY OF ENGINEERING, Chulalongkorn University in Partial Fulfillment of the Requirement for the Doctor of Philosophy

..... Dean of the FACULTY OF ENGINEERING

(Professor SUPOT TEACHAVORASINSKUN, D.Eng.)

DISSERTATION COMMITTEE

..... Chairman

(Professor ORATHAI CHAVALPARIT, Ph.D.)

..... Thesis Advisor

(Associate Professor Chanathip Pharino, Ph.D.)

..... Examiner

(Associate Professor MANASKORN RACHAKARAKIJ, Ph.D.)

..... Examiner

(Associate Professor PICHAYA RACHDAWONG, Ph.D.)

..... Examiner

(Pinida Leelapanang Kampangthong, Ph.D.)

ขวัญมนัส มีถาวร : การเพิ่มคุณภาพระบบการจัดการน้ำเสียชุมชนด้วยหลักการผู้ก่อมลพิษเป็นผู้จ่าย กรณีศึกษาเมืองในประเทศไทย. (Enhancement of Municipal Wastewater Management System with Polluter Pays Principle (PPP): a Case Study of Cities in Thailand) อ.ที่ปรึกษาหลัก : รศ. ดร.ชนาธิป ผาริโน

แหล่งน้ำสาธารณะที่มีคุณภาพต่ำเกิดขึ้นจากหลายสาเหตุ แต่สาเหตุหลักมาจากระบบบริหารการจัดการน้ำเสียที่ยังไม่มีประสิทธิภาพและไม่มีงบประมาณที่เพียงพอ ประเทศไทยได้นำหลักการผู้ก่อมลพิษเป็นผู้จ่ายมาบังคับใช้เพื่อเพิ่มความสามารถทางการเงินให้แก่ระบบการจัดการน้ำเสีย แต่หลักการนี้ยังไม่ได้ถูกใช้อย่างเป็นรูปธรรมในหลายพื้นที่ งานวิจัยนี้จึงมีวัตถุประสงค์เพื่อที่จะศึกษาปัจจัยที่ส่งผลต่อความเต็มใจจ่ายเพื่อเพิ่มคุณภาพน้ำในแหล่งน้ำสาธารณะ โดยเลือกกรณีศึกษาเป็นเมืองที่มีลักษณะต่างกันสามเมืองในประเทศไทย งานวิจัยนี้ใช้วิธีสมมติเหตุการณ์เพื่อประเมินปัจจัยที่ส่งผลต่อการตัดสินใจและระดับความเต็มใจจ่ายสูงสุด ผลจากการศึกษาแสดงให้เห็นว่า เมืองที่มีลักษณะต่างกันมีปัจจัยที่ส่งผลต่อความเต็มใจจ่ายต่างกัน อย่างไรก็ตาม ปัจจัยที่ทั้งสามเมืองมีร่วมกันคือการทราบถึงการได้รับบริการบำบัดน้ำเสีย ประชาชนที่ทราบว่าบ้านของตนเองได้รับบริการการบำบัดน้ำเสียมีแนวโน้มที่จะตัดสินใจจ่ายค่าบริการและยินดีจ่ายในอัตราที่สูงกว่าประชาชนที่ไม่ได้รับบริการหรือไม่แน่ใจว่าตนเองได้รับบริการหรือไม่ ยิ่งไปกว่านั้น พัทยาซึ่งเป็นเมืองที่ติดทะเลมีค่าระดับความเต็มใจจ่ายสูงที่สุด ตามด้วยกรุงเทพที่เป็นชุมชนเมือง และท่าแร่ที่เป็นเมืองขนาดเล็ก ตามลำดับ ปัจจัยที่ส่งผลต่อความเต็มใจจ่ายและช่วงระดับความเต็มในจ่ายค่าธรรมเนียมน้ำเสียจากการศึกษานี้ สามารถนำไปช่วยประกอบการพิจารณาและวางแผนกลยุทธ์การจัดการน้ำเสียอย่างเป็นระบบและยั่งยืนในแต่ละพื้นที่ที่มีลักษณะใกล้เคียงกับกรณีศึกษาได้อย่างเหมาะสมในประเทศไทยและในประเทศอื่นๆ

สาขาวิชา วิศวกรรมสิ่งแวดล้อม ลายมือชื่อนิสิต .....

ปีการศึกษา 2562 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

5871445421 : MAJOR ENVIRONMENTAL ENGINEERING

KEYWORD: Key factor; Polluter Pays Principle; Wastewater charge; Willingness to pay; Wastewater management

Kwanmanas Meethavorn : Enhancement of Municipal Wastewater Management System with Polluter Pays Principle (PPP): a Case Study of Cities in Thailand. Advisor: Assoc. Prof. Chanathip Pharino, Ph.D.

Poor water quality in public water bodies caused by several reasons mainly due to a lack of efficient WWM system and sufficient financial support. Polluter pays principle has long been a promising strategy to help improving water quality in pubic water bodies in Thailand. However, WW charge has not yet been practically levied. This research ains to evaluate factors affecting residents' preferences on WTPs for water quality improvement. Three different characteristic cities were selected as case studies. The technique applied to estimate WTPs is CVM to reveal key factors influencing WTP decision as well as WTP pay-out level. The result has evidenced that cities with different characteristics have factors influencing WTPs differently. However, a common factor of all city is, ones who perceive that their houses are located in the WW service area, are more likely to pay for WW charge in the higher amount than the others who do not reside within service area or uncertain whether their house are covered in the service area. As a case study, Pattaya (coastal city) has the highest rate of WW charge pay-out level followed by Bangkok (urbanised city) and Tha Rae (rural city) respectively. Key factors influencing WTPs as well as range of WTP for WW charge identified in this research could help supporting strategic planners to design suitably pragmatic WWM schemes and approaches for enhancing sustainable WWM in different context cities in Thailand and other countries.

Field of Study: Environmental Engineering Student's Signature .....

Academic Year: 2019 Advisor's Signature .....

ACKNOWLEDGEMENTS

Foremost, I would like to express my sincere gratitude to my advisor Assoc. Prof. Chanathip Pharino for support of my Ph.D study and research, for her patience, motivation, and immense knowledge. Her supportive enthusiasm helped me through the time of research and thesis. Besides my advisor, I would like to thanks the rest of my research committees, Prof. Orathai Chavalparit, Assoc. Prof. Manaskorn Rachakarakit. Assoc. Prof. Pitchaya Rachadawong and Dr. Pinida Leelapanang for their insightful comments and encouragement.

Additionally, I would like to pass my sincere gratitude to my advisor during UEHAS exchange programme at the university of Tokyo, Prof. Moriguchi Yuichi and his assistant, Nakatani Jun for their enthusiastic work and helpful advice to develop my research. My sincere thanks also goes to Dr. Thanut Wongsaichue as a consultant for statistical analysis. I could not have imagined how I can go through this journey without their supports.

I would like to declare this study received financial support from the 90th ANNIVERSARY OF CHULALONGKORN UNIVERSITY FUND (Ratchadapiseksomphot Endowment Fund). I also would like to express gratitude to the department of Environmental Engineering, Chulalongkorn university, Local government and participants for supporting research activities.

I am extremely heartfelt to my parents for their love, care and supports. They never hesitate to give me an educational opportunity. They always spiritually support in every moment and believe in me during this long and hard journey.

Last but not least, I am thankful to my siblings for their encouragement and my friends, especially Ms. Sutida Sirimugkla who have been through and helped me almost all of the time during my Ph.D life.

Kwanmanas Meethavorn

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ABBREVIATION

CVM	contingent variation method
DDS	Department of Drainage and Sewerage
Logit	binary logistic regression
MR	multiple regression
O&M	operation and maintenance
PPP	Polluter Pays Principle
WTA	willingness to accept
WTP	willingness to pay
WW	wastewater
WWM	wastewater management
WWT	wastewater treatment
WWTP	wastewater treatment pant

Chapter 1
Introduction

1.1 Background

Water pollution is one of the major environmental concerns in developing countries including Thailand. Poor wastewater treatment efficiency directly affects water quality in water bodies while water resource is necessity for human being. Rammont and Amin (2010) claimed that the main barriers for wastewater management (WWM) in developing country is not only low stringency monitoring and enforcement, but also insufficient fund for operation and maintenance (O&M) (JICA, 2011).

Polluter Pays Principle (PPP) is widely accepted to enhance performance of existing environmental laws and regulations which are generally command and control approaches. PPP in many cases is proven to be an effective tool for implementing environmental policy because it generates revenues to cover O&M costs as well as investments for enhancing future treatment capability. Besides, it creates monetary incentives to change consumers' behaviours to reduce pollution.

In ASEAN, there already are three countries where wastewater charge is successfully implemented, namely Singapore, Malaysia and Indonesia. With economic-based instrument integration, Singapore achieves high efficiency of water and wastewater management in terms of sanitation; clean and safe drinking water; adequate sewerage systems. On the other hand, although the wastewater treatment in Malaysia has not yet been well operated, the government has strong intention to solve wastewater problems and successfully enacted Sewerage Service Acts (1993) with clear purpose to raise water pollution awareness. Moreover, Indonesia shows the success of decentralisation when wastewater charge and collection method have been differentiated among cities by local government decision-making. More than 80% of wastewater charge is practically collected in Kota Medan, Banjamasin

and Kota Parapat, and plan to utilise treated wastewater in the near future (Jhermpun, 2014).

In case of Thailand, PPP has been first introduced and promoted since 1992 in 7th National Economic and Social Development Plan and wastewater treatment charge collection was mentioned in Enhancement and Conservation of Environmental Quality Acts (NEQA 1992). However, almost all of PPP implementation has been limited within industrial sector while it has low practicality in other sectors including residential areas (Teerawiroon, 2015). Together with regulatory standards, factories located in industrial estates have to pay wastewater treatment fees to centralised wastewater treatment operators since the water discharge must reach the emission standards.

To implement PPP on wastewater, local government has authority to enact household's wastewater charge according to Decentralisation Acts (1999). There are only four municipalities have utilised (i.e. Pattaya, Sansuk, Pathong and Hatyai) and a few (e.g. Bangkok and Samutprakarn) are on the process of wastewater charge implementation. As a consequence, Pollution Control Department (PCD) had studied suitable rate for wastewater charge in several cities (Simachaya, 2003). However, the proposed rate studied was considered only based on cost-effectiveness. The calculation was made from operation costs per unit while regardless of willingness to pay (WTP) from users.

WTP is important as it could reveal citizens' preferences and reflect costs of environmental damage (Jenkins & Lamech, 1992). This is because the fact that individuals should be willing to pay to stop polluting activity of polluters if pollution has welfare costs (Jenkins & Lamech, 1992). To pursue effectiveness of PPP, historical data or empirical evidences are significant to support government decision-making (Johansen, 1977).

WTP study is not new and there are numbers of WTP studies on wastewater treatment in residential area in Thailand. WTP rate of centralised WWM in Bangkok were purposed (Roomratanapun, 2001); Jhermpun and Panyasiri, 2017; Boontanon, 2014; JICA, 2011) to support wastewater charge implementation. This shows that the studies are limited in Bangkok while there are no WTP study of other cities. Although WTP ranges were provided, wastewater charge in Bangkok has not been enforced. This can be claimed that WTP information is not enough for practical implementation. Hence, understanding of constraints of economic-based instrument on WWM as well as governance through WWM structure is also significant.

However, each city has its own characteristics and governance, and residents' preferences could be varied. For national implementation, information of different types of cities are necessary because public opinions could influence on the success or failure of the policy (Rammont & Amin, 2010).

Therefore, the study is aimed to examine wastewater management structure to identify the gaps and needs for improving WWM. Different cities' characteristics will be selected to be investigated as case studies to evaluate suitable management conditions. Ranges of WTP for water quality improvement will be evaluated as well as factors influencing household's WTP to enhance water quality efficiency will be also analysed.

The information obtained from the study could be useful for policy makers for setting up proper instruments. Suggestion and recommendation for WWM for different types of cities will be analysed to improve practicality of PPP as wastewater charge implementation for systematic wastewater treatment operation to enhance WWM efficiency.

1.2 Aim and objectives

The aim of this research is to examine current water management instruments and analyse gaps for wastewater management in residential area in Thailand. The ultimate goals are to develop water quality management schemes in urban area toward sustainability. The aims are as the following;

1. To analyse existing situation and gaps for wastewater management improvement in Thailand
2. To evaluate a rate of willingness to pay for water quality improvement and analyse factors influencing an enhancement of water management efficiency in residential area
3. To develop recommendation that suitably improve overall wastewater management efficiency for different types of cities in Thailand

1.3 Research Hypothesis

Economic-based instruments could help improving wastewater management efficiency in residential areas. Residents in different scale of urbanisation may have different level of willingness to pay for improving wastewater management.

Specific Hypotheses

1. Cities with higher population density could have higher rate of households' WTP
2. Residents will prefer to reduce water consumption once wastewater charge is applied

1.4 Expected outcomes

1. Understanding challenges of water quality management along water life-cycle management in Thailand
2. Identifying ranges of willingness to pay for improving water quality of residents in selected cities in Thailand
3. Recommendations for promoting sustainable water quality management in residential area.

1.5 Novelty and significant of the study

Research contribution

1. Understand water quality management landscape and challenges to improve water quality in residential sector in Thailand
2. Validating whether economic-based instrument is possible to implement as a tool to increase efficiency of water quality improvement in different types of cities in Thailand
3. Set of recommendation scenarios to improve water quality management in different types of cities

Chapter 2

Literature Reviews

2.1 Water Quality Management

Water pollution is one of the major environmental issues in developing counties including Thailand. Poor efficiency of wastewater management practices directly affects water quality in water bodies. This is not only caused by low stringency in environmental monitoring and enforcement, but also insufficient budget for operation and maintenance (O&M) (JICA, 2011).

Rapid growth of national economic as well as urbanisation are key factors of resource consumption as a result, water pollution. To handle with these factors, sustainable water quality or wastewater management programme should be provided.

2.1.1 Urbanisation and water quality issue

Urban area can refer to an area surrounded by a city. People who live in urban area is mainly non-agricultural people. Urban areas can be towns, cities, and suburbs, where are very developed by building, roads, railways, bridges, and etc.

There are three approaches to define that is an urban area and one of them is defined by population and building density. The critical factor in urban area recognition is a minimum population is approximately 1,000 people.

Many urban areas are called ‘Metropolitan’ or ‘Greater’ as Greater New York and Greater London. To classify which area is metropolitan, Statistics Canada defines CMA as an area consisting of one or more adjacent municipalities located around a core of major urban and it must have at least 100,000 population of a half of urban core. This is also defined by the office of Management and Budget, USA that

Metropolitan is an area where one or more adjacent areas that have at least 50,000 population (OMB, 2013).

In case of towns, some geographers define a town as an area having 20,000 residents. Town is usually self-governed and have specialised economic activities such as mining. Another type of urban area is a suburb area. Suburbs areas are smaller them urban areas surround by cities. Almost all suburbs have lesser density population than cities.

Rural area, in contrast to urban area, population density is lower than urban and there is a large undeveloped land. The population is a clear indicator to differentiate urban and rural area. However, in developed country like Japan, the differences are unclear due to the large numbers of population. In the US, 2,500 residents or more are defined as urban area while Japan is 30,000 population or more. Therefore, the areas where population less than 2,500 could be claimed as rural area according to the US's definition.

Normally, where the land is used and population located even less or more, inelasticity natural resource as water are consumed and pollution is generated. Moreover, the more population means the more water consumption and water pollution.

Water pollution not only degrades water quality in water body, but also causes health problems to population and hence quality of life. The beginning of wastewater treatment service in several countries is mainly at urban area (e.g. Singapore, Japan) where water consumption and water pollution were concentrated. According to Ren et al. (2003), rapid urbanisation causes rapid water quality degradation.

This can be assumed that high population density cities could have higher costs of environmental damage and population should tend to do something such as paying at higher rate of management fees to eliminate or reduce those impacts.

Therefore, water and wastewater management became crucial for urban cities since it could help managing water resource as well as water pollution for remaining the acceptable quality of water bodies. There are successful cases of water quality management and they are detailed in the next section.

2.1.2 Water quality management in other countries

i) Singapore (Jhermpun, 2014)

Singapore achieves high efficiency of both water supply and wastewater management. Due to a lack of freshwater resource, Singapore relied on fresh water import from neighbouring country, Malaysia. However, Public Utility Board (PUB), a central government of water and wastewater management, realised the necessity of wastewater treatment facility for national sustainable water and wastewater management.

The first wastewater treatment service, Alexandra Sewage Disposal Work, was established in 1910 only for urban area. Once the country had been expanding, new wastewater treatment called Ulu Panda Sewage Treatment, was constructed to replace the old one and followed by Kim Chuan Sewage Treatment Works and Saragoon Sludge Treatment Works. Moreover, other 4 wastewater treatment plants had been developed according to the number of population and economic growth. In 1960 sewerage system was intensively planned in order to sufficiently support the rapid growth of industrial and residential areas where the majority of wastewater come from. This is because the government would like to confirm that all wastewater generated was treated before discharging into the seawater in order to prevent seawater degradation.

As the service provision needs to be financed, previously the revenue generated from wastewater fees in Singapore are from 2 main sources; Sanitary Appliance fees and Waterborne fees. However, the charge has been revised yearly and since July 2017 Sanitary Appliance fees as Sanity Fitting Unit ($2.80 per fitting) was combined into Waterborne fees which is calculated according to the proportion of water use volume at $0.92 /$m^3$ (0-40 m^3) and $1.18/$m^3$ (> 40 m^3).

The result of government's intention shows the success of wastewater treatment that service area had been expanded from 40% in 1965 to 100% in 1992 (Department of Drainage and Sewerage, 1998). Moreover, natural gas produced from sludge fermentation was used to generate electricity for internal use and treated wastewater was recycled.

ii) France (DA COSTA et al., 2015)

Water and wastewater management in France are systematic and the government set a clear goal for making management plan. In 2009, for example, water quality in water body in France was lower than the ecological standpoint, the government set the target which were stiffer than the average in Europe to achieve a good overall status of water bodies by 2015 (39% of surface water and 63% of groundwater). As a result, the ecological and chemical status in France were in line (43% of surface body and 89% of groundwater) with Europe average (43% of surface water and 79% of groundwater).

To achieve a good status of water body, Strategic Plan for Development and Management of Water (SDAGE), a six-year plan, was adopted. The plan was divided into 3 stages;

1) Guidance of how to meet the fundamental requirement for achieving the balanced and sustainable management.

2) Quality and quantity targets set for each water body based on the key issues and priorities identified in the previous stage

3) Action programme needed to meet the targets regarding to deterioration prevention and overall water body improvement

The systems were established in 1964 and the financing mechanism is based on 'user/polluter pays' principle. The projects were financed wholly by fee paid from water users and the amount of payment depends on volume of water withdrawn or used as well as water pollution generated. The revenue generated from this mechanism will be allocated to each area by the decision of Ministry of Environmental and Finance. Between 2013-2018, 10th programme of action provides 13.3 billion for water and wastewater service. Moreover, wastewater charge is revised yearly and adjusted by the estimation of real costs of service provision in the next year and water and wastewater bills are clearly detailed.

Wastewater charge structure in France is divided into 2 types;

1) Domestic Tariff

The tariff will be calculated from 2 parts; A fixed sum per period and Volume based charge. A fixed sum of per period is the minimum charge that have to be paid by a period of time (e.g. every 6 month) while Volume-based charge is the charge that calculated from volume of water use.

2) Industrial Tariff

Industrial activities are charged in addition to Domestic tariff in terms of Pollution Coefficient or Water Quality and Discharge Coefficient or Volume.

Wastewater treatment facility in France was provided and operated by local government authority. This means that each local authority has its own decision on management to operate the systems by itself or collaborate with private sectors. The statistic shows the majority of wastewater treatment plants have been operated by water companies. There are 19,750 wastewater treatment plants in France and around 6,300 plants or 1/3 of all are private company involvement.

Three-quarter of 876 large plants (total treatment capacity is over 10,000 population equivalent) or nearly 60% of national treatment capacity as well as a half of the sewer system are operated by private companies.

iii) Japan (Japan Sewage Works Association, 2016)

The mission of wastewater management in Japan has been developed from the improvement of sanitation to asset management for sustainability. The beginning of wastewater treatment in Japan is due to the waterborne diseases. The improvement of sanitation was to remove wastewater and storm water from where people live. The water pollution became more severe and funding were spent for the wastewater treatment projects in 1970.

Wastewater treatment service in Japan has been continuously developed. In 1996, the sewerage law was revised to promote sludge recycle due to the shortage of disposal site. In 2003, Combined Sewer Overflow (CSO) control was added into sewerage law to increase effectiveness for wet weather day and in 2015, aging wastewater infrastructure was highlight and the law was revised again to ensure the quality of asset for all wastewater service operator.

Japan has built 460,000 km sewer lines and 2,200 wastewater treatment plants for public. In another word, approximately 89% of Japan's population can access the service. As the system had implement for long time, aging infrastructure could cause service failure and threat sustainability of the service. Therefore, local governments are required to investigate a critical asset for service safety and sustainability purposes. Moreover, asset management implementation was enacted for life-cycle cost minimisation and asset longevity. Besides, 369 wastewater treatment plants are used as open space to public for recreational activities (e.g. sports field, car parks).

As Japan is a leader of advance technology, wastewater service was shifted from pollution control to resource recovery. Around 1.4% of total treated wastewater is

reused internally. Sludge is converted to organic and inorganic fertilisers as well as heat energy produced is used to generate electricity.

For sustainable financial aspect, Japan has a clear principle to finance wastewater service and financing are from 2 main sources; Government tax and Utility fees. Government tax is for storm water drainage while utility fees is for covering whole wastewater service costs. However, rural and semi-urban areas normally face difficulties in insufficient revenue generation from tariff applied. This is because of depopulation, decreasing water use and neglected connection to public wastewater service from potential customers. Therefore, Ministry of Internal Affairs has mandated the local government of 30,000 population or over to adopt private sector to operate wastewater service by 2019 for sustainable financial programme as Public Private Partnership.

2.2 Policy instruments

Policy makers have 2 main instrument options for making the environmental policy. In terms of wastewater and water quality management, traditional regulatory approach or sometimes known as Command and Control (CAC) and Economic-Based Instrument (EI) can be used for changing production and consumption habit in society (EPA, 2017).

2.2.1 Laws and Regulations on Wastewater management

The early of environmental policymaking, Command and Control (CAC) approach was used for environmental protection. CAC is the approach that political authorities mandate people by enacting a law as an enforcement machinery (Elazegui, 2002). There are 2 board types of CAC; performance-based and technology-based standards.

1. Performance-based standards

These can be divided into 2 types; Emission standards and Ambient standards

1.1 Emission standard

Another name of this standard is generally called “end-of-pipe”. This is the standard that was more often used in the early command and control regulation (Austin, 1999). The target emission was set uniformly to each factory and ones who exceed the standard will be penalised. However, many factories will reduce the pollution at the regulated level because there is little incentive to do for the best reduction performance.

1.2 Ambient standards

This is similar to emission standard where the ambient target was set in particular area and the target cannot be exceeded. In water quality management, this refers to minimum levels needed to be maintained for dissolved oxygen (DO), pH or acid level, Biochemical Oxygen Demand (BOD), etc. However, ambient standards cannot be directly enforced to specific pollution sources (Elazegui, 2002). Therefore, imposing emission-producing activities on polluters would be more effective.

2. Technology-based standard

These standards specify the technologies, methods or equipment that polluters need to use to meet the required emission standards. However, the process of

ratcheting up the standards will often be debated and discussed about the costs and suitability of alternatives technologies for the next enacted standards.

CAC were successful in shaping environmental policy at the first instalment of emission reduction for unregulated industries, but lately there are some burdensome (Austin, 1999). The high-level performance technology for pollution reduction was limited due to the undesired more stringency regulation. Moreover, as the standards have been ratcheted up over time, some industries suffer from financial issues of emission reduction to reach the standard requirement as well as the process and technology choices. Therefore, new instrument; economic-based instrument, regarding to market incentives became in consideration for policy decision-making as it is believed to be as effective tools for environmental management in terms of pollution control and cost-effectiveness.

2.2.2 Economic-based instrument (EI) or Market-based instrument (MBI)

Economic-based Instrument (EI) or sometimes known as Market-based Instrument (MBI) is aimed to control pollution by harnessing power of market incentives (Austin, 1999). The instrument was claimed as cost-effectiveness, high flexibility, and dynamic incentive measure. However, EI should not be applied alone. It has basically been underpinned existing regulation or so-called Command and Control (CAC) approach (WHO/UNEP, 1997).

EI was developed because economists perceive pollution as a “market failure” arisen by polluters. Consequences of production as environmental damage are usually not accounted into production costs or manufacturer’s decision-making frameworks. This is called “externalities” which is the main factor of market failure. In order to correct this market failure, externalities will be internalised into decision-making process by placing costs of pollution emission as charges or fees on every unit of effluent. This can induce manufacturer’s decisions regarding to additional costs of production from environmental responsibility internalisation. The regulator

can control overall allowable emission from different degree by changing the charge over time and ratcheting up standards. Hence, a technical definition of Economic Instruments is a “Tool that affect estimates of the costs and benefits of alternatives actions open to economic agents” (OECD, 1997).

According to market failure correction, EI is basically applied for environmental policy and it is wildly known as Polluter Pays Principle (PPP).

2.2.2.1 Polluter Pays Principle (PPP)

1. What is PPP?

Polluter pays Principle (PPP) is the principle based on monetary incentives to control environmental pollution. Ones who create pollution have to pay for the inversely effects of the consequences of the pollution as well as to prevent future occurrences. The principle was first introduced and adopted by Countries of the Organisation for Economic Cooperation and Development (OECD) formally at the1992 Rio Declaration and it was claimed as a sustainable development principle.

The principle is basically accepted internationally. Among 14 of OECD countries, 150 economic instruments were adopted in 1993 (OECD, 1997). Usually, PPP supports most of existing environmental regulation of pollution affecting land, water and air (Grantham Research Institute & Clark, 2012). The principle creates monetary incentives to polluters to reduce pollution as well as to use resource more efficiently. The mechanism of PPP is based on “Carrot and Stick” which means that one who pollutes environment, he will be penalised while the other who cleans up pollution or saves resource at a higher level of requirement, he will be rewarded (Puttasri, 2017).

As the principle of PPP is claimed as an Economic-based Instrument (EI), the benefit of PPP implementation is not only to control environmental quality or resolve environmental problems, but also generate revenue to cover operation and

maintenance costs as well as for future plan of service investment. In case of wastewater or water quality management area, the instruments applied under PPP were summarised in the next section.

2. Economic-based Instrument (EI) on Wastewater Management (adapted from WHO/UNEP, 1997 and Jhermpun, 2014)

a) Pricing

Pricing measure will include wastewater collection and treatment costs into regular water tariff as marginal pricing. This measure has ability to reduce excessive water use, induce water consumer to adopt water-saving technologies as a consequence, minimise wastewater. Recycling and reuse systems would be also included since they can minimise water pollution to the environment. Several hotels in eastern coast in Thailand, for example, recycle their water for garden irrigation because cost of fresh water is higher than cost of wastewater treatment. Moreover, Central Department Store in Chonburi, recycles water for sanitation purpose due to the same reason.

b) Pollution charge

Pollution charge or tax can be defined as a price to be paid for the use of environmental resource and the damage of environmental pollution. It can be divided into 4 main types;

i) User Charge

This is the charge collected from water users for centralised wastewater treatment operation. According to Promotion and Environmental Quality Conservation Act B.E.2535 of Thailand, local government has authority to collect wastewater charge from every water consumer. In several countries, however, this can be in the formed of Property Tax and is basically applied to citizen (i.e. Canada) (WHO/UNEP, 1997). Individuals who live in areas where accessible to wastewater treatment

service will be taxed more than ones who cannot access the service. This is because facility provision increases the land values.

ii) Effluent Charge/Emission Fees

This charge is based on wastewater discharge quality and/or quantity. The money collected is proportional to the quantity/quality of pollution.

iii) Product Charge

This charge levied on the products with environmental harmfulness along its lifecycle in terms of raw materials in production process, consumption and disposal.

iv) Administrative Charge

This charge will be collected as fees for pollution control activities of authorities such as financing license, and chemical registration.

c) Tradable or Marketable Permits

This instrument allows permit's owner to trade his effluent permission to others. In the other word, this kind of permits create pollution market as it can be bought and sold. Authority sets maximum allowable emission and distributes permission in the form of permits to polluters over specified a period of time. For example, one individual own 10 units of wastewater effluent but he emits only 7 units, the rest 3 units can be traded or sold to others who emit the pollution exceeding the permission without penalties.

d) Subsidies

This can help environmental pollution reduction by subsidise polluter to adopt pollution control technology or pollution reduction measures. Subsidies can be grants or low-interest loans, favourable tax treatment and preferential procurement policy. However, subsidy removal could be another incentive effectively. For example, the provision of irrigation water in many countries is free. This encourages

farmers to over-consume. By removing this kind of subsidy may influence them to reduce water consumption resulting in less water pollution.

e) Deposit Refund System

This approach will add surcharge as a deposit to consumers who purchase polluting products which are durable and reusable or dissipated during consumption such as drink containers, automobile batteries and pesticide containers. Once these are returned to an approved recycling facility or proper disposal, the deposits of users will be refunded.

f) Enforcement Incentives/Emission Fees

This measure is basically applied together with CAC and normally imposed on commercial or industrial polluters. Regulator sets up a standard for pollution and ones who excessively emit the standard will be get penalties (i.e. fines).

For more clarification, several EI mentioned above can be classified into direct and indirect instrument (Table 2.1). Direct instrument refers to the instrument requiring monitoring programme while indirect instrument is forced by market dynamic.

Table 2.1 Classification of Instruments

Regulatory Tool	Direct Instrument	Indirect Instrument
Market-based instruments (MBI)/Economic-based Instrument (EI)	• Enforcement Incentives/Emission Fees • Tradable/Marketable Permits	• Pricing • Pollution Charges/Taxes • Subsidies • Deposit Refund System
Command and Control (CAC)	• Emission Standards	• Technology Standards

As there are many types of EI, selecting the right tools leads to success of policy implementation. However, each tool has its own characteristics. World Bank (2012) suggests the success matrix for implementation of EI as shown in Table 2.2.

Table 2.2 Success Matrix for Implementation of EI

Economic-based Instruments	Activities and requirement for implementation	Condition for success	Strength	Weakness
Enforcement Incentives	The regulator needs to; ● Set up clear rule ● Collect the revenue	● Monitor data on pollutant must be available ● Enforcing compliance ● Institutional integrity must be very high	● Charges proportional to pollution	● More complex to coordinate with different sources of pollution ● Monitoring and enforcement are costly
Deposit Refund System	The regulator needs to; ● Set up clear rule ● Collect the revenue	● Front-end charge (deposit) combined with refund payable when quantities are turned in for recycling ● Participation by households	● Low legal, institutional, and political barriers ● No need for monitoring when voluntary	● Difficult to enforce because of the voluntary nature of the scheme ● High cost of implementation
Charges/Taxes	The regulator needs to; ● Set up clear rule ● Collect the revenue	● Enforcement Compliance ● Institutional integrity must be very high	● Multiple sources of pollution ● No need to identify an abatement level ● Works even when monitoring data unavailable ● Easy to manage ● Generate revenues	● Do not always incentivise adoption of abatement technologies ● May affect non-targeted activities ● Politically difficult to accept ● Distributional impacts can be distortive
Subsidies	The regulator needs to; ● Set up clear rule	● Enforcement Compliance ● Institutional integrity must be very high	● Incentive to actually charge system	● Taxpayer gets part of pollution burden

Economic-based Instruments	Activities and requirement for implementation	Condition for success	Strength	Weakness
Tradable/Marketable Permits	The regulator needs to; ● Set up clear rule	● Data needed for initial allocation ● Tracking system required ● Enforcing compliance	● Flexibility in their application ● Cost savings for the regulator ● Less efficient units of production are likely to stop operating	● Major regulatory requirement ● Consistent legal framework ● Political resistance

(World Bank, 2012)

3. Advantages of EI

a) High flexibility

EI allows manufacturers and individuals in deciding how to meet environmental target at the lowest cost by the market price. EI can achieve target level at the lowest cost by differentiating pollution reduction framework as charge level and quantity/quality permit for each manufacture depending on their ability to reduce pollution (Austin, 1999).

b) Continuous incentives

EI provides ongoing incentives for manufacturer to reduce pollution by adopting new pollution control technologies at greater level of abatement.

c) Revenue generation

EI has ability to generate revenue for pollution control activities. A charge, for example, could be collected to finance and fund any of environmental protection programmes.

d) Regulatory cost reduction

EI eliminate the need of large information to determine the most feasible and appropriate level of control for each plant since EI also automatically reduce the

cost of government certification for production process or technologies (WHO/UNEP, 1997)

However, EI implementation requires strong regulatory and enforcement mechanism. Related institution cooperation is also important for the success of EI as a supplement of CAC for environmental policy.

2.2.2.2 PPP as wastewater charge in other countries

For public sewerage or wastewater treatment service, user charge is generally applied for both municipal and industrial wastewater discharge. According to WHO/UNEP (1997) the effective of pollution control by the levy of user charge, appropriate charge, institutional capacity for monitoring and enforcement are required.

i) Sao Paulo, Brazil

Experience in Sao Paulo, Brazil demonstrates the importance of appropriate charge level before investing any facilities.

Largely centralised wastewater treatment facility called Susano was constructed for local paper mill factory and 90% of capacity is designed to for paper mill wastewater. Due to the high level of charge set by the state sanitation company (SABESP; Basic Sanitation Company of the State of Sao Paulo), the factory decided to install its own wastewater treatment at lower cost instead of using centralised service. As a result, Suzano treatment plant was operated at 10% of full design capacity for several years (WHO/UNEP, 1997). This shows that user's preference is significant to the success of policy distribution.

Another example is a case in the US, towns receiving federal grants for sewer system construction are required to recover the cost of operation and part of revenue generation will be from user charge of centralised municipal sewerage

treatment (WHO/UNEP, 1997). Each city has set each charge level and payment method itself. In this chapter, Oregon state will be shown as an example of wastewater charge implementation of the US.

ii) Wastewater charge in Oregon, US

The main objective of wastewater charge collection is to cover operation and maintenance costs of the services. The rate of charge and the collection procedures are different from town to town depending on the context of each town as decentralisation. Moreover, the rate is kept updating every fiscal year and the information shown in table 2.3 is for 2017-2018.

Table 2.3 Residential water and wastewater tariff of cities in Oregon state, US

City	Type	Water tariff		Wastewater tariff		Operation servicer
		Fixed rate ($/month)	Variable rate by volume ($)	Fixed rate ($/month)	Variable rate by volume ($)	
Salem	Meter size 5/8"	7.72	2.63 (per ccf)	14.02	3.31 (per ccf)	City of Salem
Portland	Meter reading (by every 30,60,90 days)	40.82	4.499 (per ccf)	18.60 (off-site charge), 10.01 (on-site charge)	10.19 (per ccf)	City of Portland
Eugene	Meter size 5/8"	20.37	1.601 (per kgal for first 8 kgal), 2.703 (per kgal for next 22 kgal), 4.378 (per kgal for over 30 kgals)			EWEB*
	Paid to MWMC			12.96	2.577 (per kgal)	MWMC**
	Paid to City of Eugene				2.261 (per kgal)	City of Eugene
Beaverto	Meter size	14.00	3.07 (per ccf)	29.78	1.97 (per ccf)	City of

City	Type	Water tariff		Wastewater tariff		Operation
n	5/8"					Beaverton

**EWEB = Eugene Water & Electric Board

*MWMC = Metropolitan Wastewater Management Commission

ccf = cubic centifoot, 100 ccf = 1 cubic foot

784 gallon = 1,000 cubic foot

(City of Beaverton, 2018; City of Eugene, 2018; City of Salem, 2018; EWEB, 2018)

Table 2.3 clearly shows that different city has different collection charge rate. Portland has fixed rate meter reading fee at US$ 40.82 by 30, 60 and 90 days. This means that 90 days billing period could save service fee per day (US$ 0.4536/day) compared to 30 days billing period at US$ 1.2607/day and 60 days billing period at US$ 0.683/day. Moreover, Eugene has progressive tariff and 2 operation servicers namely Metropolitan Wastewater Management Commission (MWMC) and City of Eugene. MWMC is in charged for central wastewater collection systems and wastewater treatment operation while City of Eugene is responsible for local wastewater collection and pumping station.

Moreover, in case of Salem city, wastewater treatment charge is higher than water tariff. Due to the regulatory standard of wastewater discharge, wastewater treatment technology is more complex and advance than water treatment for water supply. As a result, the higher rate of charge is a necessity to cover the operation and maintenance costs. This allows the facility being systematic and self-sustained by the revenue generated itself.

2.2.2.3 PPP as wastewater charge in Thailand

In Thailand, PPP was first introduced in 7th National Economic and Social Development Plan. However, it has not been practically implemented throughout the country although local government has been authorised to do so. In case of wastewater management, the study of Simachaya (2003) stated that the barriers of wastewater charge implementation in Thailand are; Public opposition, Lack of information, Funding and Politics.

Nevertheless, there are some cases of PPP as wastewater charge in Thailand. There are 21 out of 91 municipalities have levied WW charge for WWT. For example, Hua-Hin municipality earns revenues from WW charge 1.2 million Baht/year. Kuchik municipality, Nakon Ratchasima collect 10 Baht/month/household from residential area. Basically, WW charge collected is used for O&M while capital cost of WWTPs still rely on National government budget. The financial sources are mainly from Department of Public Works and Town & Country Planning, Ministry of Natural Resources and Environment, Ministry of Science and Technology, National Environmental Fund and local government budget. Appendix A summarises information of all WWTPs available in Thailand for more details.

2.3 Willingness to Pay (WTP)

2.3.1 What is WTP?

Willingness to pay (WTP) is a maximum price that individual will pay for one unit of products or services. It is a key component of consumer or demand side. In economics, WTP is sometimes known as reservation price which satisfy both producer and consumer. To illustrate, it will be a highest price when a consumer is willing to pay for products or services while it will be a lowest price when the producer is willing to sell a unit of products. However, some researchers conceptualised WTP as a range (Varian, 1992) and it has been seen in several WTP studies.

WTP study is not new. There are a number of studies in several perspectives especially in public goods such as improved residential waste management (Ezebilo, 2013), reliable electricity service (Taale & Kyeremeh, 2016), public housing (Van Ommeren & Van der Vlist, 2016) and clean water (Rodríguez-Tapia, Revollo-Fernández, & Morales-Novelo, 2017). WTP estimation could reveal the preferences and acceptability on specific goods or services provision from the demand side. The

information obtained is significant to decision-making of any strategies or policies as in US EPA guideline allows the measurement of public's WTP to be represented as economic benefits of an environmental policy to specify changes of environmental quality (Kotchen, Boyle, & Leiserowitz, 2013). This is also claimed by Ezebilo (2013), the demand side knowledge is importance to public services in developing sustainable strategy since the success depends on the household's acceptance.

Bohm (1979) also stated the importance of WTP estimation is that the information of how individual preferences variation among social groups could pursue effectiveness of policy distribution as it could vary among communities. The impacts of information obtained on public goods provision as well as financial decisions should be better known for expanding the financial capacity of such specific public goods with government budget independence.

Public goods are usually funded, financed and delivered by the government as they are fundamental for human living. However, the budget provision from central government is somehow not relative to the actual expenditures of the services. Therefore, alternating financial source could be generated by collecting from the beneficiary as Beneficiary Pays Principle (BPP), mentioned in 6th National Economics and Social Development Plan (1987-1991) or polluter as Polluter Pays Principle (PPP), highlighted in 7th National Economics and Social Development Plan (1992-1996). According to PPP, WTP study will provide the information of citizen preferences to improve practicality of PPP implementation.

Besides a quality of information, historical data and empirical evidences are practically significant on government policy decision-making. Therefore, the improvement of demand-side database and its procedure on public goods is worthwhile to be explored (Johansen, 1977).

2.3.2 WTP and public good

2.3.2.1 Public good

Public good generally is a product or a service that benefits to public. Among 4 types of goods as showed in figure 2.1, pure public good can be defined by two characteristics; non-rival and non-excludability. Non-rival means that one's consumption of a product or service does not diminish others' abilities to consume or enjoy the same product or service. Non-excludability means that individuals cannot be prevented from consuming or enjoying the product or service.

Almost all environmental quality is basically classified into public goods and air quality is a classic example. An individual breathing of fresh air does not degrade air quality for others, as well as other individuals cannot be prevented from breathing the air. According to the characteristics, environmental quality including water quality therefore, is particularly considered as a public good (Siebert, 2008).

	Excludable	Non-excludable
Rivalrous	**Private good** e.g. car, mobile phone, clothing, food	**Common pool resources** e.g. timber, coal, fish resource in rivers
Non-rivalrous	**Club goods** e.g. cinema, private parks, satellite TV	**Public goods** e.g. sun radiation, air, national defense

Figure 2.1 Types of goods

Public good is particularly provided by government as the good is defined to benefits to public and run without profit-oriented. However, source of budget is one of the most important issue for public service provision as the public project should

be smart, equity and sustainability. In terms of sustainability in this context means that it has to be inter-generation equity, or the next generation has not to be taken advantages from current generation's activities. Moreover, public good is particularly a long-term facility. Wastewater treatment is normally planned to well-operate for 20 years before the next improvement (e.g. Pattaya). During 20 years of operation, financing for operation and maintenance activities is required. Source of government funding is mainly from taxation and there are several methods for collection. According to PPP, user charge is normally applied for pollution control facility and the money collected will be financed for those activities for sustaining the system. However, to define suitable rate of charge, the information of cost-effectiveness alone is sometimes not enough for policy decision-making. Involvement of user preference as Willingness-to-Pay (WTP) information is claimed to be a key factor for the success of policy implementation.

2.3.2.2 WTP and wastewater management

Centralised wastewater management affecting public water quality is classified as public good. This means that it is basically provided by the government and WTP study is important to wastewater charge implementation policy. As mention in section 2.3.1, WTP can vary among society (Bohm, 1979) and it is proportional to the impact of pollution. This means that people who live in high pollution impact area would be willing to pay higher price for reducing that impacts as pollution has welfare cost.

However, sustainable wastewater management does not require only wastewater treatment technology but systematic governance. High performance technology alone could not resolve water pollution without sufficient financing, skilled workers and clear management plan as these are main barriers of sustainable wastewater management in developing countries.

As local government has been authorised to manage wastewater treatment themselves after the construction investment funded by central government, levy wastewater charge on users as user fee is one source to finance the system to be self-sustained. Although sustainable wastewater management requires more than financial issue, WTP could help guiding policymaker as evidence for the decision-making on the range of wastewater charge levied reasonably. This is because suitable rate of charge or user preferences are significant to the success or failure of policy distribution.

Wastewater treatment plant in Susano, Brazil, for example, is a case that shows the importance of WTP study. Ninety per cent of designed capacity of the centralised wastewater is expected to receive wastewater generated from local paper mill factory. However, the charge levied is too high for the factory to afford. Instead of connecting the pipe to the treatment service, the factory decided to construct the treatment system itself at lower cost. As a consequence, the wastewater plant had been operated at much lower efficiency than the designed capacity for decades (WHO/UNEP, 1997).

To do the WTP study, there are numbers of factors influencing range of WTP. Factors can be varied among communities as each community has its own characteristic. The next section will give some examples of these factors in a variety of WTP study on public good to see what they could probably be.

2.3.2.3 Factors influencing WTP

As mentioned, WTP has been studied wildly for public good. The section below summarised some of them in order to see factors influencing WTP in study of both foreign countries and Thailand.

Table 2.4 Factors influencing WTP

Author(s)	Year of study	Title	Studied factors
Kotchen et al.	2013	Willingness-to-pay and policy-instrument choice for climate-change policy in the United States	● Education ● Household size ● Household income ● Belief/perception ● Types of instruments
Rammont and Amin	2010	Constraints in using economic instruments in developing countries: Some evidence from Thailand's experience in wastewater management	● Gender ● Education level ● Household income ● Occupation ● Knowledge and awareness of Wastewater management
Ezebilo E. E.	2013	Willingness to pay for improved residential waste management in a developing country	● Price ● Income ● Education ● Gender ● Time ● Household size ● Dwelling type
Van Ommeren and Van der Vlist	2016	Households' willingness to pay for public housing	● Queuing time ● Market value ● Income ● Housing characteristic ● Age ● Number of members
Taale F.	2016	Households' willingness to	● Age

Author(s)	Year of study	Title	Studied factors
and Kyeremeh C.		pay for reliable electricity services in Ghana	• Gender • Married • Education • Income • Household size • House ownership • Monthly expenditure on electricity • Duration of power outage • Meter separation
Rodiguez-Tapia et al.	2017	Household's Perception of Water Quality and Willingness to Pay for Clean Water in Mexico City	• Cost of bottled water • Family income • Trust of water provider • Perception of water quality
Roomratanapun W.	2000	Introducing centralised wastewater treatment in Bangkok: a study of factors determining its acceptability	• Income • Awareness • Education • Life-style • Location of the house • Concern regarding environment • Knowledge about condition of water quality • Level of education
Jhermpun S. and Panyasiri C.	2017	Public attitudes towards wastewater treatment fees in Bangkok	• Family income • Period of stay • Water supply expenditure

Author(s)	Year of study	Title	Studied factors
			• Knowledge and comprehension of wastewater treatment • Information of wastewater treatment • Perception • Public involvement • Wastewater fees adoption • Price of wastewater fees

According to the summarisation, income is a common factor for all study, and it is significant to WTP which directly proportional to family/individual/household income. This means that higher-income families are willing to pay more than lower-income families. However, price of products or expenditures of services is also relative to WTP significantly. High cost of drinking water, for example, strongly negatively influences WTP of Mexican residents. Poor families or low-income families, on the other hand, are willing to pay for good quality of drinking water supply rather than purchasing bottled water (Rodríguez-Tapia et al., 2017). In the same way, if the price of waste management service is too high, residents in developing countries may not pay for the service (Ezebilo, 2013). This can be claimed that individuals prefer an alternative that is cheaper than the others.

Trust is another key affecting WTP for public provision service. The study of Taale and Kyeremeh (2016) shows that unreliable service which is not carried out according to the promise or expectation have negative consequences for trust and resident's WTP. The result was also the same in Rodríguez-Tapia et al. (2017), lack of trust adversely affects WTP and damages any government's policies intended to implement. Service provider is one consideration affecting resident's trust since residents in Ghana are willing to pay more if private firms are involved in service

provision (Ezebilo, 2013) as well as in Mexico when residents seek solutions in the private sector for safe drinking water (Rodríguez-Tapia et al., 2017).

Moreover, individuals' awareness and knowledge are also factors positively influencing WTP. For example, knowledge of water pollution and its impacts, the importance of charge, and recognition of wastewater treatment facilities will increase the acceptance from residents on levied charge (Rammont & Amin, 2010). The results also showed in Jhermpun and Panyasiri (2017), information of wastewater treatment has positive relationship with WTP. This means that if residents obtain information about importance of wastewater treatment facilities and impacts of water pollution, they will be raised environmental awareness and more likely to pay for the charge levied. The information could be broadcasted through television, radio, media, publication and local leader can inform the residents effectively (Rammont & Amin, 2010). Moreover, communication about service provision to consumers built trust which is directly affect WTP positively (Taale & Kyeremeh, 2016).

Moreover, WTP is positively influenced by level of adverse impacts. Duration of electricity service outage in Ghana, for example, the longer period of outage results in increase of WTP for reliable electricity supply. In case of wastewater, location of house is significant factor to impacts level. According to Roomratanapun (2001), people who live near a polluted klong (a canal) reported a higher WTP than people who live far away from klong. This is because ones who live near klong face first-hand experience with pollution while the others do not. However, majority of people who live near klong have low income and short schooling period which is In contrast to others' studies, when high income and level of education normally has positive relationship with WTP for public good development (Taale F. and Kyeremeh C., 2016; Rammont and Amin, 2010; Jhermpun S. and Panyasiri C., 2017; Kotchen et al., 2013). Therefore, this can be claimed that the first-hand experience on pollution has more significant than general socio-demographic factors and the more adverse impacts means the more WTP.

Another socio-demographic factor, size of household affects WTP in both ways; positive and negative relationship. In the study of Taale and Kyeremeh (2016) on WTP for reliable electricity service in Ghana found that size of household negatively affect WTP as well as in WTP of wastewater charge in Bangkok, household size has negative relationship with WTP (Jhermpun & Panyasiri, 2017). They assumed that this could be from the priority of attendant cost of providing for basic needs of members (Taale & Kyeremeh, 2016). Residents may prioritise the payment of basic need on electricity supply rather than the service improvement or water supply rather than wastewater treatment facilities. However, there are positive relationship in some studies Akcura (2011); (Quartey, 2011); (Bigerna & Polinori, 2011). Moreover, WTP study in Thailand have not included size of household or number of members in consideration. Therefore, this study will investigate the influence of household size to WTP to see the trend of its relationship and WTP.

Above all, there are two sides; positive and negative of relationship between influencing factors and WTP. The relationship can be summarised as follows

Table 2.5 Relationship between studied factors and WTP

Factors	
Positive relationship	**Negative relationship**
• Income • Education • Awareness • Knowledge/information • Trust (on service provider) • Adverse impacts • Size of household	• Price of products/services • Size of household

2.3.3 WTP evaluation

WTP is relative to environmental evaluation which is one of vital jobs for sustainable development. This is because it allows public to be involved in decision-making of environmental management measures (Isarangkura, 1998). Moreover, it reflects public's attitudes on environmental situation and how government should contribute resource efficiently for natural resources conservation. As mentioned in section 3.2.2 moreover, market failure is from externalities and/or public goods where environmental price is not internalised into the selling prices. Environmental evaluation is therefore used to fix the failure of the market.

2.3.3.1 Environmental Evaluation

While many people think that environmental value is unevaluable, in contrast, economists believe that environmental value can be evaluated, and it is vital for improved environmental quality management. They define environmental value as how human value the necessity of the environmental condition relating to other products or services.

In order to evaluate environmental value, however, consumers must have rational behaviours according to 4 axiom of Choices which are Reflexivity, Completeness, Transitivity and Continuity. This is because consumers' preference ordering to environment will be reflected in preference ordering function namely, Direct utility function, Indirect utility function, Expenditure function or Distance function.

Marginal rate of substitution

The main idea of environmental evaluation is consideration of how environment benefits to people and it can be divided into 2 types of questions; benefit gain and

benefit loss, i.e. if the environmental quality is improved, what is the value of consumers' benefit gain; or if the environmental quality is degraded, what is the value of consumers' benefit loss. This requires the information of consumers' preferences or attitudes to environment comparing to other products or services which are valuable in monetary units. For example, what is consumers' preferences on expressway construction nearby the houses. The project could help saving travel cost but creating noise pollution. If the majority of people go for "No", this means that the value of noise pollution is greater than the travel cost saving. On the other hand, if the majority of people say "Yes", this means that noise pollution value is lesser than the travel cost saving. This is called "Marginal Rate of Substitution" between environmental issue (noise pollution) and monetary products (travel cost).

The usefulness of Marginal rate of substitution is exact welfare measurement. This is because it is characterised as Utility Constant Welfare Measurement consisting of Compensating Variation (CV); Equivalent Variation (EV); Compensating Surplus (CS); and Equivalent Surplus (ES). Given an example, expressway construction will increase noise pollution. This means that product X (road construction) will decrease consumer's welfare or level of utility (noise pollution). However, if the government compensate by providing 10 coupons/household for free access (product Y), consumer's welfare will increase at the same level before road constructed (Constant Utility). This means that 10 coupons/household is equal to the damage of noise pollution from expressway project. This shows that environmental value can be converted to monetary unit as the value of 10 times free access and this method can be used for environmental evaluation.

Types of social welfare for environmental evaluation

Social welfare depends on the satisfaction of each person in each community. As mentioned in section above, people preferences or attitudes is important to environmental evaluation relating to other products or services. Social welfare change regarding to products or services can be divided into 4 types

1. Compensating Variation (CV) is the measurement of maximum WTP for better consuming condition (in case of welfare gain) or the minimum willingness to accept compensation (WTA) for poorer condition (in case of welfare loss). The CV is consumers' welfare measurement in status quo of utility.

2. Equivalent Variation (EV) is the measurement of minimum WTA for opportunity loss in non-existing condition (in case of welfare gain) or the maximum WTP for avoidance of non-existing condition (in case of welfare loss). The EV is the consumers' welfare measurement at in the change level of utility.

3. Compensating Surplus (CS) is the measurement of maximum WTP for better condition (in case of welfare gain) or the minimum willingness to be paid for the acceptance of poorer condition (in case of welfare loss). It could be said that CS is the measurement of the difference between minimum WTA and actual payment of consumers or the area under Marshallian Demand line where over the actual payment.

4. Equivalent Surplus (ES) is the measurement of the vertical difference between Indifference Curves as CS. The ES is the measurement of minimum WTA of environmental quality improvement.

According to Hickian welfare, CV and EV have relationship with WTP and WTA, and CV and EV is not necessary to be equal (Johansson, 1993). The relationship of WTP and WTA with CV/CS and EV/ES is summarised as table 2.6 as well as relationship between WTP and WTA with environmental change in figure 2.2.

Table 2.6 Relationship between WTP/WTA and social welfare

Condition	Social welfare	
	CV/CS	EV/ES
Welfare gain (e.g. price decrease)/ Environmental improvement	Maximum WTP to obtain	Minimum WTA to forego
Welfare loss (e.g. price increase)/ Environmental damage	Minimum WTA to accept	Maximum WTP to avoid

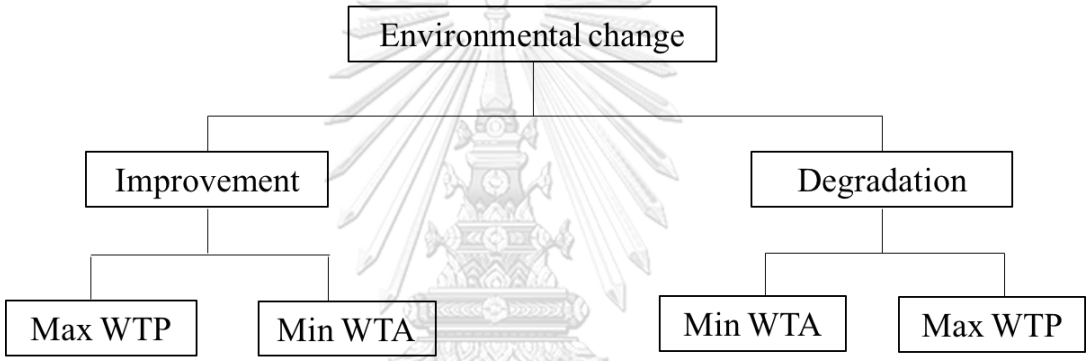

Figure 2.2 Relationship between WTP and WTA with environmental change

Public goods or environmental value evaluation will raise awareness among society in terms of the limitation of environmental resource and capability of natural self-recovery. This will reflect environmental and social costs when activities for economic development diminish environmental quality (Isavilanont, 1995).

Types of Environmental Value

According to (Pearce, 1992), total Economic value of environment can be divided into 2 main groups namely Use Value and Non-Use Value showed in figure 2.3.

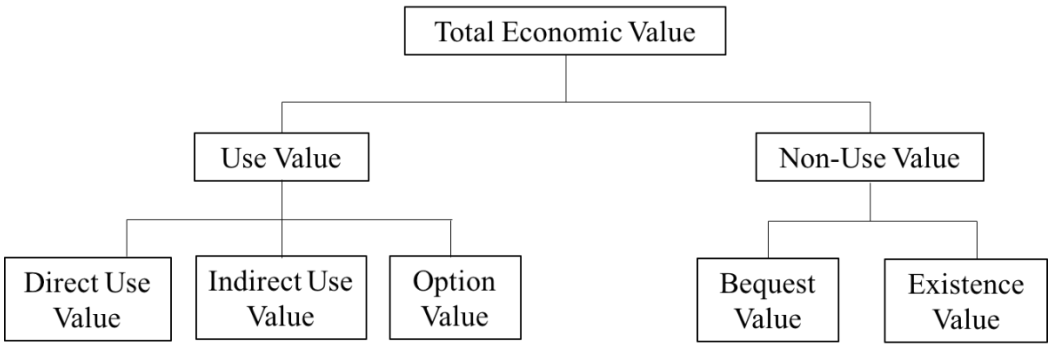

Figure 2.3 Types of Environmental Value (Pearce, 1992)

Total Economic Value can be expressed as

Total Economic Value = Use Value + Non-Use Value

= (Direct Use Value + Indirect Use Value + Option Value)

+ (Bequest Value + Existence Value)

1. Use Value is tangible value and it can be divided into 3 value types

1.1 Direct Use Value is the value that directly benefits to people (e.g. health impacts from air quality, risks from improper chemical substance disposal.)

1.2 Indirect Value is the value that reflect public satisfaction of environmental and gain benefits (e.g. good water quality in water body will help reducing cost of water supply operation).

1.3 Option use is the Value that residents are expected to gain benefits. In the other word, it is opportunity value to be exploited in the future for direct and indirect uses.

2. Non-Use-Value is the environmental value that satisfy public's desire of environmental quality although they have not been benefited from that. It can be divided into 2 types

2.1 Bequest Value is the value that public gains from environmental quality that is good enough for future generation.

2.2 Existence Value is the value that public gains from the remaining of good environmental quality (e.g. existing of reserved species, existing of biodiversity).

Environmental Assessment by Economic-based Approach

Approaches can be mainly divided into 3 approaches; Market valuation; Surrogate Market and Hypothetical Market.

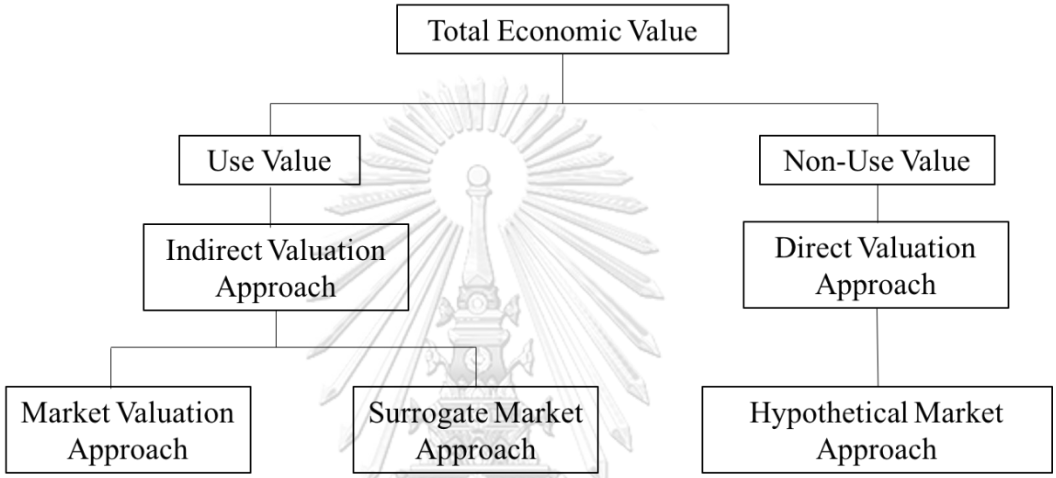

Figure 2.4 Environmental Assessment by Economic-based Approach

1. Market Value Approach

This approach is environmental assessment by converting impacts into monetary value based on related market. This is on the basis of environmental quality change, revenue or expenditure will be changed and this monetary change could represent environmental degradation value. This technique can be used in terms of change in productivity or preventive expenditure.

2. Surrogate Market-Value Approach

This approach will be used when environmental value cannot be directly evaluated. (e.g. Estimate National Park Value by using travel cost valuation)

3. Hypothetical Market Approach

This is valuation method by creating hypothetical situation. There are several valuation techniques, but one commonly is Contingent Valuation Method (CVM). This is the technique where hypothetical situation of environmental issues is used for evaluating Willingness to Pay (WTP) or Willingness to Accept Compensation (WTA) of residents for those environmental situations.

Apart from above 3 approaches, other environmental impact assessment technique based on idea of demand curve and not demand curve (others) techniques is shown in figure 2.5.

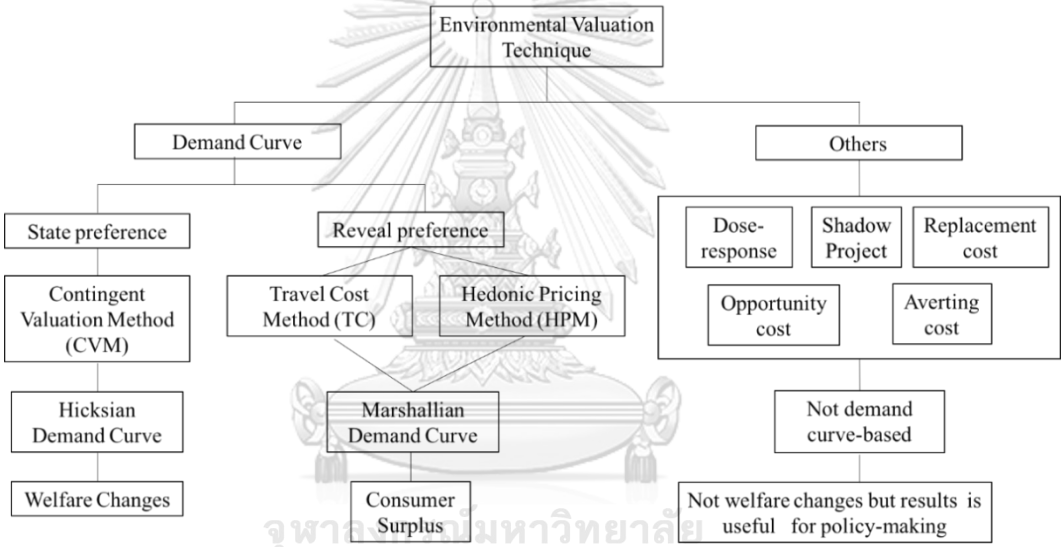

Figure 2.5 Environmental Assessment Technique

(Seenprachawong, 2013)

1. Demand Curve

This approach consists of Direct and Indirect Valuation method. Direct Valuation method or state Preference Method is the valuation of direct WTP i.e. CVM while Indirect Valuation Method or Reveal Preference Method is indirect WTP e.g. Travel Cost Method (TCM), Hedonic Pricing Method (HPM) which will result as Welfare Change and Consumer Surplus.

1.1 Direct Valuation Method or State Preference Method

1.1.1 CVM is a high flexibility method because this can be used to evaluate environmental impacts both Use Value and Non-Use Value. This will create scenario or hypothetical situation for residents' attitudes survey.

1.2 Indirect Valuation Method or Reveal Preference Method

This method is the environmental valuation that the environmental value is in the market itself but there are some latent environmental values in other products. The common methods are Travel Cost Method (TCM) and Hedonic Pricing Method (HPM).

1.2.1 TCM is environmental valuation in non-market by analysing from consumer behaviours. TCM is commonly used for recreation and tourist attractions e.g. the value of a public garden could be represented by travel costs estimation with Weak Complementary between travel cost and environment assumption.

1.2.2 HPM is implicit price valuation of differentiated products. This method uses implicit price function model to evaluate welfare change e.g. evaluate air quality value by asset value.

2. Others

This method does not evaluate welfare change but analyse in terms of policy. This technique could be dose-response and Averting-cost. For dose-response, impacts of environmental quality can be evaluated by estimating from dose-response function in terms of rate of illness and death. The finding will then be converted into monetary value. Averting Cost is expenditure estimation from individual averting or reducing risks of illness or decease. (e.g. cost of air filter for indoor air quality improvement in order to averting respiratory tract decease.

However, environmental value cannot perfectly be ensured by valuation of a single method. More than one method will therefore be used in the same valuation and the results will be compared for precision and accuracy of the results.

For environmental quality assessment, Productivity Loss Approach, Costs of illness Approach, Hedonic Pricing Method and Contingent Valuation Method are generally chosen for evaluation. Yet CVM is basically selected for environmental impacts evaluation to find out social welfare cost. This method will set scenario or hypothetical situation for evaluation of several aspects from respondents.

2.3.3.2 Contingent Valuation Method (CVM)

CVM is one of direct method for nonmarket valuation of environmental good changes from status quo. CVM is often used in environmental policies or damages to estimate total economic value; use value and non-use value. Since CVM allows individuals to state their preferences, hence, it is called state-preference technique. Basically, individuals are asked about the status quo versus an alternative. Solicited information will be elicited how individual feels about the alternative relative to the status quo as well as WTP to obtain the alternative. For example, how much is an individual damaged by a polluted water?

CVM execution and design for WTP could be explained step by step as follows.

Step 1: Construction of hypothetical market

Scenario which corresponds as closely as possible to the real situation is usually hypothetical for interview as contingent in CVM refers to hypothetical. 3 steps of how to construct hypothetical situation are in the followings.

1. The reason for payment

Respondents must clearly understand the scenario of what improvement specified is contingent on their payment (e.g. safe water will be provided).

2. The method of payment

This can be called “bid vehicle” and this will fulfil the conditions with respect to incentive compatibility, realism and subjective justice among respondents. The payment method could be

a. Fund/contribution
b. Tax
c. Direct payment
d. Payment in the form of basic commodity by increasing the price (e.g. higher water supply price)

3. Provision rule

This is a mechanism of how the good will be provided as a function of stated value.

Step 2: Obtaining the data

The data could be collected through interview from selected samples and possible ways of interview could be

1. Personal interview by person to person

This method is recommended because this increases engagement and awareness by interviewee. This also reduces misunderstanding of what scenarios are as well as the objective of this interview.

2. Personal interview by using interactive medium (e.g. computer)

This method is sometimes advantage especially when the path of questions is complex or there are several alternatives in the questions.

3. Questionnaire
4. Telephone interview

Table 2.7 Relationship between CV/EV and WTP/WTA

Welfare measure	Price increase	Price decrease
EV (In the change)	WTP to avoid	WTP to forego
CV (In the status quo)	WTA to accept	WTP to obtain

Source: A.M. Freeman (2003)

CVM is focusing on finding out consumers' satisfaction on hypothetical situation in terms of Maximum WTP for better environmental quality and resource efficiency, or Minimum WTA for compensating poorer environmental quality and resource efficiency (Mitchell & Carson, 1989).

CVM question formats

1. Open-ended Question

This approach allows respondents to express their maximum rate of WTP since they can say any amount that they prefer. However, this kind of question may create uncomfortable situation to respondents or make Strategic bias and this can create high variation of WTP (Mitchell & Carson, 1989)

2. Close-Ended Question or Dichotomous Choice Approach

This technique called referendum CVM question as it will offer rate of WTP for interviewees to accept or deny. This is based on the fact that people do normally not mention the exact value, or the value is hard to be defined. Therefore, offering WTP for interviewees' consideration to accept or deny is a strong point of this method.

The Closed-Ended Question can be divided as follows

a. Close-ended Single Bid

This approach offers only one price for respondent to accept or deny. There are 2 probabilities of answers which are Yes (to accept the offered price) and No (to deny the offered price). For example, are you willing to pay X bath for environmental improvement? The probabilities of 2 events are

Pr (No to X) = Pr (X > max WTP)

Pr (Yes to X) = Pr (X ≤ max WTP)

However, Closed-Ended Single Bid has low efficiency due to the high variation of WTP (Mitchell & Carson, 1989) and Double Bounded Dichotomous Choice is introduced.

b. Double Bounded Close-Ended

Firstly, one WTP will be offered to respondents to accept or deny as initial bid. Secondly, increase the offered WTP as Upper bid if the respondent says Yes in the first Bid. On the other hand, the offered price will be decreased if the respondents say No for Initial Bid price as Lower Bid.

For example, will you pay X Baht to support environmental improvement project? If the answer is Yes, offer increased price as X", but if the answer is No, offer decreased price as X'. The probabilities are 4 events as follows

P(YY) = Pr^{YY} (X, X") = Pr (X" ≤ max WTP)

P(YN) = Pr^{YN} (X, X") = Pr (X ≤ max WTP ≤ X")

P(NY) = Pr^{NY} (X, X') = Pr (X ≥ max WTP ≥ B')

P(NN) = Pr^{NN} (X, X') = Pr (X ≥ max WTP, and X' > max WTP)

c. Bidding Games

Bidding game can be divided into 2 groups; Single bidding and Iterative bidding. After interviewee has been clearly informed about the project, in single bidding,

interviewee state one price for bidding, while in iterative bidding, interviewer can bid until reach the maximum WTP. For example, the question would be will you pay X Baht for environmental quality improvement? If the answer is Yes, X will be added to X+Y, and follow by a larger amount and questions stop when the answer is No. On the other hand, if the answer is No at X Baht, X will be decreased as smaller amount until the interviewer say Yes. This approach is similar to doubled bound closed-ended but allows interviewer answering more than 2 times.

d. Payment Card

In this approach, the different possible amount is indicated on the cards and let the interviewer select the largest amount of WTP.

Table 2.8 Summarisation of CVM question technique

	Actual WTP	Discrete Choice
Single question	• Opened-ended • Single bid • Payment card • Bidding Game	• Closed-ended single bid
Iterated or series of questions		• Double-Bounded Closed-Ended • N-Bounded Close-Ended

Key consideration for CVM (adapted from Isarangkura (1998) and Theerawatanakul (2007))

Although CVM can be used for estimating environmental values both quantitative and qualitative values, there are some weak points in the followings.

1. Results from CVM may contain Bias from respondents and the bias can be classified as follows

a. Strategic Bias or Strategic Behaviour; e.g. the respondents do not express their real preferences. The respondents may report WTP lower than the real preference because they are afraid of the charge implementation. On the other hand, they may report higher than their preferences if the charges will not be implemented.

b. Instrument or Vehicle of payment Bias; the respondents may not agree with the instrument applied or method for payment. (e.g. respondents prefer donation to taxation)

c. Hypothetical or Information Bias; this may be caused by insufficient, unclear information provided to respondents and lack of result reliability as a consequence of misunderstanding.

2. Value may be obtained embedding effect. The respondents may report the same value in every single situation even though the situations are different in environmental changes significantly. The cause of Embedding Effect is due to the fact that some respondents have Warm Glow or the recognition of environmental conservation without considering the level of damage.

3. The difference between WTP and WTA is normally occurred in the same situation of environmental change and WTA is normally higher than WTP. The format of question could help WTP and WTA to be more accurate. In case of WTP, the question should be like “If the environmental quality is degraded, how much will you pay for the damage protection?”. For WTA, “If the environmental quality is not improved, how much will you prefer to be compensated?”

According to the bias and other errors possibly being happened, CVM should be carefully and suitably designed for the most reliable results. Hoevenagel (1994) suggested that questionnaire pretesting could help reducing these kinds of errors.

2.3.3.4 Sample size selection

Selecting sample or population size is important in statistical study since it will be representative of whole population. However, sampling error is generally existing because zero error will be only in census survey which is suitable for small populations e.g. 200 or less. Therefore, a sample with the smallest error will be considered as a good representative of the population and bigger sample size has lesser errors as showed in figure 2.6.

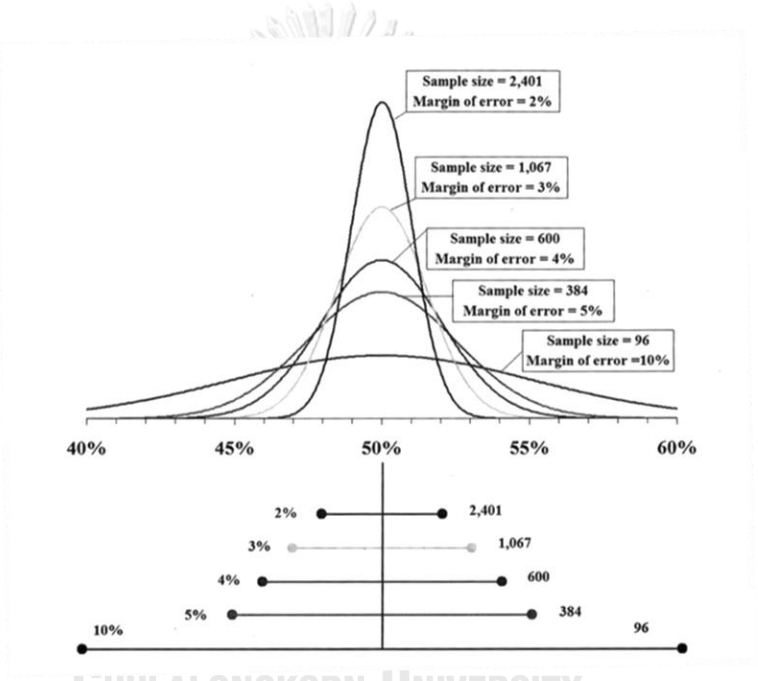

Figure 2.6 Relationship between sampling error and sample size

(Sarmah & Bora Hazarika, 2012)

Sample Size Criteria *(Isarael, 1992)*

With good precision, three criteria are usually considered to determine the adequate and appropriate sample size namely level of precision, confidence level and degree of variability.

1. Level of Precision

Level of precision or sampling error is difference between estimated value and actual population value and is often expressed in percentage. For example, if an acceptable sampling error is ±5% or ±0.05, 70% of samples are willing to pay the WW charge, it can be concluded that 65%-75% of population are willing to pay the WW charge.

2. Confidence level

Confidence level known as risk level tells how confidence of the error does not exceed in the precision specification. It is under the idea of Central Limit Theorem when the population is repeatedly sampled, the average value obtained by those samples is equal to the actual population value. It is ascertained through normal distribution where the Central Limit Theorem mathematically proves that the means of samples becomes more normal distribution as the sample size increases and the confidence level at 95% and 99% of probability are usually taken.

To illustrate, 95% confidence level in normal distribution means 95 out of 100 samples will have estimated value in the range within specified precision mention in 1 or in two standard deviations of the actual population value (e.g. mean). However, there is always a chance of extreme values that does not in the population value as showed in shaded area in figure 2.7.

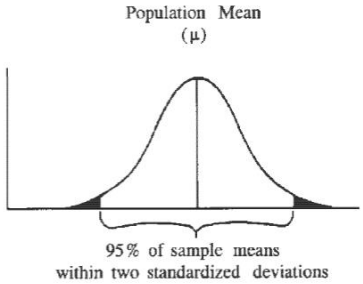

Figure 2.7 Normal distribution of means for repeated samples

(Isarael, 1992)

3. Degree of Variability

The degree of variability is measured to refer the attributes in the population. More heterogeneous population requires more sample size to obtain a given precision level. Note that a proportion of 50% is the maximum of variability in a population because the other proportions such as 20% and 80%, indicate the majority of interest. Therefore, a proportion of 0.5 is often used to determine a more conservative sample size and sample size may be larger than those if the attribute of population were used.

Sample Size Determination Strategies

For appropriate sample size, several approaches are available for the determination when different sampling techniques are used. Random sampling technique is the simplest method and most common. The approaches include a census for small population, a sample size of a similar study, published tables, formulae calculation to determine the sample size.

1. Census for small population

This approach is attractive for small number of population (e.g. 200 or less) because it uses whole population as the sample. It also eliminates sampling error to reach the desired precision level.

2. Sample size of a similar study

This suggests using the same sample size as those studies which similar to the planned study. Literature review can provide the guidance of typical sample size used in this kind of the study.

3. Published tables

Published table present sample size with necessary criteria combination of precision, confidence level and variability.

Table 2.9 Yamane's sample size for ±1%, ±2%, ±3%, ±4%, ±5% and ±10% precision level, 95% confidence level and variability = 0.5

Size of Population	Sample size for precision of:					
	±1%	±2%	±3%	±4%	±5%	±10%
500	a	a	a	a	222	83
1,000	a	a	a	385	240	91
1,500	a	a	638	441	255	94
2,000	a	a	714	476	267	95
2,500	a	1,250	769	500	277	96
3,000	a	1,364	811	517	286	97
3,500	a	1,458	843	530	333	97
4,000	a	1,538	870	541	353	98
4,500	a	1,607	891	549	364	98
5,000	a	1,667	909	556	370	98
6,000	a	1,765	938	566	375	98
7,000	a	1,842	959	574	378	99
8,000	a	1,905	976	580	381	99
9,000	a	1,957	989	584	383	99
10,000	5,000	2,000	1,000	588	385	99
15,000	6,000	2,143	1,034	600	390	99
20,000	6,667	2,222	1,053	606	382	100
25,000	7,143	2,273	1,064	610	394	100
50,000	8,333	2,381	1,087	617	397	100
100,000	9,091	2,439	1,099	621	398	100
>100,000	10,000	2,500	1,111	625	400	100

a = Assumption of normal population is poor (Yamane, 1967). The entire population should be sampled

Table 2.10 Krejcie and Morgan's sample size for ±5% precision level, 95% confidence and 0.5 variability (KREJCIE & MORGAN, 1970)

Size of population	Sample size	Size of population	Sample size	Size of population	Sample size	Size of population	Sample size	Size of population	Sample size
10	10	100	80	280	162	800	260	2,800	338
15	14	110	86	290	165	850	265	3,000	341
20	19	120	92	300	169	900	269	3,500	346
25	24	130	97	320	175	950	274	4,000	351
30	28	140	103	340	181	1,000	278	4,500	354
35	32	150	108	360	186	1,100	285	5,000	357
40	36	160	11	380	191	1,200	291	6,000	361
45	40	170	118	400	196	1,300	297	7,000	364
50	44	180	123	420	201	1,400	302	8,000	367
55	48	190	127	440	205	1,500	306	9,000	368
60	52	200	132	460	210	1,600	310	10,000	370
65	56	210	136	480	214	1,700	313	15,000	375
70	59	220	140	500	217	1,800	317	20,000	377
75	63	230	144	550	226	1,900	320	30,000	379
80	66	240	148	600	234	2,000	322	40,000	380
85	70	250	152	650	242	2,200	327	50,000	381
90	73	260	155	700	248	2,400	331	75,000	382
95	76	270	19	750	254	2,600	335	100,000	384

4. Formulae calculation

Formulae calculation allows to determine the sample size when using different combination of precision, confidence level and variability which is not available in published table. There are several formulae for sample size calculation but in this report, Cochran's and Yamane's formulae are reviewed because these two are extensively used compared to others.

4.1 Cochran's formula for calculating a sample for proportion when population is infinite (A. Robb, 1963)

For large populations, Cochran (1977) developed the Equation 2-1 as a representative sample for proportions.

$$n_0 = \frac{Z^2 pq}{e^2} \qquad \text{equation 2-1}$$

where n_0 = sample size

z = desired confidence level

p = estimated proportion of attributes in population

q = 1-p

e = desired level of precision

4.2 Cochran's formula for calculating a sample proportion when the population is finite

If the population is finite, the sample size can be slightly reduced. Cochran developed Equation 2-2 for the final sample size of finite population.

$$n = \frac{n_0}{1+\frac{(n_0-1)}{N}} \qquad \text{equation 2-2}$$

where n_0 = sample size derived from equation 1

N = population size

4.3 Yamane's formula for calculating a sample size

This is an alternative to Cochran's formula. Yamane (1967) developed the simplified equation to calculate the sample size as equation 2-3.

$$n = \frac{N}{1+N(e^2)} \qquad \text{equation 2-3}$$

where n = sample size

N = population size

e = level of precision

2.3.3.5 Sampling Methods

After obtained sample size from section 2.3.3.4, selecting samples from population is also important as these samples will represent the result for entire population.

Sampling methods can be divided into 2 main methods; Probability sampling and Nonprobability sampling.

a.) Probability sampling

Sampling based on probability allow every unit of population have equality in being selected and the method can be classified in the followings.

This method is simple and suits for small number of population. Members of population in random sampling has equal probability to be chosen as drawing lots.

i) Systematic sampling

This method is similar to simple random sample but more convenience. This is because the population is able to be systematically ordered by prescript sequence such as student ID, telephone number, etc. The desired samples size will then be calculated, and samples will be selected one by every sequenced set until it lasts.

ii) Stratified sampling

This method will classify population into strata. This method is used when population attribute is known as homogenous within strata (i.e. categories of school). The allocation of samples can be carried out through two allocation methods namely proportional allocation and non-proportional allocation.

Proportional allocation was originated by Bowley (1962) where the sampling fraction of $\frac{n}{N}$ is the same in all strata. The calculation can be made by equation 2-4.

$$n_i = n\frac{N_i}{N}\ ; i = 1, 2, 3 \qquad \text{equation 2-4}$$

where n = sample size

N_i = population size of i^{th} strata

N = population size

This method is simple, fast doing and has higher degree of precision.

Non-proportional allocation is opposite to proportional allocation where the sampling does not follow proportion principle but depends on investigator's consideration.

iii) Cluster sampling

In this method, population will be divided into groups called clusters and population should be homogenous between each cluster. After that, simple random sampling method is then used to select samples. This method is often used in marketing research.

iv) Multistage sampling

This method suits for sampling of large population and the population is infinite (i.e. national population, regional population). The population will be grouped from large to small number at each stage by homogenous factors for each group.

b.) Nonprobability sampling

i) Haphazard or Accidental sampling

This sampling method depends on the willingness of samples until reaching the desired sample size.

ii) Quota sampling

The method is pre-set the desired number of each group and the sample will then be selected (e.g. 50 samples from men and 30 samples from women)

iii) Purposive sampling

This is the most common method when the samples have been pre-selected criteria from research question. For example, the study is attempted to study the students who get GPA more than 3.00.

2.4 Study reviews

This section will summarise WTP of both foreign and Thai's study in order to see the method of data collection and analytical technique of each study. Almost all of them used CVM although CVM has some weaknesses. This is because environmental economists are still seeing its usefulness for environmental evaluation to manage natural resource and environmental quality. CVM has, therefore developed for the most reliable results.

2.4.1 Foreign WTP study review

Table 2.11 Foreign WTP study on Public good

Author(s)	Year of study	Title	Method
Kotchen et al.	2013	Willingness-to-pay and policy-instrument choice for climate-change policy in the United States	**Data collection:** CVM: Mix method ● Closed-ended question ● Payment cards **Analytical measure:** Censored regression model
Ezebilo E. E.	2013	Willingness to pay for improved residential waste management in a developing country	**Data collection:** CVM: Dichotomous choice **Analytical measure:** Binary Logit model
Van Ommeren and Van der Vlist	2016	Households' willingness to pay for public housing	**Data collection:** Hedonic approach **Analytical measure:** Linear Regression: Ordinary Least Square(OLS)
Taale F. and Kyeremeh C.	2016	Households' willingness to pay for reliable electricity	**Data collection:** Interview (95%) and

Author(s)	Year of study	Title	Method
		services in Ghana	questionnaire (5%) **Analytical measure:** Tobit model
Rodríguez-Tapia et al.	2017	Household's Perception of Water Quality and Willingness to Pay for Clean Water in Mexico City	**Data collection:** Hick's wellness theory CVM: Mix method • Open question • Referendum • Double limit referendum **Analytical measure:** Tobit Censored Econometric model

According to table 2.11, seeing that CVM was selected in most of all study since they can use for both qualitative and quantitative data collection. Moreover, Tobit method was mainly used for analytical technique. This could be because Tobit method or censored regression model suits for ones that contain latent variables. Normally, CVM question format as dilemma or chosen alternatives such as Dichotomous choices and Closed-ended question, contain this kind of variables. This kind of question is usually used for CVM even though there will create some limit of observation. This is because it provides respondents convenience and easiness in terms of selecting alternatives as well as less time consuming rather than open question. Therefore, Tobit could be claimed to be the most suitable method to reduce the errors or improve result accuracy from latent variables.

2.4.2 WTP Study in Thailand

In this section, only WTP regarding to water quality was selected to show for the revision of previous study as summarised in the table 2.12. Seeing that WTP study in

Thailand on water quality is not new as it has been found more than 20 years ago in TDRI and HIID (1995).

Table 2.12 WTP study on public goods related to water quality in Thailand

Author(s)	Year of study	Type of public good	Method	Results
Boontanon S. K. (Boontanon, 2014)	2014	Wastewater in Bangkok	- 301 samples for Questionnaire - In-depth interview of BMA, PDC, Department of Drainage and Sewerage	- Avg. WTP = 89 Baht/month-household - Range of WTP = 39-197 Baht/month-household
JICA (JST cited in JICA (2011))	2010	Wastewater in Nong Bon area, Bangkok	- 350 samples - CVM - Logit linear method	- Avg. WTP = 73.3 Baht/month-household
BMA (JST cited in JICA (2011))	2010	Wastewater in Bangkok	- 2,300 samples - Three answer choices	- Avg. WTP = 41.4 Baht/month-household
BMA (JST cited in JICA (2011))	2006	Wastewater in Bang sue area, Bangkok	- 326 samples - Open questions	- Avg. WTP = 39.2 Bath/month-household
IDRC and others (JST cited in JICA (2011)	1999	Wastewater in Bangkok	- 1100 samples - CVM	- Avg. WTP = 100.8 Baht/month-household
Roomratanapun W. (Roomratanapun,	2001	Wastewater in Bangkok	- Closed-ended referendum (10-100 Baht)	- Avg. WTP = 86.87 Baht/month or

Author(s)	Year of study	Type of public good	Method	Results
2001)				3.28 Baht/m^3 (Assumed that WW generation = 80% of water consumption)
TDRI and HIID (TDRI & HIID, 1995)	1995	Wastewater in Phuket	- Bidding Game	- Avg, WTP = 2.08/m^3 or 79 Baht/month (lower than actual cost of operation (7 Bath/m^3))
Ngernvichit A. (Ngernvichit, 1998)	1998	Wastewater at Rama9	- Bidding Game	- Avg. WTP = 45 Bath/month-household
Suanjai P. (Suanjai, 1990)	1990	Wastewater at Chomthong community, Chonburi	- CVM	- Avg. WTP = 107/month
Supphachai (Supphatchai, 1996)	1996	Mahanag and San Sab Canals clean-up project	- CVM	- Avg. WTP = 360 Baht/person/year

According to table 2.12, CVM was chosen as data collection technique and there are a variety of question formats. Most of the WTP study were done for in Bangkok for wastewater treatment (Boontanon, 2014; JICA, 2011; BMA 2006, BMA, 2010; IDRC and others, 1999; Roomratanapun, 2001; Ngernvichit, 1998) and water quality improvement in canals (Suppachai, 1996). The results show the WTP variation among each study even the studies were done in the same main area and same

kind of public service (i.e. wastewater treatment Bangkok). This confirms the statement of Bohm (1979) that consumers' preferences could be varied among society. Moreover, factors included as well as types of question format could affect the variation of WTP.

Vitally, WTP had been done for decades to support the wastewater charge policy for the improvement of environmental quality. However, the charge levied has not been implement practically. This shows that there are other factors influencing the implementation of charges rather than the information WTP. As the main objective of this study is to develop water quality management towards sustainability, other gaps and needs for the improvement will be investigated in supportive of range of WTP. The methodology of the study will be detailed in the next section.

Chapter 3
Methodology

Chapter introduction

The study will be carried out by qualitative and quantitative methods. The methodologies will be divided into 5 sections according to main activities which will be conducted for the study. To achieve the objectives, the methodologies can be summarised as follow.

3.1 Overview of Research Methodologies

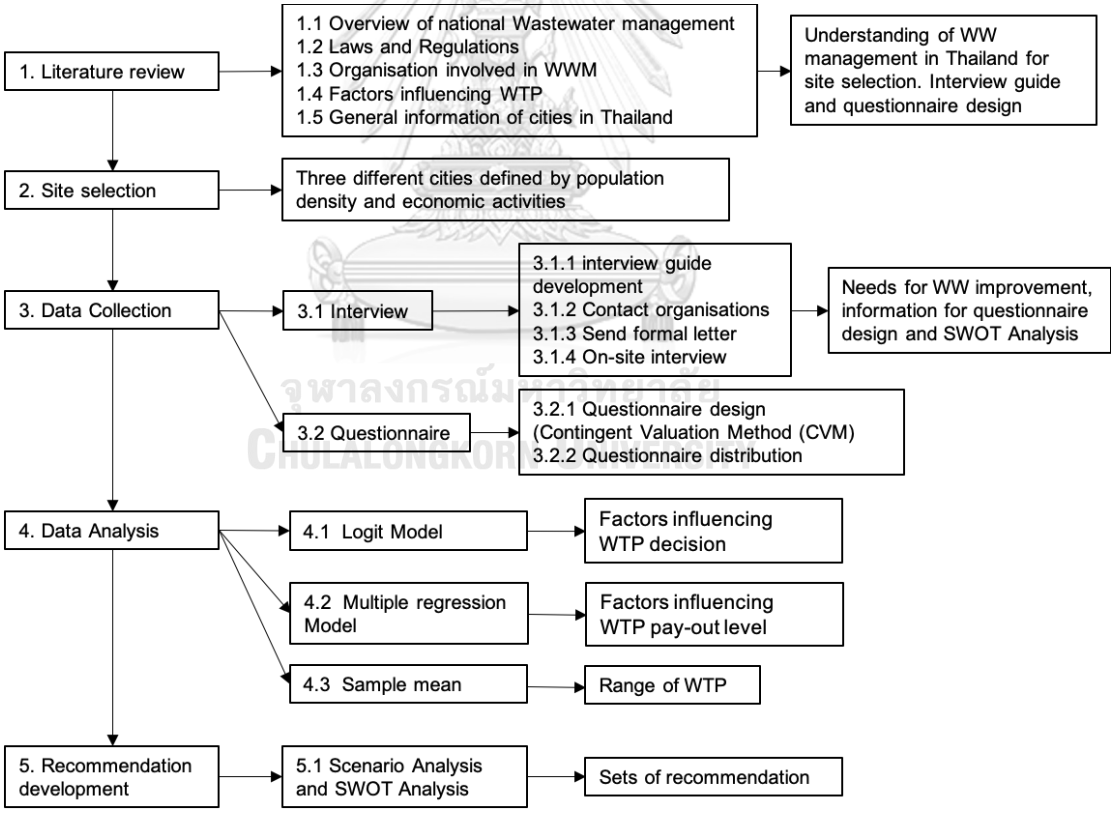

Figure 3.1 Overview of research methodologies

3.2 Literature reviews

Literature review will be conducted to understand overall situation of wastewater management in Thailand and obtain preliminary information of wastewater management. The information will be obtained from books, journals, articles, reports, published previous studies, and internet-based information sources. The expected results from this is to see gaps and needs for improvement of wastewater management and obtain some information to select study sites, design interview guide as well as questionnaires.

3.2.1 To understand overall situation of wastewater management in Thailand

In order to achieve this objective, the information and data from literature review could be summarised as follows.

i) Overview of National Water pollution and Wastewater Management

Background knowledge of national water pollution and wastewater management practice are significant since these will provide the information to develop interview guide as well as design the questionnaire for WTP estimation.

ii) Laws and Regulations

Laws and regulations related to water quality and wastewater management will be obtained to understand the existing environmental instruments. The existing instrument includes both command and control, and Economic-based approaches. This will allow seeing correlation between each instrument and its effectiveness. The information is available in official Pollution Control Department (PCD) and other internet-based sources. Related laws and regulations will be mentioned in the list below.

- National Economic and Social Development plan
- Enhancement and Conservation of Environmental Quality Act 1999

- Public health Act 1992
- Decentralization Act 1999
- Notification of National Environmental Committee on Centralised Wastewater Charge
- Ordinance of Centralised Wastewater Charge

iii) Organisation involvement in Wastewater Management

Besides laws and regulations, organisation involved in wastewater management information is also important. This is because the information will inform roles of each organisation throughout wastewater management structure. However, the information on literature reviews may not enough so direct interview will be conducted to obtain that unavailable information. Moreover, this would help guiding for interview planning in terms of organisations that have to be contacted as well as question areas would be asked to obtained missing information in published document. The list of organisations both national and local level will be summarised as follows.

- Pollution Control Department (PCD)
- Bangkok Metropolitan Administration (BMA)
- Wastewater Management Authority
- Department of Sewerage and Drainage
- Department of Public work
- Local Administrative Organisation

3.2.2 To select study site

Basic information of city in Thailand will be obtained and considered for study-site selection. The information acquired are listed in the followings

- Number of population and population density

- City's economic activities
- General geographic information
- Wastewater management practice
- Wastewater charge enforcement

3.2.3 To develop Interview guide

The information obtained from literature review will be used in developing interview guide in order to see practical difficulties of wastewater management in selected study sites. According to literature review, 5 mains factors; insufficient budget; lack of skilled workers; unclear plan; poor cooperation between departments; low maintenance, affecting wastewater management performance are identified and these will be developed to be interview guide to get insight information or in more details on each factor. The interview guide development is mentioned in section 3.3.1.

3.2.4 To develop questionnaire

The questionnaire was designed to determine factors influencing individual's WTP for water quality improvement in residential area. The questionnaire was divided in to 2 main parts. The first part mainly focuses on factors potentially influencing WTP and the second part is hypothetical situation description of CVM to estimate WTP preferences from residents.

In the first part, potential factors were designed to be captured. Respondents were generally asked about their sociodemographic information, major environmental concerns WWM knowledge and perception, pros environmental behaviour and water pollution impacts. In the second section, hypothetical situation of water quality was described compared to status quo with diagram. This section begins with the introduction of current situation of poor water quality in Thailand and

followed by hypothetical management programme used economic-based instrument (WW charge collection) for better water quality status.

To avoid influence of initial purport and non-response, the question for estimating WTP is divided into 2 steps. First is dichotomous choices which asks for a "Yes" or "No" question. This was designed to let respondent get familiar with social context and place a simple question to reduce non-response (A. Myrick Freeman, Herringes, & Kling, 2014)

"WW charge collection programme will enable water quality to be usable and safe to human health without bad odour and improve city scenery, are you willing to pay for water quality improvement?"

If the respondents answered "Yes", the next question would be "What is the maximum you would prefer to pay monthly?". This question was design in direct open-ended format to reduce influence of initial purport. It allows respondents to specify their number and reflect individual's preference (A. Myrick Freeman et al., 2014). Followed by WW charge payment method choices of preferences. On the other hand, if the respondents disagree to the programme, the next question would be about the reasons of rejection. Full Questionnaire can be found in Appendix B.

3.3 Data collection and Analysis

The data well be obtained from both primary data and secondary data sources. Primary data is a major source for this study, and it will be obtained from interview and questionnaire approaches while secondary data is obtained from previous studies, published reports books and other internet-based sources.

3.3.1 Interview guide

Insight interview method will be used to understand the situation of wastewater management practices in selected sites. The interview will be conducted through organisations involved in wastewater management structure. Limitation and barriers will be interviewed. The result is expected to see the gaps and needs for the improvement of wastewater management in terms of funding sources, operation performance, maintenance, cooperation between organisation, Action on wastewater charge enforcement, current and future plans.

Table 3.1 Interview guide

Organisation	Areas of interview question
National Organisation ● Department of Local Administration ● Wastewater management Authority (WMA)	● Limitation and Barriers of Economic-based instrument implementation ● Laws and regulations supporting Economic-based instrument implementation ● National environmental strategy and planning ● WWTP in Thailand and their status
Local Organisations/Leaders	

Organisation	Areas of interview question
Bangkok ● Bangkok Metropolitan Administration (BMA) ● Department of Drainage and Sewerage ● Department of Public Work ● Wastewater treatment plant operators	● Coverage area of wastewater treatment service and future plan ● Current wastewater treatment performance ● Main barriers of operation and management ● Source of funding and financial issues ● Barriers of wastewater charge implementation ● Roles and cooperation/communication between organisation
Pattaya ● City of Pattaya Office ● Wastewater treatment plant operators	● Coverage area of wastewater treatment service and future plan ● Current wastewater treatment performance ● Main barriers of operation and management ● Main source of wastewater ● Impacts of tourism to water pollution ● Source of funding and financial issues ● Barriers of wastewater

Organisation	Areas of interview question
	charge implementation ● Other organisations/stakeholder involvement in wastewater management ● Roles and cooperation/communication between organisation
Tha Rae, Sakhon Nakhon ● Tha Rae Municipality Office ● Wastewater treatment plant operators	● Coverage area of wastewater treatment service and future plan ● Current wastewater treatment performance ● Main barriers of operation and management ● Main source of wastewater (e.g. agricultural activity, household) ● Source of funding and financial issues ● Barriers of wastewater charge implementation ● Other organisations/stakeholder involvement in wastewater management ● Roles and cooperation/communication between organisation

Organisation	Areas of interview question
Local Residents	● Attitude to current water pollution and wastewater management ● Attitude to wastewater charge collection

For all interview, the procedures will be conducted as follows

I. Contact organisations in advance by phone before going to visit (1-2 weeks) and inform all details of the study and schedule of interview
II. Send formal letter to the organisation contacted and inform all details of the study and schedule of interview
III. Direct interview with prepared interview guide
IV. Note taking and sound recording by recorder or smart phone for data collection
V. Summarise all information for next step of the study

3.3.2 Questionnaire

WTP study for the improvement of centralised wastewater management will be accessed by economic valuation method with scenario formulation under hypothetical market. This is because the fact that wastewater management is unmarketable and state preference will be the suitable method for WTP evaluation.

Questionnaire method will be used to evaluate ranges of WTP for the improvement of wastewater management efficiency and analyse factor influencing WTP in residential areas in different cities in Thailand.

i) Questionnaire design

Questionnaire was firstly done with pilot survey with smaller number of samples than the planned sample size for few times before going to be finalised. In CVM, the pilot survey is normally conducted to obtain sensible amount of initial bid for bidding game format. However, in this research open-ended format is used, still pilot questionnaire is useful to measure that respondents can follow the direction as indicated correctly as well as to test liability of Likert's scale questions which are included in the questionnaire. Advantageous participatory survey, the respondents are able to return their comments and suggestions in order to develop as suitable as the questionnaire could be made. For instance, they could reflect how hard to answer the questions and to test whether the hypothetical situation description is understandable correctly because respondents are general residents with different backgrounds. Questionnaire was finally developed to be academic yet understandable easily and this would reduce unreliability of following results.

Resulting from pilot survey, questionnaire is divided into 8 sections for estimating WTP decision choice and factors influencing WTP for water quality improvement. Sociodemographic factors including gender, age, occupation, education, number of household member, and income are organised in section 1, types of house and house ownership are in section 2.

Income and education level are expected to positively affect WTP decision. According to (Jhermpun & Panyasiri, 2017; Kotchen et al., 2013; Rammont & Amin, 2010; Taale & Kyeremeh, 2016) studies, they claimed that respondents are more likely to pay WW charge in higher education level and income group. Number of household member is expected to have negative relationship since the payment would be prioritised for basic need sufficiently rather than environmental improvement (Jhermpun & Panyasiri, 2017; Kotchen et al., 2013). In terms of types of house, different types of house affect WTP in Ezebilo (2013) study of improving residential waste management. Therefore 4 mains types of living choices; single house, apartment/condominium, shop house and townhouse, in Bangkok are

included as one factor influencing WTP to see the statistical relationship. The rest sociodemographic factors are not expected to significantly influence WTP.

Water bill costs and payment responsibility are in section 3 to see the relationship of water bill and WTP. Water tariff is expected to have negative relationship to WTP. This means that the more water tariff paid monthly, the less probability of WTP for water quality improvement. Ones who in charge for water bill are expected to be less likely to pay for WW charge rather than ones who are not because it is additional payment of them to be responsible for.

Environmental problem concerns, wastewater management knowledge, pros environmental behaviour, adverse impact of water pollution are in section 4, 5, 6 and 7 respectively. In section 4, several environmental pollution issues are provided to be ranked the first 3 of the most concerns. In section 5, 6 and 7, Likert's scale format is designed to score respondent's understanding and knowledge on WWM, pros environmental behaviour and adverse impact level from water pollution respectively. Ones who have knowledge and pros behaviour above the average score are expected to be more likely to pay for WW charge than the others. Roomratanapun (2001) claimed that the more adverse impact received, the more WTP. Therefore, water pollution is expected to be positive relationship to WTP.

The last section, Contingent Variation Method (CVM) is designed to estimate WTP preference for water quality improvement from Bangkokians. Open-ended format was chosen as it openly allows respondents to rate WTP of WW charge freely whereas other formats would limit range of WTP answer and sometimes they would not reflect the real preferences if the initial recommended value is not sensible.

CVM is one of direct method for nonmarket valuation of environmental good changes from status quo. CVM is often used in environmental policies or damages to estimate total economic value; use value and non-use value. Since CVM allows individuals to state their preferences, hence, it is called state-preference technique.

Basically, individuals are asked about the status quo versus an alternative. Solicited information will be elicited how individual feels about the alternative relative to the status quo as well as WTP to obtain the alternative. For example, how much is an individual damaged by a polluted water?

ii) Sample size and sampling method

a. The sample size is used Yamane's published table as well as Yamane's formula to calculate the required number of questionnaires. The precision, level of confidence and variability level were selected as 0.05, 95% and 0.5 respectively. According to section 2.3.3.4, the sample size and questionnaire distribution can be summarised as follow.

Table 3.2 Sample size at 0.05 precision, 95% confidence, 0.5 variability by Yamane's formula

City	Population size	Sample size requirement	Minimum questionnaire distribution (+30%)	Collected samples
Bangkok	5,666,264	400	520	667
Pattaya	119,532	400	520	565
Tha Rae	6,944	378	492	510

Note that the number of calculated simple size will be added 30% for the distribution number to compensate the nonresponse or incomplete form.

b. Focus group of the study is residents. This is because the fact that wastewater generated from household earns the largest share and this will be travelled to centralised wastewater treatment. The respondents will be randomly sampling but before allowing respondents to answer the questionnaire, they will be screened and make sure that they are local residents.

iii) Questionnaire distribution

Offline questionnaires were printed out as hard copy of document. All questionnaires were distributed in person since face-to-face distribution allows respondents to be clearly explained about the purposes of the survey and able to ask whether they have any queries as well as to make sure that the respondents could follow the direction correctly. Data collection team members were recruited from local people. They were trained and mocked up with the real situation until they clearly understood the main objective of the survey as well as the target respondents.

During December 2018, Bangkok residential population were randomly sampled, and questionnaires were collected from 10 different cluster-districts throughout Bangkok. The distribution was aimed to spread through each area suitably varied depending on number of populations of each district as showed in Table 3.3.

Table 3.3 Number of questionnaire distribution in each cluster

	District	Distributed Questionnaire
1	Bang Sue	50
2	Chatuchak	70
3	Nong khaem	50
4	Bang Khae	50
5	Pathum Wan Ratchathewi	100
6	Sathon	51
7	Bang Rak Yan Nawa	43
8	Phra Nakhorn	29
9	Pam Prab Sattru Phai Sampanthawong	71
10	Din Daeng Huai Khwang	113

	District	Distributed Questionnaire
	Phaya Thai	
11	Others	47
	Total	**674**

In Tha Rae, Sakon Nakhon, the distribution was made during January - February 2019 at local government's office where local people mostly come for doing their business daily and at some local shops and restaurants. Additionally, door-to-door data collected was also made. This is because there are not many public spaces for people to gather up and the majority of residents live in detached houses. The distributors are local residents who live and work in Tha Rae. They were trained and mocked up before collecting the data.

Similar to Tha Rae, questionnaire in Pattaya was distributed door-to-door by local residents. They were distributed at local shops, restaurants and residential building throughout Pattaya city both northern and southern part. However, the data collection was made for 2 times during April-May and June-July 2019. This is because after cleaning the data process of the first batch, the number of questionnaires was lower than the required samples. Hence, data collection was made again to add up the number of samples.

iv) Quality control of data (Data cleaning)

In order to improve data quality, data cleaning is an inherent part to reduce errors before analytical process. All questionnaire collected were cleaned by removing some number of questionnaires which contain large incomplete answers (i.e. answers were missed for a whole page), crucial variable absence (i.e. WTP question in section 8 was not responded.), and duplicated response (i.e. same responses are showed in successive questionnaire order).

v) Analysis tools and methods

Analytical process was divided into 2 steps and 2 different analytical models were used. The first step is to investigate factor influencing WTP decision or factors influencing probability of respondents to say YES to WW charge collection for water quality improvement in residential areas. The other step is to investigate factors influencing pay-out level of WTP among respondents who are willing to pay for WW charge.

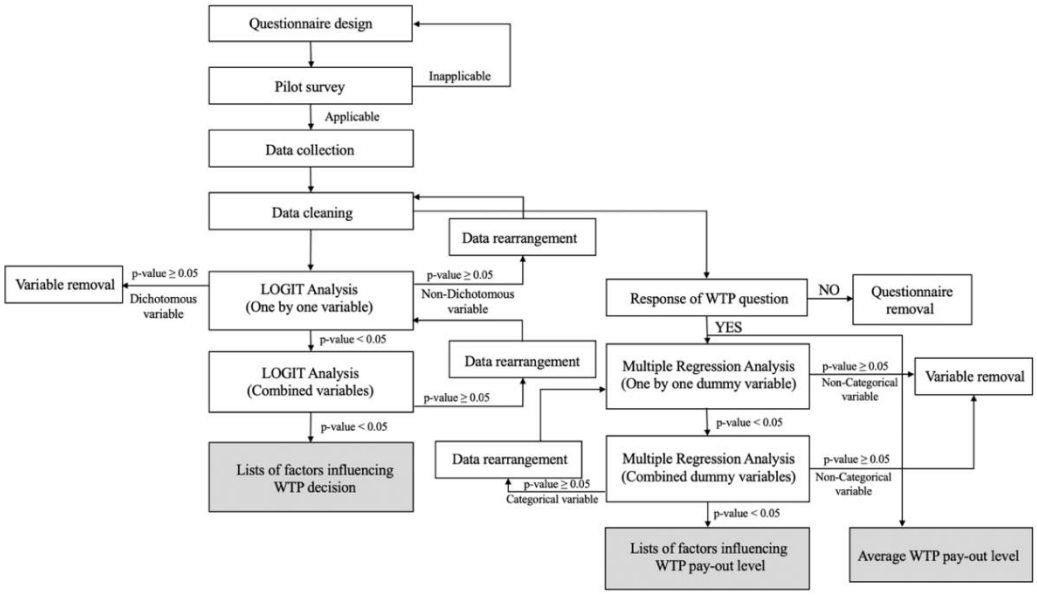

Figure 3.2 Analytical flow

a. Ranges of WTP

To estimate range of WTP amount, mean mode and median were used for consideration. *Mean* is the sum of the value of each observation in a dataset divided by the number of observations. This is also known as the arithmetic average. However, mean includes every value in the distribution the mean is influenced by outliers and skewed distributions; the tendency for the values to be more frequent around the high or low ends of the x-axis (WTP amount). *Mode* is the most commonly occurring value in the distribution while *Median* is the middle value in distribution when the values are arranged in ascending or descending order. The

median is less affected by outliers and skewed data than the mean and is usually the preferred measure of central tendency when the distribution is not symmetrical. Since each value has it positive and negative points, range of these three values were drawn to represent range of WTP.

However, there are some outliers and extreme values in the dataset. To reduce the influence of outlier to mean value, 3 S.D. measure was used to cut the extreme values out.

The standard deviation (S.D.) show the value of dataset varies from the mean. Then the values are spread apart the S.D. is large whereas when the values are tight, the S.D. is small. Effectively, the dataset with normal distribution, values are closed to mean whereas the extreme values are far apart. Many natural phenomena have normal distribution but not field research. 3 S.D. helps screening extreme value out of the dataset because 99% of dataset with normal distribution are less than 3 S.D.

b. Factors influencing WTP decision

Logistic regression model (Logit) suits for dichotomous dependent answer such as YES or NO. Logit model was developed from regression model to estimate probability of event happened. The model uses odd ratio to predict probability of those interested dichotomous response and the ratio can be expressed as

$$Odds = \frac{\Pr\,(success)}{\Pr\,(failure)}$$

Since,

$$\Pr(success) + \Pr(failure) = 1$$

So,

$$Odds = \frac{\Pr\,(success)}{1 - \Pr\,(success)}$$

$$Odds = \frac{e^{\alpha+\beta x}}{1 - e^{\alpha+\beta x}}$$

Where, $\alpha = constant$

$\beta = coefficient\ of\ independent\ variable$

$x = independent\ variable$

According to the expression, Odd ratio is always positive value where greater than 1 but not less than zero. The values can be interpreted into words as follows.

If the value is greater than 1, for example odds ratio is 1.6, it means that the probability of success event is 1.6 times more than baseline. On the other hand, if the value is less than 1, the meaning will be in percentage. For example, Odd ratio equalling to 0.6 means the probability of success event is 1-0.6 or 0.4 (40%) decreasingly.

Once natural logarithm (ln) was taken into account, the equation was derived to

$$\ln\left(Odds\right) = \ln\left(\frac{e^{\alpha+\beta x}}{1-e^{\alpha+\beta x}}\right)$$

$$\ln(Odds) = \alpha + \beta x$$

This ln(Odds) is called Logistic transformation or Logit of Pr(success) or probability of success. Unlike MR, the model uses Maximum Likelihood Estimation (MLE) techniques while simple regression and MR use Least Square (LS) technique for model fit. Therefore, the result interpretation from Logit would be in the different way to MR.

The equation above shows only one independent variable. If the study interests to estimate more than one independent variable, the equation can be expressed as

$$\ln(Odds) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_i x_i$$

Where $\alpha = constant$

$\beta = coefficient\ of\ independent\ variable$

$x = independent\ variable$
$i = number\ of\ independent\ variable$

Applying to the study, the result would show the probability of respondents' preferences on WTP decision choice for water quality improvement in terms of YES or NO as well as the direction of their relationship. The relationship between independent variables and dependent variable could be either direct (positive) or inversely direct (negative) relationship of each independent variable.

c. Factors influencing WTP pay-out level

Multiple regression (MR) is used to understand the relationship between one dependent variable and more than one independent variable and form linear relation between dependent and independent variables (Uyanık & Güler, 2013). The model uses Least Square (LS) technique for model fit. Therefore, MR is used to see relationship of factors and WTP pay-out level.

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_i x_i$$

Where $y = dependent\ variable$
$\alpha = constant$
$x = independent\ variable$
$i = number\ of\ independent\ variable$

d. Selecting variables into the analytical model

To obtain preferable results from Logit, the first step of analysis is taking one by one variable into the model and see whether it gives significant result. If any give significant value, they will then be selected for further analysis. On the other hand, with insignificant value, the variable will then be rearranged into the most suitable form in order to obtain the most satisfying results until those variables are transformed into dichotomous variable and still give insignificance.

Similar to Logit analysis, variables for MR is also tested one by one with dummy variable form. All variables will be rearranged and tested over again until they

become non-categorical variables and give insignificant value. They will be removed.

After one by one analysis and multicollinearity effect check, if all significant variables are not affected by multicollinearity (spearman's value is lower than 0.75) they will be included in the model to analyse their influencing power.

3.4 Development of Recommendation

Sets of recommendations were drawn and discussed based on data collection and analysed results of both primary and secondary data. They are (1) data from interview, (2) results of WTP estimation both factors influencing WTP decision and factors influencing WTP pay-out level. Moreover, (3) average WTP pay-out amount was used to recommend rate of WW charge in different characteristic cities. Additionally, (4) secondary data from literature review, local government reports or relevant documents were also used for drawing recommendation and suggestion for tailor-made WWM scheme to fit local contexts. Different characteristic cities in Thailand were grouped accordingly to case studies and used the results from analysis of each cities to draw the recommendation as well as considering the local context of each case study (figure 3.3).

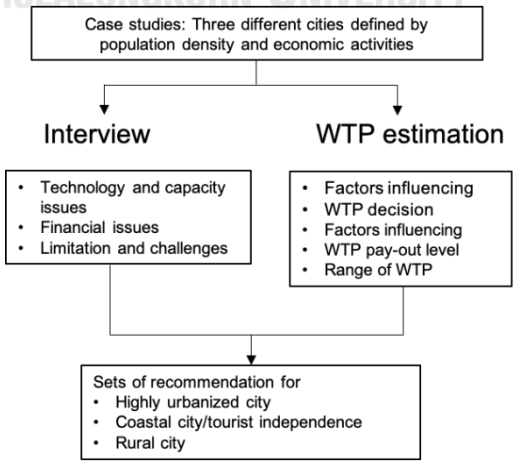

Figure 3.3 Recommendation development flow

The recommendation is expected to show how economic-based instrument help supporting existing command and control approaches. Moreover, how WWM scheme should be for different types of city will be recommended to be a guide for achieving the best efficiency and effectiveness in terms of wastewater operation performance, governance and residents' satisfaction.

Chapter 4
Results and discussion

Chapter introduction

This chapter presents results accordingly to research objectives. It is divided into 3 main sections presenting (a) results following by (b) discussion of each analysis. Firstly, current situation of water quality and WWM of each case study is presented. Secondly, results of WTP estimation is reported and then discussed. This includes descriptive analysis, significant factors influencing WTP decision, significant factors influencing WTP pay-out level as well as average amount of WTP. Thirdly, recommendation and suggestion for WWM applied from results of different characteristic city is drawn to scaling up systematic WWM throughout Thailand.

4.1 Current situation of wastewater management

There are numbers of organisations related to wastewater management or water quality control in Thailand. In national scale, Pollution Control Department (PCD), Office of Natural Resources and Environmental Planning (ONEP) under the Ministry of Natural Resources and Environment (MONRE) are responsible for planning and policy providing to local government. While Wastewater Management Authority (MWA) under the Ministry of interior is taken action for providing centralised WWTPs in specific areas both renovating aged facility and constructing new WWTPs.

According to decentralisation to Local Government Organisation Act, local governments have authority to take responsibility of public facilities and services as well as environmental quality control in their own administrative areas. WWM is one of local government responsibility. In addition to management power, providing WWT facility and operating require huge amount of financial resources.

Before 1992 Public Work department under the Ministry of Interior was in charged for WWM, WWTPs were funded by central government support and once it had been completely constructed, it was transferred to local government for operation. Therefore, WWTPs which constructed before 1992 were financially supported by the organisation taken action to (Appendix A). However, WWM responsibility has been transferred to MONRE and the financial sources for WWT facility could be from two main sources; 1) Central government 2) Environmental Fund. In the case of Environmental fund, financial support can be subsidy and loan for local government including Bangkok Metropolitan Administration (BMA), Pattaya city, Municipality, Provincial Administrative Organisation (PAO) and Tambol Administrative Organisation (TAO), and private sectors which have taken for any activities of enhancement and conservation of environmental quality. However, the process and criteria of subsidisation depends on several aspects by Environmental Fund Committee under supervision of National Environmental Board with ONEP as secretariats of the committees. Moreover, where financial support is from national budget, PPP has to be implemented or in the other word, WW charge has to be levied to generate revenue accordingly to the Enhancement and Conservation of National Environmental Quality Act B.E. 2535, section 88.

Section 88

"In any pollution control area or locality where the government's central wastewater treatment system or central waste removal system has been constructed and operated by allocations from the National budget or revenues of the local government and allocations from Fund as provided under this Act, the National Environment Board shall, with the advice of the Pollution Control Committee, fix the rates of service fee to be applicable within the limits of each pollution control area or locality where the site of the system in question is located. The determination of service fee rates under paragraph on shall be published by notification in the Government Gazette".

In 3 case studies of this research, WWM of each area by local government are provided in detail below.

4.1.1 Bangkok

Wastewater management in Bangkok is under the Department of Drainage and Sewerage (DDS) of BMA. The DDS was first established in 1977 in order to be in charge of rainfall drainage, flood protection and WWM or water quality management.

In terms of WWM, DDS is responsible for entire management cycle related to water quality improvement on a basis of sustainable living and pollution-free. The main tasks are planning, controlling, raising public awareness and carrying out works related to water drainage, the maintenance of drainage systems, the prevention of floods and WW treatment. Currently, all activities are financially supported by fiscal budget allocation from the Budget Department of BMA, and additionally WW charge collection could be applicable to be done by DDS as another source of financial support for O&M.

Although DDS is the main key player in water quality control in Bangkok, cooperation between other departments is also crucial to maximise management performance, namely Public Works Department, Environmental Department, the BMA Budget Department and district offices. Decentralised responsibility, 50 district offices are in charge of controlling water quality in minor canals and encourage water saving campaign to public. From 1,682 canals, 1,464 are district offices' duties (CPD, 2016).

Technology and capacity

Currently, there are 8 main WWTPs servicing for 21 out of 50 districts throughout Bangkok and it covers 212.74 sq.km. (Table 4.1). Insufficiently, the total capacity is 1,112,000 m^3/day or approximately 45% of all WW generated daily which is mainly

from residential area caused by household activity (more than 70%) (DDS, 2016). In addition to the main WW treatment plants, 24,800 m^3/day of 12 small plants transferred from National Housing Authority, adding up to main treatment capacity, maximises total capacity up to 1,136,800 m^3/day (CPD, 2016)

Moreover, the existing WWTPs have been operated only around 75% of full designed capacity because WW collection system has not been covered all the service area (Appendix A). It is evidently shown in budgeting plan 2020 of BMA which construction budget includes expanding WW collection lines connecting to existing WWTPs.

Table 4.1 Main wastewater treatment plant in Bangkok

	Name of the project	Service area (sq.km)		Population	Capacity (m^3/d)	Pipe length (km)	Technology
1	Nong Khaem	44	Nong Khaem, Phasi Charoen, Bang Khae	520,000	157,000	46	Vertical Loop Reactor Activated Sludge (VLR-AS)
2	Ratanakosin	4.1	Phra Nakhon	70,000	40,000	16.25	Two Stage Activated Sludge
3	Si Phraya	2.7	Prom Prab Sattru Phai, Sampanthawong, Bang Rak	120,000	30,000	2.3	Contact Stabilisation Activated Sludge
4	Thung Khru	42	Thung Khru, Rat Burana, Chom Thong	177,000	65,000	26	Vertical Loop Reactor Activated Sludge (VLR-AS)
5	Chong Nonsi	28.5	Bang Rak, Yan Nawa, Sathon, Bang Kho Laem	580,000	200,000	51	Cyclic Activated Sludge System

	Name of the project	Service area (sq.km)		Population	Capacity (m^3/d)	Pipe length (km)	Technology
							(Benzoni & Telenko)
6	Din Daeng	37	Pom Prab Sattru Phai, Sampanthawong, Pathum Wan Ratchatewi, Dusit, Phra Nakhon, Phaya Thai Din Daeng	1,080,000	350,000	63	Activated Sludge with Nutrients (Nitrogen and Phosphorus) Removal
7	Chatuchak	33.4	Dusit, Paya Thai, Huai Khwang, Chatuchak	432,000	150,000	28.2	Cyclic Activated Sludge System (Benzoni & Telenko)
8	Bang Sue	20	Bang Sue, Chatuchak, Dusit	223,990	120,000	30.3	Step Feed Activated Sludge
	Total	**212.74**		**3,202,990**	**1,112,000**	**236.05**	

Obstacles of WWM capacity expansion

Insufficient WWT capacity, expanding WWT service area together with collection system network could increase overall treatment capacity and it is one of challenges for WWM improvement (SED, 2014). 19 WWTP projects will be launched in the near future. By 2022, BMA planned to have 4 new WWTPs with 1.777 million m^3/d, and this will increase treatment capacity to 71% of WW generated. Moreover, the last other 15 WWTPs will further add treatment capacity up to 96% of WW generated with 1.631 million m^3/d by 2040. Following the plan, this means that in the next 20 years, there will be 27 WWTPs to fully service throughout Bangkok.

Table 4.2 Summary of WWTPs projects

	2019	2022	2040	Total
Capacity (million m^3/day)	1.112	1.777	1.631	4.52
Number of plants	8	4	15	27
Cumulative coverage	43%	71%	96%	
Construction costs (million Baht)	N/A	36,161.5	71,033	107,194.5
O&M costs (million Baht/year)	589	485	1,190	2,264

However, there are some possible obstacles of new project establishment. BMA has faced restriction of land for construction, limited budget for new WWTPs, unsystematic WWT and collection system, and people protest.

In terms of land for construction, new WWTPs are planned to locate on the land of public park or the land from the treasury department since available land for public project in Bangkok is limited. Earning revenue to cover O&M costs, WW charge collection has been intensively re-examined in terms of types of residence being charged and rate of WW charge. Revision event of Bangkok local ordinance of WW charge collection was organised in June 2019 and WW volume calculation was adjusted from 100% to 80% of water consumption volume (Bangkok Ordinance about Wastewater Treatment Fee, 2019). Moreover, public hearing has been organised before every project is constructed to avoid people protest.

Budgeting

According to the number of current WWTPs and future projects, the more plants means the more operation and maintenance (O&M) costs. Eight main WWTPs require more than 600 million Baht for operation. Currently, O&M of all plants are fully subsidised by BMA. Annually, the departments have to propose the desired budget

with clarified activities to the finance department for all projects. The projects could be new WWTPs investment, WWTPs maintenance, WWTPs operation, WW collection network expansion and etc. Then, budget will be set and allocated accordingly to BMA revenues and Bangkok strategic development plan (Figure 4.1 and table 4.3). In 2020 fiscal year, BMA budget allocation for Drainage and sewerage activity is accounted for 11.8% of total budget (Finance department, 2019).

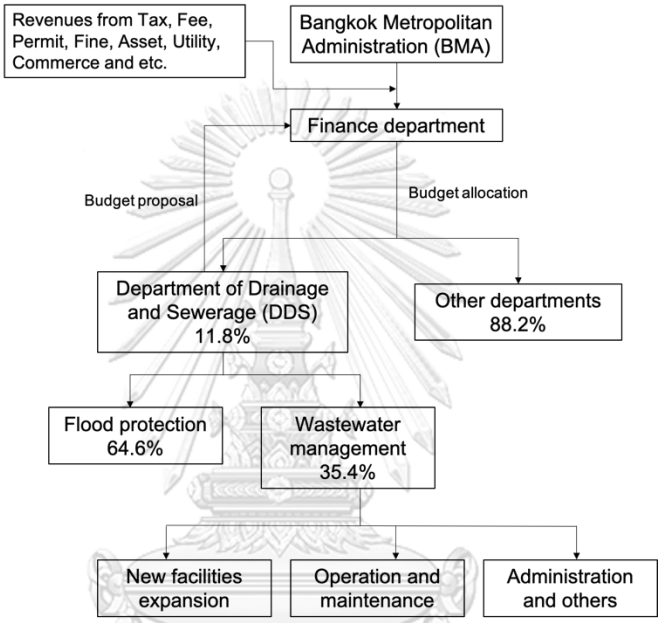

Figure 4.1 Budget allocation for WWM flow of Bangkok

Table 4.3 Budget allocation of BMA as of 2020 fiscal year

Activity	Budget	Percent
1. Administration	25,474,597,275	30.5
2. Cleanliness and	13,586,985,330	16.3
3. Civil work and traffic management	16,362,413,180	19.6
4. Drainage and sewerage	9,863,013,440	11.8
5. Development and social service	6,345,502,550	7.6
6. Public health	6,733,262,485	8.1
7. Education	4,634,243,740	5.6
8. Commerce	398,920,000	0.5
Total	83,398,920,000	100

For drainage and sewerage activities, 8,213 million Baht of annual expenditures were allocated to DDS for flood protection, drainage and water quality control activities. Only 2,910 million Baht were allocated for water quality control and it can be broken down as shown in table 4.4.

Seeing that, two huge chunks are in construction of new facilities and O&M activities. Construction budget is for Min Buri WWTP and expanding WW collection system network. Only 5 WWTPs operated by private outsources are budgeted whereas there is no evidence of budget allocation shown for supporting the other 3 plants operated by BMA. Moreover, fiscal budget allocation plan could assume that all expenses of machines malfunction or repair in 5 WWTPs operated by private sector have to be absorbed by BMA itself. This can be claimed that huge expenditure of construction and O&M significantly affect WWM in Bangkok.

Due to this financial burden, BMA has brought WW charge back in consideration and the charge collected will be used not only for O&M, but also future investment to completely provide WWT service throughout Bangkok.

Table 4.4 Budget allocation for water quality control as of 2020, fiscal year

Category	**Budget (Baht)**
Permanent employee	115,060,400
Temporary employee	10,368000
Consult and accessories	47,025,000
Utilities	10,778,900
New facilities construction	2,244,140,645
Outsource for WWTPs operation	478,100,000
Din Daeng	(198,800,000)
Chatuchak	(110,800,000)

Category	Budget (Baht)
	Nong Khaem-Thung Khru (43,500,000)
	Bang Sue (67,000,000)
	Chong Nonsri (33,000,000)
WW charge operation system	5,000,000
Total	**2,910,472,945**

Efforts on Bangkok wastewater treatment charge

BMA Local Ordinance of WW charge collection has been enacted since 1st June 2004. WW charge collection will be proportional to water consumption volume and the rate for residential area is 2.00 Baht/ m^3 (Bangkok Ordinance about Wastewater Treatment Fee, 2004, 2019). More than a decade passed; however, the charge has not been practically collected. This is because the conflict of collection method as well as suitable rate of WW charge. BMA expected that WW charge will generate 800-900 million Baht yearly revenue for O&M and future investment projects supportively. Moreover, the master plan suggests that BMA should have 27 WWTPs to fully cover service area throughout Bangkok which is considered to be done by 2040 (JICA, 2011).

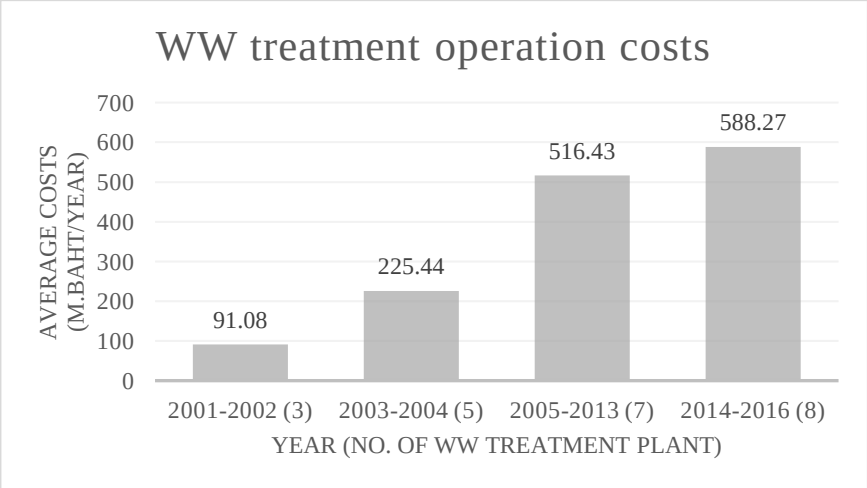

Figure 4.2 Average wastewater treatment operation costs

Obviously seen an enthusiastic movement on WW charge collection in recent several years, there have been some WW charge collection strategies announcement to Bangkok's residents and the latest one was public hearing about the Draft Amendment of WW charge ordinance on 5th June 2019.

After the public hearing event, BMA claimed that 80% of residents are willing to pay WW charge. Residents who live in 21 districts where WWTPs servicing will be charged proportional to water consumption and it was expected to execute within October 2019. For systematic collection measure, DDS was budgeted 5 million Baht for computer-based system development for WW charge collection operation from 2020 fiscal year by the BMA Budget department. (SED, 2018). However, charge collection method has not yet been clear and up until now (February 2020) WW charge has not been levied in residential areas.

Nonetheless, according to water sold statistic of MWA (2019), if water consumption from Bangkok's residential are assumed to be 605 m^3/household/year and 80% of water consumption is WW with 2.4 million households in BKK (NSO, 2010) at 2.00 Baht/m^3 of WW charge, revenues generated from WW charge collection in residential area would possibly be up to 970 million Baht/year. This amount of money can fully cover O&M expenditures of existing WWPTs.

Table 4.5 Statistic information (MWA, 2019)

	unit	Fiscal year				
		2015	2016	2017	2018	2019
Water production	million cu.m.	1,835.1	1,965.9	2,063.8	1,997.1	2,075.2
Water sold	million cu.m.	1,406.3	1,206.3	1,408.6	1,401.4	1,467.4
Efficiency of water distribution	percent	76.6	71.5	68.2	70.2	70.2
Number of water consumer	million households	2.226	2.281	2.328	2.375	2.423

Challenges of wastewater management

I. Insufficient WWT capacity and WW collection network: The total capacity of WWTPs is only 45% of all WW generated within 21 out of 50 districts throughout Bangkok. Also, some WWTPs do not be operated at full designed capacity. This could be from unwell operated as well as lack of WW collection networks meaning that not all households could access WWT service.

II. Low financial security for WWM: Only 11.8% of annual budgeting was allocated to DDS for sewerage and drainage purpose. Amount and where the budget goes to depends on BMA revenues and strategic planning. This means that the allocation could not probably meet the actual expenditures accordingly to finance department consideration. Moreover, DDS has to responsible for both drainage and sewerage, only 35.4% of all allocated budget were distributed for WWM.

4.1.2 Pattaya

Pattaya is one of the most attractive coastal places in Thailand. Besides to around 2 million tourists visiting yearly, tourism business has been growing rapidly. Fast economic growth and city expansion leads to environmental pollution including wastewater. Government provision of wastewater treatment was not sufficient as a consequence, illegally wastewater discharge to seawater and seawater which is the main natural resource for Pattaya's economic activities, has been degraded and inversely affected tourism business of Pattaya significantly (PDC, 2004).

Due to this environmental degradation and inadequate treatment service, Pattaya was defined as pollution control area in 1992. The pollution had been stringently addressed and seawater quality has been continuously monitored since 1993.

Technology and capacity

Currently in 2020, there are 2 WWTPs in Pattaya city located in northern and southern part of Pattaya. The southern Pattaya WWTP is the oldest one constructed completely and started operating in 1994 with 20,000 m^3/day treatment capacity. This capacity is far lower than WW generated daily due to economic growth of tourists and hospitality business. The latter one located in the northern Pattaya was engineered in 2000. This WWTP is the main WWT facility of Pattaya city with greater capacity than the old one. The treatment capability is 65,000 m^3/day and planned to expand the capacity to 137,500 m^3/day by 2010 to cope with the increasing WW quantity.

Gaps in terms of technology

Almost 20 years from 2000, however, the treatment plant had not been improved for increasing water pollution generation according to the growth of business activities. The well-operated wastewater treatment plant has reached the critical

operation performance. Wastewater generation is increasing while the maximum capacity is still at 65,000 m^3/day. In addition to the insufficient capacity of both treatment and collection system, some equipment was operated with low maintenance especially pumping station, the wastewater generated has exceeded into Pattaya's beach and as a consequence, degrading seawater quality. Although, the southern Pattaya WWTP was renovated and re-operated in 2014 to supplement the northern WWTP with 43,000 m^3/day, the WW influent is far lower than the designed capacity due to limited budget for operation and maintenance. This shows that the existing wastewater management needs to be improved and the capability have to be expanded. This will require large amount of financing source, time of construction and cooperation between all stakeholders.

Table 4.6 Main wastewater treatment plant in Pattaya (Pattaya City, 2020)

	Name of the project	**Service area (sq.km)**		**Capacity (m^3/d)**	**Influent (m^3/d)**	**Techno-logy**
1	Pattaya beach	32.6	Pattaya (North) (Soi Nong Yai temple)	65,000	77,540	Activated Sludge (AS)
2	Jomtien beach	4.1	Pattaya (South) (Soi Boonkanchanaram temple)	43,000	19,897	Activated Sludge (AS)
	Total	**36.7**		**108,000**		

Financial sources for WWM

Capital costs of the first WWTP in northern Pattaya was funded by Department of Public Work and Town & Country Planning of Ministry of Interior. The second WWTPs in southern part of Pattaya was mainly supported by National Environmental Fund and Ministry of Science and Technology with conditional agreement. Pattaya city had to additionally contribute 10% of construction costs and pay back to the financial

sources by 15 years together with expanding the treatment capacity to 137,000 m^3/day by 2010. Both WWTPs were operated by private sector and this requires huge budget to spend for. Apart from investment costs, the allowance for other WWM activities is allocated annually from financial department (Figure 4.3). Two main expenditures, O&M and utility costs earn around 80% of all expenditures of WWM activities (table 4.7). Therefore, WW charge has to be levied to generate revenue accordingly to the Enhancement and Conservation of National Environmental Quality Act B.E. 2535, section 88.

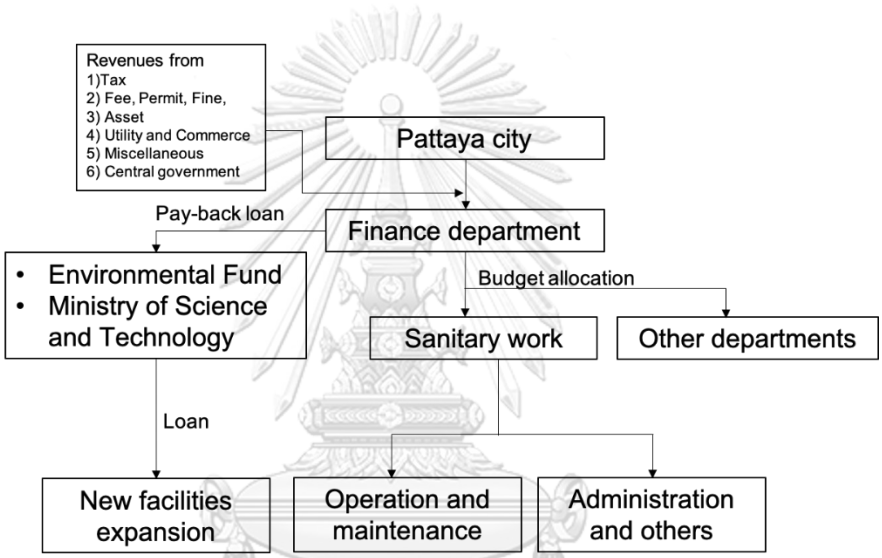

Figure 4.3 Financial flow for WWM of Pattaya city

Table 4.7 Fiscal budget allocation for WWM activities and expenditure, 2018 (Pattaya City, 2018)

Category	Budget (Baht)	Expenditures (Baht)
Workers	5,064,240.00	4,895,160.07
Employee's welfare	418,000.00	543,047.00
Operation & Maintenance	44,580,000.00	39,089,610.24
Accessories	3,180,000.00	886,669.55
Utilities	40,802,000.00	38,720,221.56
WWTPs construction	10,000,000.00	10,000,000.00
Total	**104,044,240.00**	**94,134,708.42**

WW charge collection

Because of new centralised wastewater treatment plants to support wastewater generated in the next 20 years and levy WW charge to fund the service., the charge has to be levied on all sectors, namely, households, government offices, state enterprise offices, small and medium business and heavy industrial business. However, the rate was differentiated by types of activities and household was collected at 2.50 Baht/m^3 (PDC, 2004).

However, from Interview of local residents, WW charge has not been levied in residential areas but only in commercial buildings which includes, hotels, restaurants and hospitality service while residents are only charged water tariff. Moreover, when comparing water tariff in Pattaya and the other 2 case studies, rate of water tariff is greater than Bangkok and Tha Rae of water consumption. This means that living costs of people living in Pattaya is greater than in the other cities significantly.

Table 4.8 Rate of Water tariff of 3 cities

Water usage (m^3)	Water tariff (Baht/m^3)		
	Bangkok	Pattaya	Tha Rae, Sakon Nakhon
0 - 10	8.50	10.20	6.00 (0-15m^3)
11 – 20	8.50	16.00	7.00 (16-30m^3)
21 - 30	8.50	19.00	
31 – 40	10.03	21.20	8.00 (31-45m^3)
41 - 50	10.35	21.20	9.00 (46-60m^3)
51 - 60	10.68	21.60	

Challenges of wastewater management

I. Insufficient treatment capacity and collection system: The actual WW influent of the southern WWTP is greater than the plant capacity. Moreover,

wastewater collection system covers only 53% of overall areas. This could degrade sea water quality, which is crucial for hospitality business, the major economic activity of Pattaya city.

II. Aged technology: Since the WWTPs has been operated for almost 20 years, some equipment needs to be repaired to increase operational performance and this require huge investment capital costs.

4.1.3 Tha Rae, Sakon Nakhon

Wastewater treatment plant of Tha Rae municipality was engineered on 50 Rai land at the edge of Nonghan lake to supplement the main plant in Sakon Nakhon municipality due to the population growth and city expansion. This is to enhance water quality discharging into Nonghan lake, the largest freshwater lake in Thailand, yet the water resources for water supply system. The construction was done in December 2000 and the plant started operating on February 2001.

Technology and capacity

The technology used is oxidation pond followed by constructed wetland. Three oxidation-ponds and Cattail (*Typha augustifonia L.*) is used in eight construction wetlands as wetland plants. The design capacity is 2,054 m^3/day as for 20 years lifetime. As it has been started operating since 2001, the system will last by B.E. 2564. However, the current influent of wastewater into the system is less than half of the full capacity. According to the information from officer interview, the latest flowrate measurement was at 831 m^3/day (in 2018) due to the broken pumping system and under-provided of service area.

Service area and Collection system

Tha Rae municipality use combined system for wastewater collection. The 7,766-meter collection network covers only 67% of municipal area, in the south of the Sakon Nakhon – Nakhon Panom road (Route 22) shown in figure 4.4.

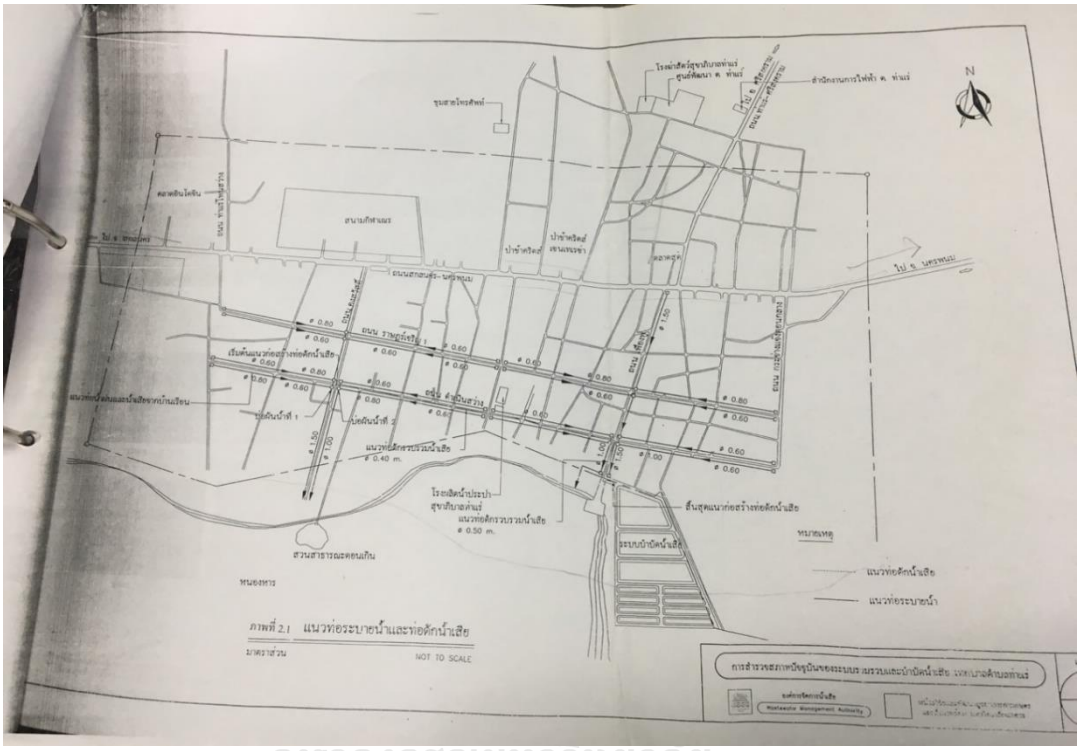

Figure 4.4 Current wastewater collection network, Tha Rae, Sakon Nakhon

Gaps in terms of technology and capacity

The collection system is only 67% serviced throughout the municipality area. In 1996, the second phase of wastewater collection system was proposed but the project was frozen up until 2017, the project feasibility was done. However, the second phase was unapproved, and the collection system coverage area is still not 100%. Moreover, the treatment system will last by 2021 according to the design. Yet, the improvement project has not been proposed.

Table 4.9 Main wastewater treatment plant in Tha Rae

	Name of the project	Service area (sq.km)	Capacity (m^3/d)	Pipe length (km)	Technology
1	Tha Rae WWTP	1.49	2,054	7.776	oxidation pond followed by constructed wetland

Financial Management

The rationale of wastewater charge collection

The capital investment for wastewater facility were from financial allocation of the Environmental fund 20.171 million Baht and the loan of Japan Bank of International Cooperation (JBIC) 43.988 million Baht. Therefore, wastewater charge is subjected according to the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992), section 88.

Gaps in terms of financial management

Practically, WW charge collection has been successfully collected in 2009 although the current rate of WW charge, 1.00 Baht/m^3, has not been adjusted since the first period of collection according to the wastewater charge schedule (Appendix C). The wastewater charge is billed together will the water supply but showed separately in a different column (figure 4.5). The money collected will then be separated to the department which is in charge. The water tariff will be sent to the department of water supply while the wastewater charge will be sent to the financial department. Annual payment, 3.5% of WW charge collection monthly has to pay-back to Environmental Fund and the rest will be used for WWM activities (table 4.10).

Table 4.10 Monthly WW charge collection distribution (Tha Rae, 2019)

Year	Month	WWM activities (Baht/month)	Pay-bake to Environmental Fund (Baht/month)	WW charge collection (Baht/month)
	October	21,359.27	774.73	22,134.00
2017	November	22,291.44	808.56	23,100.00
	December	22,645.62	821.38	23,467.00
	January	25,091.88	910.12	26,002.00
	February	24,484	743	25,227.00
	March	28,221.38	1023.62	29,245.00
	April	20,793.76	754.24	21,548.00
2018	May	26,122.49	947.51	27,070.00
	June	24,002.40	870.60	24,873.00
	July	21,936.34	795.60	22,731.94
	August	25,633.25	929.75	26,563.00
	September	19,780.52	717.48	20,498.00
	Total	282,362.35	10,096.59	292,458.94

Division of public work is normally budgeted yearly from the division of finance for WWM activities 342,000 Baht. The main expenditures of WWM can be divided into 3 activities, namely (1) WWT operation, (2) WWT maintenance and (3) water quality monitoring. However, the budget is insufficient. It can cover only operation costs including workers and electricity but not maintenance costs as showed in figure 4.6. Additionally, another financial source is from division of public health and environment at the exact amount for water quality monitoring.

This raised questions in terms of budget approval and its spending authority. Even though wastewater management is under the department of public work, the decision-making power is at the department of finance. This management structure makes the process of project development or future investment (e.g. expanding wastewater collection system) taking a long time since the budget has to be approved by the department of finance once a development project is proposed by

the department of public work. Moreover, the budget is yearly set insufficiently just for the operation costs (i.e. worker salary and utility costs) not for maintenance. For example, the pumping stations have been broken and the fixing process need to be idle until the next fiscal year when the proposal is approved. Also, the current wastewater treatment facility will last by 2021. Still, the project of expanding is inactive and apart from Loan of Environmental Fund and JBIC, any further investment costs of WWTPs and WW collection system have to wait for support from Office of Natural Resources and Environmental policy and Planning.

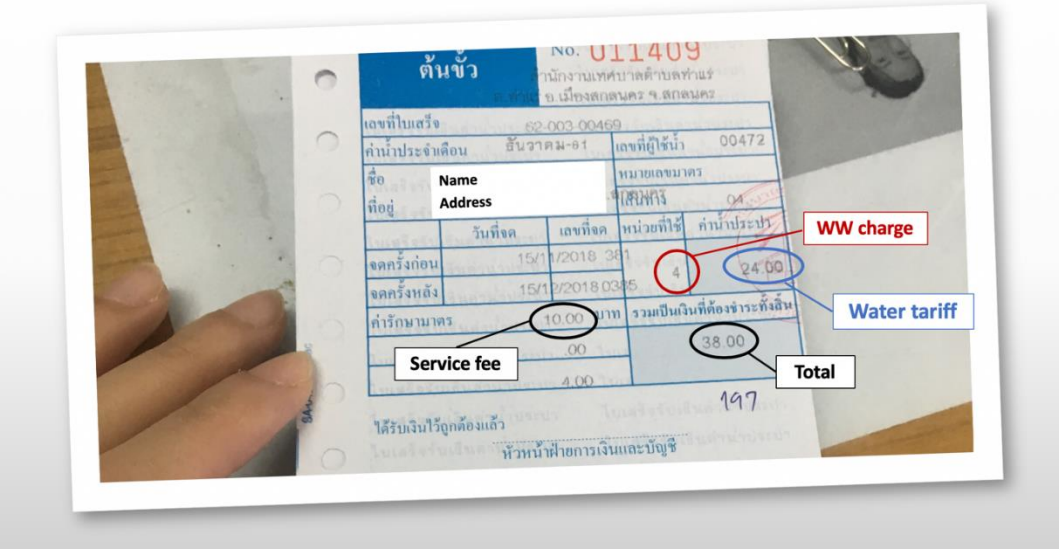

Figure 4.5 Typical residential water bill of Tha Rae Municipality, Sakon Nakhon

Typical Residential bill calculation example

Total = WW charge + Water tariff + Service fee

	Charge (Baht)
Wastewater charge	4
Water tariff	24
Metered-service fee	10
Total	**38**

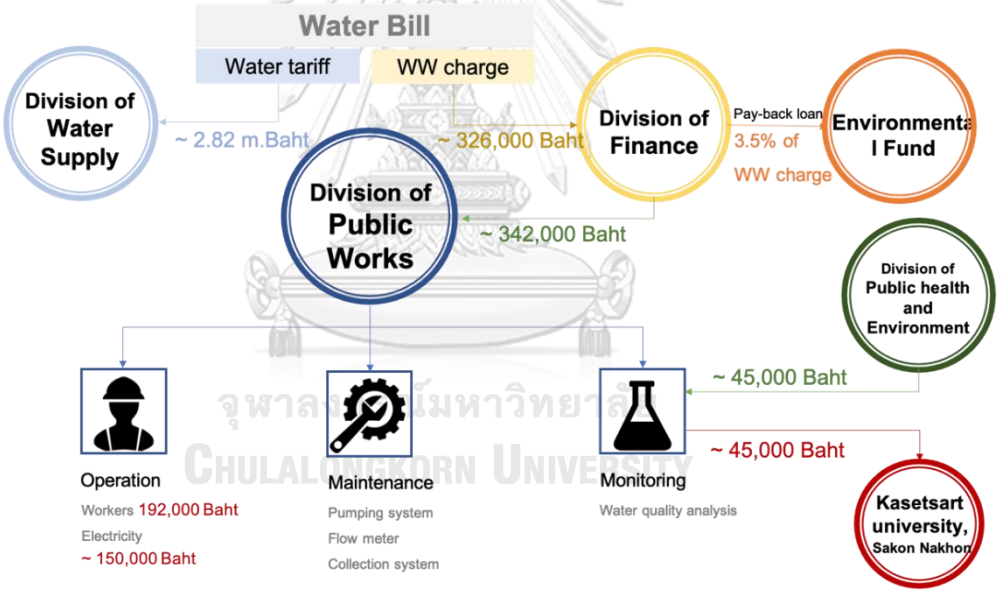

Figure 4.6 Flow chart of financial management

The use of WW collection could be for any WWM activities and mainly for operation and maintenance. Example of WWM activities financially supported by WW charge is summarised in table 4.11.

Table 4.11 Use of WW charge comparison between Eugene city, US and Tha Rae, Sakon Nakhon

Use of WW charge	**Eugene, US** (Activated sludge)	**Tha Rae** (Oxidation ditch)
Operation and maintenance	Operate and maintain 30 pump stations (26 local, 4 regional)	Only electricity and workers costs for operation but not for pumping station
Inspect/Clean wastewater collection lines	Yes (almost 390 miles of wastewater lines)	No
Water quality tests	Yes (Conduct more than 35,000 tests)	Yes (Financially supported by division of public health)
Sludge treatment	Yes (Process 2,000 dry tons of biosolids)	No (Different WWT technology)
Invest in capital improvements	Yes	No

Water quality test

Water quality test is conducted yearly by faculty of Science and Engineering, Kasetsart University Chalermphrakiat Sakonnakhon Province Campus with the supportive budget from the division of Public Health and Environment, Tha Rae. In addition, the water quality test is also reported by the Reginal Environmental Office 9 (Udonthani). Effluents of the treatment reached the effluent standard. However, WWTP has not been well-operated so far and this may cause poor water quality in the lake in the near future.

Table 4.12 Results of treated water quality compared with effluent standard

	Parameter	unit	Standard	7 September 2016	26 May 2017	5 April 2018
1	pH	-	5.5-9.0	7.20	6.78	7.88
2	BOD	mg/	<20	11.2	11.8	10.3
3	Total Nitrogen	mg-N/l	<20	11.2	11.8	10.3
4	Total Phosphorus	mg-P/l	<2.0	ND	ND	ND
5	SS	mg/l	<30	22.0	10.0	32.0
6	Oil & Grease	mg/l	<5	0.07	0.01	0.31

Challenge of wastewater management

I. Insufficient funding for O&M and expanding WWT capacity: Although WW charge is practically collected. The amount does not meet basic expenditures of operation. Apart of 3.5% of WW charge collection sending to Environmental fund, division of finance has to additionally budget to meet basic operational costs monthly. In terms of further investment, the main financial support has to wait for Office of Natural Resources and Environmental Policy and Planning decision which takes times.

II. Inconsistency operation and maintenance: Due to lack of funding, costs of maintenance are not covered in annual allowance but only normal expenditures of plant operation. No advance maintenance allowance proposed to division of finance. Consequently, once any equipment is malfunctioned, operation process has been stopped causing poor water quality.

4.2 WTP Estimation

4.2.1 Descriptive Analysis

Sociodemographic summary

Sociodemographic of collected data indicated from returned questionnaire. Number of female respondents is slightly greater than male respondents in 3 cities which female is around 60% and male is around 40%. Majority (up to 80%) of all respondents are adults which can be divided into two groups; early adulthood (20-39 year-old) and adulthood (40-60 year-old). In terms of education level, above 50% of urban respondents (Bangkok and Pattaya) have schooling years up to 12 years while majority of respondents in rural area (Tha Rae) have not completed secondary school or less than 9 years in education system. However, around 20% of respondents in Bangkok and Pattaya completed at least bachelor's degree. This is in accordance with national statistic of average educated years of Thai workers (Ministry of Education, 2018). Average year of education is 9.52 years or completed secondary school level. Tha Rae respondents has lowest average income among these 3 cities. Almost all respondents (80%) have monthly income less than 15,000 Baht. Only 10% on top of previous respondents could earn up to 25,000 Baht/month whereas distribution of income range of major respondents (90%) in Bangkok and Pattaya varied from less than 8,000 up to 50,000 Baht per month. Detached house takes the largest proportion of living type in Tha Rae, upto 90%. While living types in BKK and Pattaya can be divided into 2 major types namely, detached house and shophouse. Statistical data is provided in Appendix G.

Environmental concern attitude

Water pollution is not the major concern of Bangkok's and Pattaya's respondents. The first 3 major environmental concern in Bangkok are traffic congestion, air

pollution and waste disposal. Nearly 50% of Bangkokian prioritise traffic congestion as the 1st problem affecting them followed by air pollution and waste disposal. Also, Pattaya's residents concern traffic congestion the most. Not water pollution, flooding and inundation is also one of major concerns of Pattaya's respondents. In contrast, traffic congestion accounted for a small portion of concerns in Tha Rae while water pollution is prioritised as the 1st concerns (30%) followed by waste disposal and air pollution.

According to Likert's scale question format asking about water pollution impact level, Bangkokians perceive moderate level (2.99 out of 5). Slightly above moderate level, Pattaya and Tha Rae areas perceive water pollution impact at 3.52 and 3.58 respectively.

Willingness to pay for WW charge proportion

Results of Bangkok and Pattaya residents' opinions on WTP for water quality improvement is similar when slim majority are not willing to pay (slightly greater than 50%) for WW charge. On the other hand, 76.8% of residents in Tha Rae municipality are willing to pay for WW charge. However, rate of pay-out level from Tha Rae is the lowest among these 3 cities. The details about pay-out level are discussed in section 4.2.2.2

Table 4.13 WTP preferences of 3 cities

City	WTP preference					
	Yes		No		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Bangkok	323	49.3	332	50.7	655	100
Pattaya	267	47.3	298	52.7	565	100
Tha Rae	350	76.8	106	23.2	456	100

According to the survey data, respondents who said No to WW charge could be because they perceive that WWT is government responsibility and the fee is already included in civil tax. Moreover, some do not trust how WW charge could help improving WWM and water quality due to government unreliability. The reasons of WTP response both Yes and No, are summarised in the table 4.14 and 4.15 respectively.

Table 4.14 Reason of WTP response on Yes (willing to pay for WW charge)

	Reason	Bangkok	Pattaya	Tha Rae
1	WW treatment is an important part for water quality	21.7%	25.9%	30.7%
2	Responsibility of household activities	28.2%	28.9%	23.7%
3	Want to be a part of water quality improvement	32.0%	25.5%	23.5%
4	To conserve water resource for future usage	17.8%	19.4%	21.7%

Table 4.15 Reason of WTP response on No (not willing to pay for WW charge)

	Reason	Bangkok	Pattaya	Tha Rae
1	No money	3.1%	36.8%	18.2%
2	It should be included in tax (e.g. civil tax)	26.3%	15.5%	20.3%
3	It's government responsibility	37.3%	18.4%	20.3%
4	Don't believe that the collected charge could help improving WWM	13.4 %	10.4%	21.9%
5	Water pollution is not a problem	16.9%	8.0%	4.3%

Water saving attitude

In terms of water saving attitude, more than 60% of Pattaya and Tha Rae respondents will reduce water consumption once WW charge levied. On the other hand, only 40% of all Bangkok respondents will save water consumption once WW charge applied. Also, this is one of significant factors influencing WTP estimation that will be discussed in the next section.

Table 4.16 Water saving attitude once WW charge is applied of 3 cities

City	Water saving attitude							
	Yes		Depend on WW charge rate		No		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Bangkok	271	41.4	86	13.1	298	45.5	655	100
Pattaya	385	68.1	99	17.5	81	14.3	565	100
Tha Rae	356	78.1	52	11.4	48	10.5	456	100

4.2.2 Factors influencing WTP preference

4.2.2.1 Factor influencing WTP decision

Results of factors influencing WTP decision were analysed from Logit model which fit for dichotomous answer as “Yes” or “No”. This not only reveal list of significant factors, but also shown the relationship direction of each factors to WTP decision whether positive or negative.

Table 4.17 List of significant factors influencing WTP decision and its relationship

No.	Factor (influencing WTP decision)	Bangkok	Pattaya City	Tha Rae, Sakon Nakhon
1	Wastewater service perception	(+)	(+)	(+)
2	Education	(+)	(+)	(-)
3	Income	(+)		
4	Age	(-)		
5	Household size	(+)	(-)	(-)
6	Water saving awareness	(+)	(+)	
7	Gender (male)		(+)	
8	Water bill	(-)	(-)	
9	Water bill responsibility		(-)	
10	Types of residence (single house)	(+)		
11	Residence ownership (owner)		(+)	
12	Water pollution impact	(+)		(+)
13	Knowledge about wastewater management		(+)	(+)

(+) positive relationship

(-) negative relationship

Based on key factor summarised in table 4.17, different cities have different factors influencing WTP for water quality improvement. There are 9 significant factors in Bangkok and Pattaya city, and 5 factors in Tha Rae municipality. Among these factors, some are in common while the others are not. They can be categorised into common factors of 3 cities, common factors of 2 cities and uncommon factors.

(a) Results of LOGIT Analysis for estimating factor influencing WTP decision

Bangkok

Table 4.18 Results from LOGIT Analysis for factors influencing WTP decision in Bangkok

Variables	B	Sig.	Exp(B)
Age		0.000	
Age (1)	-1.598	0.013	0.202
Age (2)	-2.148	0.001	0.117
Age (3)	-1.441	0.027	0.237
WWser		0.006	
WWser (1)	-1.085	0.008	0.338
WWser (2)	-1.121	0.001	0.326
Housesize_6	0.404	0.088	1.498
Singlehouse	0.556	0.003	1.745
Waterbill_250	-0.534	0.005	0.586
ImpLev_4.0	0.406	0.069	1.501
WaterSaving		0.000	
WaterSaving (1)	-0.800	0.000	0.449
WaterSaving (2)	-1.201	0.000	0.301
Bachelor	-0.985	0.015	0.373
Inc_15000	0.246	0.336	1.278
Bachelor by	1.283	0.005	3.608

Variables	B	Sig.	Exp(B)
Inc_15000			
Constant	3.100	0.000	22.199

- The results show that older people have less likely to pay for WW charge than the younger people (early adult around 80%, adults around 90%, and elderly around 75% less than teenagers).
- Residents who earn more than 15,000 Baht monthly with bachelor's degree have higher probability to pay WW charge than the others 3.608 times.
- Residents who live in detached house type have greater probability to pay WW charge than ones who live in the other types around 1.745 times.
- The bigger household size, the more likely to pay WW charge. Household which involves at least 6 members have greater probability to pay WW charge than the smaller size around 1.498 times.
- The greater water tariff, the less probability to pay. Residents who have costs water tariff monthly greater than 250 Baht have less likely to pay WW charge rather than the others around 42%.
- The greater water pollution impact, the greater probability to pay. Ones who received larger effects from water pollution are more likely to pay WW charge rather than those who receive less around 1.5 times.
- One who don't perceive that their houses are in the WWT service areas have less likely to pay WW charge than those who do. (No = 66.2%, don't know = 67.4%)
- Ones without water saving awareness have less likely to pay WW charge than those who do. (No = 55.1%, depends on rate = 69.9%)

Table 4.19 Description of variables used in estimating WTP decision for water quality improvement in Bangkok

Variable name	Description
Age	Teenage group who are 19 year-old or lower
Age (1)	Early adulthood group who are 20-40 year-old
Age (2)	Adulthood group who are 41-60 year-old
Age (3)	Elderly group who are older than 60 year-old
WWserv	The respondents perceived that their houses are in WWT service area
WWserv (1)	The respondents perceived that their houses are not in WWT service area
WWserv (2)	The respondents do not know whether their houses are in WWT service area
Housesize_6	Household which consists of 6 members or greater number
Singlehouse	
Waterbill_250	Household which has water tariff greater than 250 Baht/month
ImpLev_4.0	Respondents high water pollution impact (1) (4 out of 5 scale)
WaterSaving	Respondents will save water consumption once WW charge is applied
WaterSaving (1)	Respondents will not save water consumption once WW charge is applied
WaterSaving (2)	Respondents will decide to save or not save water consumption once WW charge is applied depending on WW charge rate
Bachelor	Respondents who receive bachelor's degree or higher
Inc15000	Respondents who earn greater than 15,000 Baht/month or greater

Pattaya

Table 4.20 Results from LOGIT Analysis for factors influencing WTP decision in Pattaya

Variables	B	Sig.	Exp(B)
Gender	0.412	0.049	1.510
Ownership		0.000	
Ownership (1)	-0.929	0.003	0.395

Variables	B	Sig.	Exp(B)
Ownership (2)	-1.388	0.000	0.250
BillRes	-0.664	0.010	0.515
KNW_4.2	0.578	0.007	1.782
Waterbill_400	-0.878	0.000	0.416
Diploma	0.660	0.002	1.934
WWser (Yes)	0.421	0.086	1.524
Housesize_5		0.000	
Housesize_5 (1)	0.757	0.031	2.131
Housesize_5 (2)	1.176	0.001	3.242
Housesize_5 (3)	1.030	0.001	2.801
Housesize_5 (4)	1.121	0.000	3.069
WaterSaving		0.004	
WaterSaving (1)	-0.976	0.002	0.377
WaterSaving (2)	-0.526	0.059	0.591
Constant	3.100	0.071	2.207

- Male has higher probability to pay WW charge than female at 1.51 times
- Respondents who live in their house and own the properties have higher probability to pay WW charge than those who do not own the properties or rent the house for living. (reside = 60.5%, Rent = 75%)
- Ones who are in charge for water tariff bill has less likely to pay WW charge than those who are not around 48.5%.
- Ones who have water tariff bill greater than 400 Baht per month has less likely to pay WW charge around 58.4% than those who have less.
- Residents who have knowledge about WWM greater than average score have more likely to pay WW charge than the others at 1.782 times.
- Ones who earns diploma or greater level of education have more likely to pay WW than those who earn less at 1.934 times.

- Residents who perceive that their house are in the WWT service areas has more likely to pay WW charge than those who do not at 1.524.
- The smaller household size, the greater probability to pay. Households which consist of less than 5 members has more likely to pay WW charge than household consisting of 5 members or greater. (1 person = 2.131, 2 ppl = 3.242, 3ppl = 2.801, 4ppl = 3.096)
- Ones who have water saving awareness have more likely to pay for WW charge. (No = 62.3%, depends = 40.9% less than who save water)

Table 4.21 Description of variables used in estimating WTP decision for water quality improvement in Pattaya

Variable name	**Description**
Gender	Male
Ownership	Respondents who live in their own houses and own the property
Ownership (1)	Respondents who live in their own house but not own the property
Ownership (2)	Residents who rent houses
BillRes	Respondents who in charge for water tariff bill
KNW_4.2	Respondents who have knowledge about wastewater management higher than average score
Waterbill_400	Household which has water tariff greater than 400 Baht/month
Diploma	Respondents who earns diploma or greater level of education
WWser (Yes)	The respondents who know their houses are in WWT service area
Housesize_ 5	Household which consist of 5 members or greater number
Housesize_ 5 (1)	Household which consists of 1 member
Housesize_ 5 (2)	Household which consists of 2 members
Housesize_ 5 (3)	Household which consists of 3 members
Housesize_ 5 (4)	Household which consists of 4 members
WaterSaving	Respondents will save water consumption once WW charge is applied
WaterSaving (1)	Respondents will not save water consumption once WW charge is applied
WaterSaving (2)	Respondents will decide to save or not save water consumption once WW charge is applied depending on WW charge rate

Tha Rae, Sakon Nakhon

Table 4.22 Results from LOGIT Analysis for factors influencing WTP decision in Tha Rae

Variables	B	Sig.	Exp (B)
Housesize_8	-1.815	0.001	0.163
KNW_4.0	0.727	0.024	2.069
WWser_DK	-0.738	0.028	0.478
ImpLev_3.2	0.739	0.002	2.094
Edu		0.063	
Edu (1)	-0.607	0.027	0.545
Edu (2)	-0.534	0.089	0.586
Constant	0.772	0.026	2.164

- The smaller household size, the greater probability to pay. Households which consist of less than 8 members has more likely to pay WW charge than household consisting 8 or greater members.
- Residents who have knowledge about WWM greater than average score have more likely to pay WW charge than the others at 2.069 times.
- Residents who do not know that their house whether are in the WWT service areas have less likely to pay for those who knows around 52.2%.
- The greater water pollution impact, the greater probability to pay. Ones who received larger effects from water pollution are more likely to pay WW charge rather than those who receive less around 2.094 times.
- The higher years of schooling, the less likely to pay WW charge. Residents who earn high school level less likely to pay WW charge than those who earn less around 45.5% and ones who earn higher than certificate level have less likely to pay WW charge than those who earn less than 9 years of schooling around 41.4%.

Table 4.23 Description of variables used in estimating WTP decision for water quality improvement in Tha Rae

Variable name	Description
Housesize_8	Household which consist of 8 members or greater number
KNW_4.0	Respondents who have knowledge about wastewater management higher than average score
WWser_DK	Adulthood group who are 41-60 year-old
ImpLev_3.2	Respondents high water pollution impact (1) (4 out of 5 scale)
Edu	Respondent who earns educational degree less than secondary school (less than 9 years of schooling or matthayom 3)
Edu (1)	Respondent who earns educational degree in high school (12 years of schooling or matthayom 6)
Edu (2)	Respondent who earns educational degree in certificate or higher (more than 12 years of schooling)

b) Discussion of LOGIT Analysis for estimating factor influencing WTP decision

Common factors of 3 cities

There are 3 common factors among these case studies. They are wastewater service perception, education and household size. However, they gave different relationship direction and interpretation.

WW service perception is the only factor gave same relationship direction among these 3 cities. Residents in Bangkok and Pattaya who perceive that their houses are in WWT service areas are more likely to pay WW charge than ones who do not. In similar relationship, those who do not certain that their houses are in WW service area, are less likely to pay WW charge than ones who are certain in Tha Rae context.

According to WTP decision statistic, Tha Rae has the highest percentage of residents perceive WW service in their areas with 78.1%, while Pattaya is 27.8% and Bangkok is the smallest with 9.8%. It is obvious that WW service clarification is one of crucial factors to be considered to increase success of WW charge policy implementation.

Education: Tha Rae gave the opposite direction with Bangkok and Pattaya. The higher level of education, the higher probability to pay WW charge in Bangkok and Pattaya whereas the lower probability to pay WW charge in Tha Rae. With higher education level of Bangkok and Pattaya, the results are in accordance with Taale and Kyeremeh (2016), Rammont and Amin (2010), Jermpun and Punyasiri (2017) and Kotchen et al. (2013) studies reported that respondents are more likely to pay WW charge in higher education level and income group.

Household size: Tha Rae and Pattaya shows that the bigger household size, people will less likely to pay WW charge while the higher number of household members, the higher probability in Bangkok. This could be claimed that payment would be prioritised for basic household need sufficiently rather than environmental improvement (Taale and Kyeremeh, 2016 and Jhermpun & Panyasiri, 2017).

Common factors of 2 cities

Common factors between Bangkok and Pattaya

Apart from 3 factors mentioned above, there are other 2 factors in common which are water saving awareness and water bill cost.

Water saving awareness: With same relationship direction in both cities, people who has water saving awareness has higher probability to pay WW charge than the others. *Regarding water bill costs*, the more water bill costs, the less likely to pay WW charge. The results show that resident who has water bill more than 400 baht in

Pattaya and more than 250 Baht in Bangkok are less likely to pay WW charge in addition to monthly water tariff than those who have cheaper water bill.

The results confirmed that there are 5 factors influencing WTP decision in common between Bangkok and Pattaya city namely, WW service perception, household size, education level, water saving awareness and water bill.

Common factors between Bangkok and Tha Rae

Water pollution impact is the only common factor influencing WTP decision on water quality improvement. The more pollution, the more probability of willingness to pay WW charge. This result is in accordance with Roomratanapun (2001). This could be claimed that pollution has welfare costs and residents would like to pay for better welfare quality in exchange.

Common factors between Tha Rae and Pattaya

Knowledge about WWM is also the only common factor affecting WTP decision. The more understanding and awareness about WWM, residents are more likely to pay WW charge rather than those who have less awareness. The results are supported by (Jhermpun & Panyasiri, 2017; Rammont & Amin, 2010) studies. Therefore, WWM comprehension is fundamental to local residents in order to increase probability of success in WW charge policy.

Uncommon factors of each city

Bangkok

To begin with Bangkok, there are 4 different factors affecting WTP compared with Pattaya and Tha Rae. Firstly, *Age:* the older people, the less likely to pay for WW charge. This might be because young generation have more environmental

awareness than older generation (Ballew et al., 2019; Smith, 2013). Secondly, *Income;* ones who earns more than 15,000 baht per month or the minimum salary of bachelor's degree are willing to pay WW charge rather than those who earn less. Thirdly, *Type of residence:* ones who live in detached house are more likely to pay for WW charge than those who live in other types and detached house is a majority living type in Bangkok. Lastly, *Water pollution impact:* the higher impact the more likely to pay WW charge. They might be willing to pay because they would like to get rid of this polluted situation.

Pattaya

Next with Pattaya, *Bill responsibility:* residents who in charge of monthly water tariff are less likely to pay for WW charge. This might be because they have loads of payment and prioritise basic needs rather than environmental quality improvement. *Residence ownership:* resident who live in their own house are more likely to pay WW charge than ones who rent houses. This might be because most people come to Pattaya for jobs but not Pattaya's originally. They do not own their houses but rent instead due to the flexibility to move once new opportunities come. Therefore, this group of people are less likely to pay for the utilities that they are uncertain to use in the future. *WW knowledge understanding:* residents who scored about WWM understandings higher than average score, are more likely to pay WW charge than the others.

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The last with Tha Rae, there is no uncommon factors of Tha Rae compared with Bangkok and Pattaya. Education, WW service perception, household size and gender are also significant factors in the other 2 cities. However, this considers only in terms of list of factors but neglect the relationship direction. if considering about both factors and their direction, it could be claimed that Tha Rae has 4 different factors

influencing WTP decision compared with Bangkok and Pattaya because all fours factors gave opposite relationship direction.

4.2.2.2 Factors influencing WTP pay-out level

After analysing factors influencing WTP decision, respondents who answered 'Yes' for WW charge will then be further analysed to see factors influencing pay-out level.

This section reports the results of factors influencing WTP pay-out level from the respondents who are willing to pay for WW charge in order to see impact of each factors on level of WTP amount if they prefer paying less or more. After obtaining factors influencing WTP decision for water quality improvement, data of respondents who said "Yes" for WW charge collection were used for further analytical process Results of factors influencing WTP pay-out level were analysed from Multiple Regression (MR) model which fit for multiple independent variables affecting one dependent variable. This not only reveal list of significant factors, but also shown the relationship direction of each factors to WTP pay-out level whether positive or negative.

All factors were firstly added into the model one by one to see statistically significant value. Preparing data, all categorical variables were transformed into dummy variables (1 and 0) which is fit the MR analysis. After transformation, final model of analysis with all significant factors are shown in table 4.24.

Table 4.24 List of significant factors influencing WTP pay-out level and its relationship

Factors	BKK	Pattaya	Tha Rae, Sakon Nakhon
WW service	(+)	(+)	
Water saving awareness	(+)	(+)	
Water bill	(+)	(+)	
Household size		(+)	
House owner		(+)	
Income	(+)		(+)
Education			(+)
Water pollution	(+)		

(+) positive relationship

(-) negative relationship

Based on key factor summarised in table 4.24, different cities have different factors influencing WTP for water quality improvement. There are 9 significant factors in Bangkok and Pattaya city, and 5 factors in Tha Rae municipality. Among these factors, some are in common while the others are not. They can be categorised into common factors of 3 cities, common factors of 2 cities and uncommon factors.

(a) Results of MR Analysis for estimating factor influencing WTP pay-out level

Bangkok

Table 4.25 Results from Multiple Regression analysis for WTP pay-out level in Bangkok

Constant	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	33.112	5.618		5.894	0.000
WWser_Yes	19.047	8.912	0.119	2.137	0.033
Waterbill_250	10.672	5.810	0.102	1.837	0.067
WatSav_Yes	20.446	5.884	0.196	3.478	0.001
ImpLev_4.0	29.523	6.651	0.253	4.439	0.000
Inc_25000	16.410	6.186	0.148	2.653	0.008

- Ones who perceive that their house are in WWT service area are willing to pay 19.047 Baht greater than who do not.
- Ones who pays water tariff greater than 250 Baht per month are willing to pay 10.672 Baht greater than the others.
- Ones who will save water once WW charge applied are willing to pay more than those who will not.
- Ones who receive water pollution at high level are willing to pay 29.523 Baht more than those who affect less.
- Ones who earn greater than 25,000 Baht monthly are willing to pay 16.410 more than those who earns less.

Table 4.26 Description of variables used in estimating WTP pay-out level for water quality improvement in Bangkok

Variable name	Description
WWser_Yes	The respondents perceived that their houses are in WWT service area
Waterbill_250	Household which has water tariff greater than 250 Baht/month
WatSav_Yes	Respondents will save water consumption once WW charge is applied
ImpLev_4.0	Respondents high water pollution impact (4 out of 5 scale)
Inc_25000	Respondents who earn greater than 25,000 Baht/month or greater

Pattaya

Table 4.27 Results from Multiple Regression analysis for WTP pay-out level in Pattaya

Constant	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	132.550	17.195		7.708	0.000
WWser_Yes	36.708	12.132	0.233	3.026	0.003
Waterbill_400	33.650	16.475	0.161	2.043	0.043
WatSav_Yes	-50.959	16.206	-0.248	-3.144	0.002
Housesize_5	24.419	14.312	0.132	1.706	0.090
House renter	-30.734	13.218	-0.184	-2.325	0.021

- Ones who perceive that their house are in WWT service area are willing to pay 36.708 Baht greater than who do not.
- Ones who pays water tariff greater than 400 Baht per month are willing to pay 33.650 Baht greater than the others.
- Ones who will save water once WW charge applied are willing to pay 50.959 less than those who will not.
- Household involves 5 member or greater are willing to pay 24.419 Baht more than those which consist of less members

- Ones who rent house for living are willing to pay 30.734 Baht less than the others.

Table 4.28 Description of variables used in estimating WTP pay-out level for water quality improvement in Pattaya

Variable name	Description
WWser_Yes	The respondents perceived that their houses are in WWT service area
Waterbill_400	Household which has water tariff greater than 400 Baht/month
WatSav_Yes	Respondents will save water consumption once WW charge is applied
Housesize_5	Household which consist of 5 members or greater number
House renter	Respondents who rent houses for living

Tha Rae, Sakon Nakhon

Table 4.29 Results from Multiple Regression analysis for WTP pay-out level in Tha Rae, Sakon Nakhon

Constant	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	28.418	2.663		10.672	0.000
Inc_15000	24.839	4.380	0.303	5.671	0.000
M3_lower	-13.959	3.409	-0.219	-4.095	0.000

- Ones who earn greater than 15,000 Baht per month are willing to pay 24.839 Baht more than those who earn less.
- Ones have less than 9 years of schooling are willing to pay 13.959 Baht less than those who earn more years in educational system.

Table 4.30 Description of variables used in estimating WTP pay-out level for water quality improvement in Tha Rae, Sakon Nakhon

Variable name	Description
Inc_15000	Respondents who earn greater than 15,000 Baht/month or greater
M3_lower	Respondent who earns educational degree less than secondary school (less than 9 years of schooling)

(b) Discussion of LOGIT Analysis for estimating factor influencing WTP pay-out level

From 13 factors influencing WTP decision on WW charge, only 5 factors significantly affect WTP pay-out level in BKK and Pattaya, and only 2 factors in Tha Rae. There are no factors in common among 3 cities.

Common factors in 2 cities

Bangkok and Pattaya

There are 3 common factors between Bangkok and Pattaya. First is WW service perception. Ones who perceive that their houses are in the WWT service area are willing to monthly pay 19.05 Baht, 36.71 Baht more than those who so not in Bangkok and Pattaya respectively. The second is water saving awareness. Respondents who will save water consumption once WW charge is applied are willing to pay more than those who will not. The third is water bill costs. The higher water bill, the greater pay-out level. In Bangkok, people who pay water tariff greater than 250 Baht per month are willing to pay 10.67 Baht more than those who have lower water tariff. Respondents who pay greater than 400 Baht per month are willing to pay more than those who have lower water tariff at 33.65 Baht per month. This might be because they consume more water, so they would like to compensate water pollution by paying more WW charge.

Bangkok and Tha Rae

In addition, income is only one significantly common factor between Bangkok and Tha Rae. Respondents with greater income are willing to pay WW charge more than those who earn less. In Bangkok, ones who earns greater than 25,000 Baht monthly are willing to pay 16.41 Baht greater than those who earns less. Also, respondent who earns greater than 15,000 Baht per month in Tha Rae are willing to pay more than those who earn less at 24.83 Baht per month. However, 80% of all respondent in Tha Rae have monthly incomeless than 15,000 Baht per month. Nevertheless, Tha Rae and Pattaya has no common factors.

Uncommon factors of each cities

Bangkok

To begin with case of Bangkok, water pollution impact is only different factors. Ones who perceive greater adverse impact from water pollution are willing to pay WW charge 29.52 Baht more than those who affect less. This relationship was also claimed by (Roomratanapun, 2001). The greater impact, the greater WTP.

Pattaya

Followed by case of Pattaya, there are 2 different factors affecting WTP pay-out level. First, house ownership, ones who own their house are willing to pay WW charge more than those who rent. Ones who rent houses will pay 30.73 less than those who are house owners. This might be because people who rent the house are not originally local residents but come to Pattaya for career opportunity. So, they may have lack of sense of ownership. Second, household size, the greater household size, the greater pay-out level. Household that involves 5 members up are willing to pay 24.42 Baht more than the smaller size. This could possibly be from greater

income with greater members or larger volume of WW discharge with greater members. Therefore, bigger household size has greater pay-out level.

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Lastly with Tha Rae, education level is the only factors affecting pay-out level. Ones who has schooling year less than 9 year or less than secondary school are willing to pay 13.96 Baht less than those who have longer schooling period.

4.2.2.3 Factors prioritisation of each cities

This section presents significant factors influencing WTP pay-out level of each city in the form of equation. According to multiple regression equation, the value of unstandardized B could be used as coefficient in the equation. This value can be interpreted into impact level of each factors as well as relationship direction. Among these 3 cities the equation can be written as follow.

Bangkok

$$WTP_{Bangkok} = 33.112 + 19.047B_1 + 10.672B_2 + 20.446B_3 + 29.523B_4 + 16.410B_5$$

B_1 = WW service perception

B_2 = Water bill cost greater than 250 Baht per month

B_3 = Water saving awareness

B_4 = water pollution impact level greater than 4.0

B_5 = Income greater than 25,000 Baht per month

All significant factors of Bangkok are in positive direction with WTP pay-out level for water quality improvement. However, impact level of each factor on WTP is varied. The highest impact level goes to water pollution impact level at 29.523 meaning that

ones who perceive water pollution effect lager than average score are willing to pay 29.523 Baht more than those who perceive less. The second is water saving awareness followed by WW service perception, income and water bill cost respectively.

Pattaya

$$WTP_{Pattaya} = 132.550 + 36.708P_1 + 33.650P_2 - 50.959P_3 + 24.419P_4 - 30.734P_5$$

P_1 = WW service perception

P_2 = Water bill cost greater than 400 Baht per month

P_3 = Water saving awareness

P_4 = Household size greater than 5 members

P_5 = House ownership (renter)

Among 5 factors, 3 factors gave positive relationship while 2 factors gave negative relationship direction with WTP pay-out level for water quality improvement in Pattaya. The greatest impact level of pay-out is water saving. In contrast to Bangkok, residents who have water saving awareness will pay 50.959 Baht less than the rest. The second is WW service perception. Ones who perceive that their house are in WW service area will pay 36.708 Baht, more than those who do not. The third, the fourth, and the fifth are Water bill costs, house ownership and household size respectively.

Tha Rae, Sakon Nakhon

$$WTP_{Tha\ Rae} = 28.418 + 24.839R_1 - 13.959R_2$$

R_1 = Income greater than 15,000 Baht per month

R_2 = Education level lower than M3 (9 years of schooling)

There are only 2 factors significantly influent pay-out level in Tha Rae. Income is the most impactful to WTP pay-out level. The more monthly earn, the more WTP. Also, the lower schooling years, the lower WTP.

Above all of 3 cities, it can be claimed that the most impactful factor influencing WTP pay-out level is water pollution impact for Bangkokians, water saving awareness for Pattaya's residents and income for Tha Rae's inhabitants. Seeing that different cities have different factors and level of WTP pay-out. Therefore, enacting WW charge should be differentiated for each city by taken significant factors into consideration. This could be increase acceptance from residents and hence increase success rate of policy implementation.

Nevertheless, reason of rejection from the other side of respondent should not be abandoned. The main reasons of respondents who refuse to pay WW charge is "No money". In respondents' opinions, WW management is government duty and civil tax should be included this payment.

4.2.3 Average amount of WTP

WTP pay-out of respondents who said Yes to WW charge were taken to calculate average WTP. The distribution of WTP amount preference of respondents in Bangkok, Pattaya and Tha Rae are shown in figure 4.7, 4.8 and 4.9 respectively.

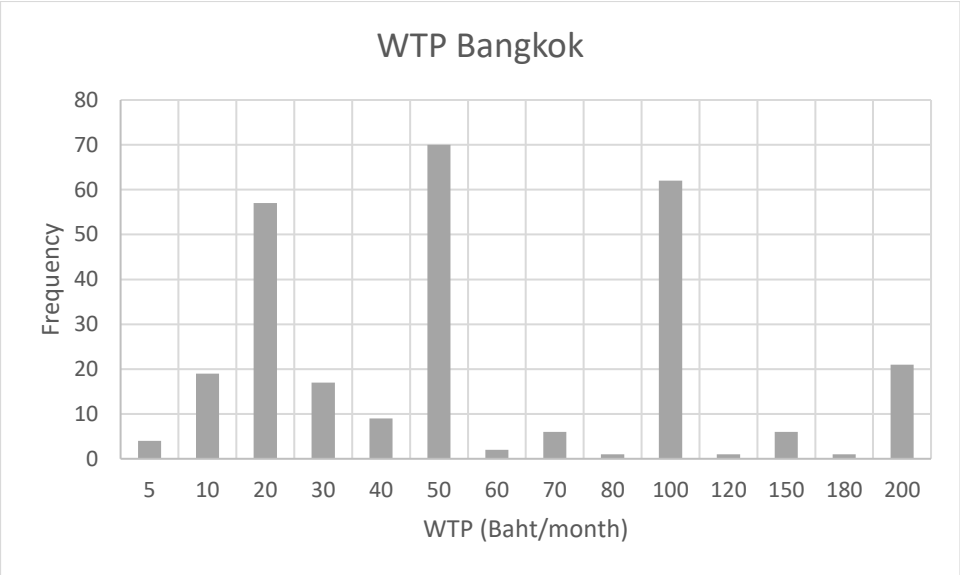


Figure 4.7 WTP distribution of Bangkok

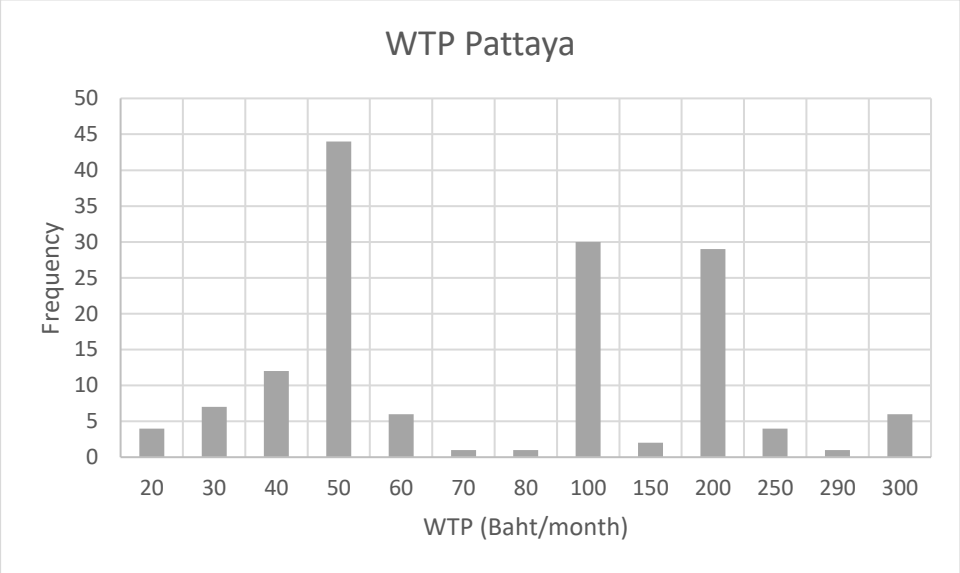


Figure 4.8 WTP distribution of Pattaya

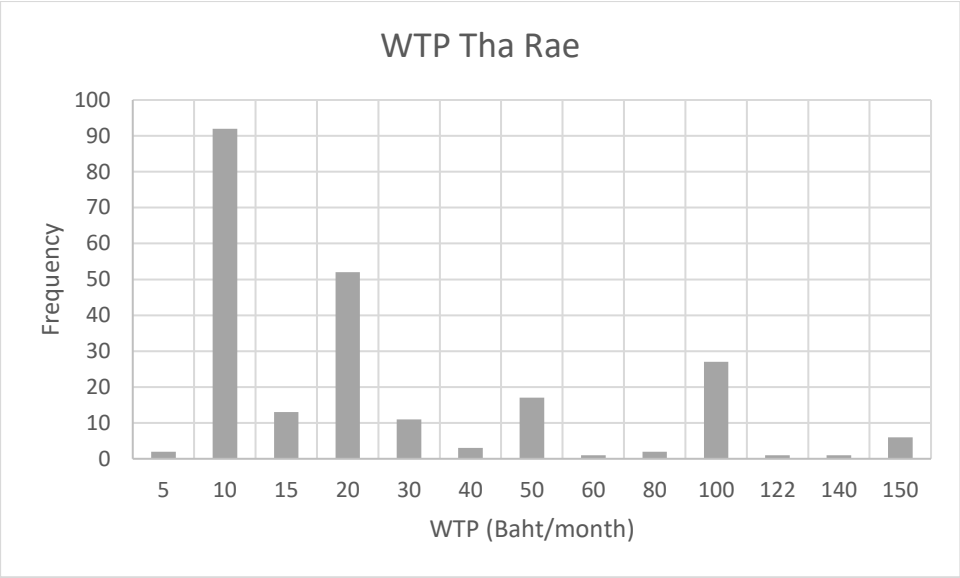


Figure 4.9 WTP distribution of Tha Rae

Three different cities give 3 different pay-out level. Table 4.31 shows three statistical values; mean, median and mode of 3 cities. The highest mean value of WTP amount is in Pattaya city at 106.6 Baht/month/household following by Bangkok at 65.0 Baht/month/household and Tha Rae at 26.1 Baht/month/household. The mean value is sum of all dataset divided by number of samples. It represents the average value of dataset and it might be affected by the extreme values. However, in this study outliers were removed before taking the data for analysis (see section 3.3.2). The mode value is the most frequent value or the WTP that the most respondents mentioned. Bangkok and Pattaya gave the same value at 50 Baht/month/household whereas Tha Rae gave 10 Baht/month/household. Although, mode represents suitably when the data is nominal, it represents the most WTP preference of respondents. Median is the middle value when data is arranged in order of magnitude. It has less effected from outliers and skewness. Pattaya also gave the highest value which is 70 Baht/month/household followed by Bangkok and Tha Rae at 50 and 10 Baht/month/household respectively. Although median has less effect from outliers and is preferred as central tendency, it does not represent the most preference of respondents.

Table 4.31 statistical data of WTP in 3 cities

	Mean	Median	Mode	Min.	Max.	S.D.
Bangkok	65.0	50	50	5	200	52.16
Pattaya	106.6	70	50	20	300	77.58
Tha Rae	26.1	10	10	5	150	31.93

Statistical WTP values obtained could probably not meet the actual WWM expenditures depending on WWTPs technology and capacity. Different WWT technologies require different costs for investment and O&M. The advance and complex technology (e.g. activated sludge) could consume more investment and operation costs than the simple technology (e.g. oxidation ditch). However, table 4.32 shows the comparison between O&M costs and revenues generated from WW charge accordingly to WTP statistical values to see how WW charge could help supporting financially for WWM.

Table 4.32 Comparison between O&M expenditures and WW charge revenue from statistical WTP values of mean mode and median of 3 cities

	Number of households	O&M Expenditures (Baht/year)	Revenues from WW charge (Baht/year)		
			WTP mean	WTP median	WTP mode
Bangkok	2,959,524	478,100,000	2,308,428,720	1,775,714,400	1,775,714,400
Pattaya	38,184	39,089,610	48,844,972	32,074,560	22,910,400
Tha Rae	3,211	342,000	1,005,685	385,320	385,320

Note: O&M costs based on budget allocation information of each city and revenue from WW charge calculated from 100% of households number.

The household information is from government database and O&M expenditures is based on annual budget allocation of each city. Assuming that WW charge could be collected from every single household, revenue generated from WW charge in Bangkok could fully cover O&M costs of all WTP mean, median and mode values.

Moreover, it is much enough to cover other WWM activities. In the same way, all WTP value in Tha Rae can fully cover operation costs and means give almost triple value than the others. However, only WTP mean value can cover O&M costs in Pattaya while mode and median can cover around 82% and 59% of O&M costs respectively. Seeing that if WW charge could be practically implemented, the revenue generated could help financially supporting WWM. This could reduce government budget independent and increase financial security for WWM.

Moreover, when compare mean of WTP for WW charge with average monthly water tariff bill, it shows that Pattaya gave the highest ratio between WW charge and monthly water tariff. Pattaya's residents are willing to pay 35.5% on top of their water tariff (65 out of 351). Bangkok's residents prefer to pay around 20.6% on top (106 out of 450) and the lowest is Tha Rae's residents at 14.0% on top (26 out of 186) of their average water tariff per month (table 4.33 and figure 4.10).

Table 4.33 WW charge on-top of water tariff in 3 cities

City	WTP pay-out level for WWT treatment (Baht/month)	Water tariff bill (Baht/month)	On-top percentage (WTP/(WTP+Water tariff)
Bangkok	65.0	250	20.6
Pattaya	106.6	290	26.9
Tha Rae	26.1	160	14.0

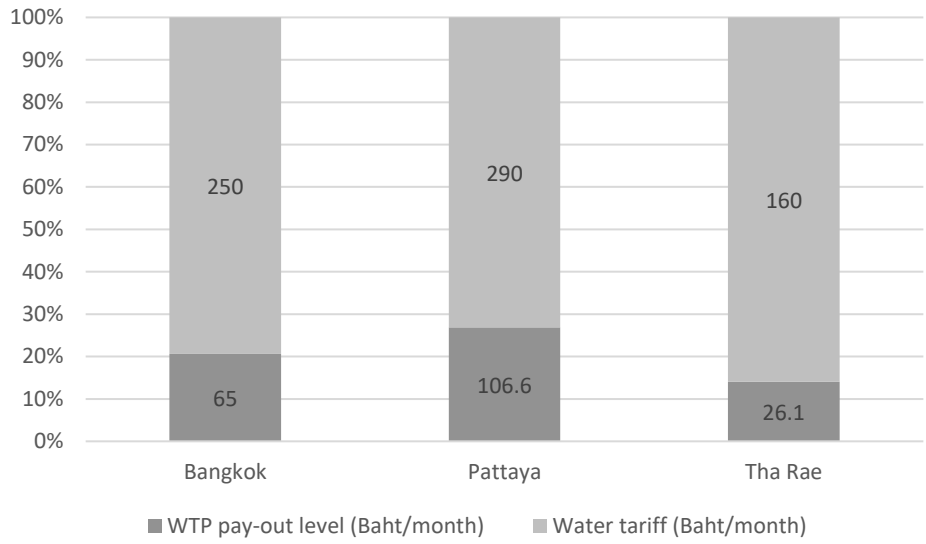


Figure 4.10 WW charge on-top of average water tariff in 3 cities

Bangkok was hypothesised to have the highest average pay-out level because the more population density, the more water consumption and pollution. following by Pattaya city and Tha Rae municipality where the population density is the lowest among these 3 case studies. However, this can be argued that Pattaya's residents value water quality the highest among these 3 cities and this could be because the business activities in Pattaya rely on water quality. It is tourism destination and coastal scenery is one of the most important environmental qualities.

4.3 Recommendation and suggestion from the results applying for 91 municipalities of existing WWTPs

Among the number of cities throughout Thailand, cities where WWTPs are available would be the first group of applying for WW charge reasonably. There are 105 WWTPs in 91 municipalities with WWT service (Appendix A). All these facilities are managed by local government under the authority of MWA. However, these cities have different characteristic. Therefore, implementing WW charge policy could be varied accordingly to local context.

4.3.1 City characterisation for WW charge implementation

The optimal implementation should consider local context insightfully because 91 municipalities are basically not identical. However, this must consume both time and resources. Employing significant factors affecting WTP for water quality improvement from empirical study into consideration for those similar cities would be more feasible and economical. From 91 municipalities, it can be categorised in to 3 main groups according to cities characteristic and spatial administration of local government or city size (table 4.34).

City characteristics

1. Highly urbanised areas

Among 76 provinces in Thailand, Bangkok is the biggest city in terms of economic and population although it is the top 10 smallest cities spatially. This make Bangkok become the city with the highest population density in Thailand, not only registered population but also latent population from other areas. It is a capital city where administration system is independent from central government and has its own ordinance.

This group also includes where municipal WW are not only from local population, but also high latent population from non-local but reside in this area for career opportunities causing high population density. Also, latent population could be from short-stay tourists who rent places for staying from house owners locally (e.g. Airbnb) instead of hotels. Although WW not directly affects city's income, WW generated are for higher than from local population and require large capacity of WWT service. An example of a city in this case is Bangkok, a capital city where people came from every part of Thailand for jobs. From NSO, Bangkok latent population in 2018 was 2.05 million people compared to registered population, 5.66 million people (NSO, 2018). Apart from Bangkok, most of this type of city could be administrated by city

municipality. This is the second largest city type in Thailand by number of population and financial status.

2. Coastal city/tourist dependence

This is a group where water quality affecting economic activities or main business of the cities. There are 13 cities out of 91 municipalities with 20 WWTPs. These are seaside destination from tourists all over the world. The majority of city's income are from hospitality business i.e. 90% of Gross Provincial Product (GPP) are from beach-related product and services in Pattaya. This can be claimed that good status of water quality is crucial to city's economic. The size of this character could be but mostly is city and town municipality and Pattaya is considered as city municipality.

3. Rural areas

This group earns the largest share of cities in Thailand. They could be Town municipality; a medium size of local administration system (187 Town municipality) and Subdistrict municipality or Subdistrict Administrative Organisation (SAO); the smallest local administration system in Thailand in terms of population number and city financial status. There are 5,557 cities divided into 2,237 subdistrict municipality and 5,320 SAO. However, there are only 54 municipalities where WWTPs are available. This type of cities not only contain small number of populations, but also small land area under administration. Most of them are in rural or remoted area with limited facilities. They are not target cities for tourists as well as job seekers. Therefore, it can be argued that latent population could be negligible.

Table 4.34 3 groups of cities based on characteristic

	City characteristic	City size by administrative system	No. of city
1	Highly urbanised city	BMA and City municipality (Appendix D)	24
2	Seaside city	City municipality/Town municipality/Subdistrict municipality (Appendix E)	13
3	Rural city	Town municipality and Subdistrict municipality (Appendix F)	54
		Total	**91**

4.3.2 Strategies for WW charge implementation

Although tailor-made strategy is desired to fit city context locally, some aspects in common for all groups are recommended to increase probability of WW charge implementation as follow.

I. **Creating public engagement on WWM to residents especially ones who live in WWT service areas.** This could increase probability of WW charge collection significantly since residents who perceive that their house are in the service areas, not only have higher probability to pay WW charge, but also pay at the higher rate. Residents will consider that they receive the service and prefer paying WW charge in exchange.

II. **Residents should be raised awareness of water quality situation relatively to negative impact.** This is because residents who have high understanding about WWM have higher probability to pay WW charge as well as residents who perceive high water pollution impact are more likely to pay WW charge at higher rate. In Bangkok, the campaign of environmental awareness could be done by

district offices since they are closer to residents and understand the context of location more than central administration. In the other cities, the campaign could be done by local government directly or integrated into schooling system.

III. **Collected WW charge spending activities should be transparently reported.** This may not only increase government reliability, but also help reducing protest from residents who do not trust government. This is from the survey data of respondents who said No to WW charge because they do not believe how the government will use the charge collected to improve water quality.

Collection method

The most preferred collection method is billing together with water tariff with clarification of water and WW charge. This facilitates payment to the residents yet increase collection efficiency to the collector. Therefore, cooperation systematically between organisation responsible for WWM and water supply is necessary.

To achieve this in Bangkok, cooperation between Metropolitan Waterworks Authority (MWA) and Department of Drainage and sewerage (DDS), BMA is crucial in order to develop the system of collection precisely and accurately. In other municipalities, the division which in charge for water quality control or WWM should work with Provincial Water Authority (PWA) or local water supply division.

Utilisation of collected WW charge

The use of WW charge collection could be varied depending on how much it could be collected and how it can cover expenditures of such activities. However, it should be spent on any activities related to WWM. These could be to cover O&M costs or to initiate public hearing or public engagement campaign to raise awareness and WWM knowledge to local residents.

In terms of O&M, the costs vary based on technology and treatment capacity. The advance and complex technology with large capacity requires much more costs than those of simple technology with small capacity. For general operation, O&M costs

could be operating and maintaining pumping station, obtaining chemical substance, treating biosolid, cleaning wastewater collection pipelines, testing and monitoring water quality to keep the WWPTs operating continuously.

In addition to common aspects, tailor-made recommendation accordingly to local context are drawn in terms of recommended WW charge rate, collection method, collected WW charge spending activities, limitation and concerns, following by specific recommendation of each type of cities.

WW charge rate recommendation

Instead of strongly selecting the only one represented value, mean mode and median values were taken into consideration to recommend range of WW charge rate for each city (table 4.35). The recommendation was drawn from range of those statistical values not only because each value has its own positive point, but range allows flexibility for implementation. Mean could represent suitably of average value, mode could represent the most preferable value of respondents and median has less effect from outliers and skewness when data is not symmetric distribution. Moreover, volumetric charge rate were calculated from mean value divided by average volume of water consumption analysed from water bill costs of respondents (Appendix G).

Table 4.35 WW charge rate recommendation

	Fixed WW charge (Baht/month/household)	Volumetric charge rate (Baht/m^3)
Highly urbanise city	50-65	2.00
Coastal city	50-110	3.50
Rural city	10-30	1.00

Highly urbanised city: WW charge should be directly proportional to water consumption volume. Total payment of WW charge monthly is recommend approximately 50-65 Baht/month or around 20% on top of water bill. The average

water tariff of Bangkokians is 250 Baht with 30-35 m^3 per month. Therefore, recommended rate is around 2.00 Baht/month which is accordingly to household WW charge mentioned in Bangkok ordinance (Appendix H).

Coastal city: WW charge should be proportional to water consumption volume. However, the charge recommended is 3.50 Baht/m^3, higher than Bangkok. Based on WTP study of Pattaya city, residents are willing to pay around 106 Baht/month with average water consumption 21-30 m^3/month. This rate is around the rate mentioned in general WW charge in residential areas where local ordinance levied. However, the mentioned rate in the ordinance consider both type of building and BOD concentration (Appendix H). The more BOD, the more WW charge rate. As of China, developed coastal cities are normally have much higher rate of water tariff including sewage treatment fee. This is because they have much greater WW volume and need larger capacity to treat this WW than less-developed cities (THE WORLD BANK, 2009)

Rural city: The collection amount could be either varied by water consumption volume like pay as you go or fixed monthly depending on local government administration. If the government goes for "pay as you go", the recommended rate of WW charge could be 15-20% of their water tariff. This is in accordance with current rate in Tha Rae, at 1.00 Baht/m^3 which is accounted around one-sixth or 16.67% of water tariff. This could stimuli residents' water saving awareness because the more they consume, the more they pay. On the other hand, if the government goes for monthly fixed payment, the recommended rate of WW charge is around 10-30 Baht per month. This is referenced from the study of Tha Rae WTP for water quality improvement, average payment of residents is around 10-30 Baht per month. Moreover, Kutchik, subdistrict municipality, Nakhon Ratchasima has collected WW charge at 10 Baht/month/household (Appendix A). The rated recommended seems to be little and could probably not cover all expenditures of WWM activities. However, this could raise environmental awareness to resident and concerns of their responsibility to water resources.

Specific recommendation for each city

1. Highly urbanised city

I. **Levying WW charge with single house people as the first group could be effective.** The study shows that residents who live in single house have high probability to pay than those who live in the other types of house. Also, it has the biggest portion among all type of residence in Bangkok. BMA also stated that commercial building including shophouse will be the first group been charged.

II. **Levying WW charge with residents who live in the WWT service area as the first group could be effective.** It is reasonable to charge residents who live in WWT service areas. However, they need information about WWTPs and perceive the service. The districts office could make some programme to provide this kind of information to their administrative areas. This is because one who perceive that their houses are in the service area are more likely to pay WW charge rather than ones who do not.

SWOT Analysis for Highly urbanised city

Strength • Residents have high average income and education level. • Almost all household access water supply and water consumption can be metered	Weakness • Difficulties of cooperation between organisation due to Large size of organisations and independent work (e.g wate supply and WWM).
Opportunity • WW charge could generate large amount of revenues due to large numbers of population.	Threats • Great volume of WW generation due to numbers of population. • Land for WWTPs facility construction could be limited due to high population density

Figure 4.11 SWOT analysis of highly urbanised city

2. Coastal city/tourist dependence

I. **WW charge could be possibly collected in the form of civil tax:** The results of factor influencing WTP decision shows that ones who own their house properties are more likely to pay WW charge than the others. Also, residents who pay higher water bill have less likely to pay WW charge than those who have less water bill costs. This means that it could be charge via civil tax which is basically paid by property owner. For example, WW charge could be collected from rental building owners via civil tax instead of charging single renters by water consumption volume including in the water bill monthly.

SWOT Analysis for coastal city

Strength • High WTP rate due to desire of good water quality • Residents have high average income and education.	Weakness • Residents have high basic living costs because rate of water supply is higher than the other types of cities. • WWTPs investment capital cost is needed from outsources
Opportunity • Good status of water quality is crucial for city economic activities	Threats • High latent population who rent houses for living • Large WWT capacity and advance technology is required due to economic activities and limited land areas.

Figure 4.12 SWOT analysis of coastal city

3. Rural city

I. Integrated knowledge about WWM in elementary level of educational system could increase residents' understanding and acceptance. Based on the results of factors influencing WTP, higher years of schooling respondents have high probability to pay for WW charge yet in greater rate. In addition, high awareness and knowledge about water pollution and WWM shows the higher probability of WTP than ones who have lack of knowledge.

II. **Fiscal budget from central government is still needed for new facility.** This money is aimed to use to expand WWT capacity; collection network and WWT facilities, while WW charge could help supporting O&M costs.

III. **Department in charge for WWM should be authorised to make financial decision for O&M.** This could avoid the time of unserviceability and improve WWT performance. The department can fix the system failures immediately.

SWOT Analysis for rural city

Strength ● Cooperation between departments would be effective because almost all division work in the same area leading to less difficulties on communication. ● Local government is closed to residents	**Weakness** ● Residents have low average income and education level. ● WWTPs capital costs need to be supported by central government and it takes times
Opportunity ● Implementation of WW charge collection could be easy due to low rate of WW charge	**Threats** ● Low amount of WW charge collection due to low numbers of population. ● Some houses cannot access water supply system and water consumption cannot be monitored

Figure 4.13 SWOT analysis of rural city

Seeing that different characteristic of cities should have different implementation strategies accordingly to their local context. Recommendation of mentioned above can be summarise as follow.

Table 4.36 Recommendation for WW charge implementation by city characteristic

	City type	WW charge rate recommendation	Significant factors
1	Highly urbanised city	Uniform rate at 2.00 Baht/m^3 or fixed rate at 50-65 Baht/month/household	- Single house is an effective target
2	Coastal city/tourist dependence	Uniform rate at 3.50 Baht/m^3 or fixed rate at 50-110 Baht/month/household	- Property owner is an effective target
3	Rural city	Uniform rate at 1.00 Baht/m^3 or fixed rate at 10-30 Baht/month/household	- Integrated WWM knowledge into schooling system could be effective

Limitation of recommendation

The study is specifically scoped in residential sector. The recommendation is not only based on the results from the study, but also latently influenced by the local context of the case studies which differentiated by city size considered from population density and economic activities. Grouping municipalities by their characteristics could be differ from this study when other insight factors are taken into consideration locally. The recommendation based on the case studies is expected to be a guidance for similar cities where WWTPs are existing and WW charge collection is possibly capable. However, particular local context of each city is totally vital for consideration before applying WW charge strategy. To the real situation, administrative system, and public hearing and engagement from local residents as well as all stakeholders are necessary in order to avoid objection and reach favourable goal. Moreover, in different sectors such as commercial areas and

government offices, the recommended WW charge rate could be varied accordingly the load of WW generation and pollution effects.

Chapter 5
Conclusion

5.1 Current situation of WWM

The challenge of current situation of WWM in Thailand are (1) insufficient WWT capacity and (2) insufficient funding for operation and maintenance. All activities of WWM of all cities relies on fiscal budget allocation from local government and it is normally not enough for whole WWM activities especially for fixing the malfunction system. Although Tha Rae municipality can collect WW charge from residents, the collected money is returned to the division of finance not the division of public work which in charge for WWM directly. This make Tha Rae still rely on fiscal budget allocation as the other where WW charge have not been collected. WWM in these 3 case studies shows a chicken and egg situation. Lack of financial sources (WW charge collection) obstructs WWT capacity expansion as well as O&M causing poor water quality. On the other hand, lack of service provision, WW charge from residents could not be levied causing lack of budget for O&M and poor water quality as a consequence.

5.2 WTP estimation

In terms if WTP estimation, local context is matter to resident preferences significantly. Slightly less than a half of Bangkok and Pattaya respondents said “No” to WW charge while 80% of Tha Rae, Sakon Nakhon respondents said “Yes”.

Moreover, Cities with different characteristic have different factors affecting WTP and amount of wastewater charge preference. Therefore, different cities should not use the same strategies to implement WW charge policy or same WWM schemes. However, wastewater service perception is the only a common factor influencing WTP decision and pay-out level among these 3 case studies. The results show that

one who perceive that their houses are in WWT service area are not only more likely to pay WW charge rather than the others, but also pay-out at the higher rate. This can be claimed that WW service perception is one of crucial factors to be considered to increase success of WW charge policy implementation.

In addition, coastal city (water quality dependence) has the highest WTP pay-out level followed by urbanised city and rural city respectively. This is because water quality is crucial to economic activities in coastal city like Pattaya where 90% of economic is from seaside related hospitality business. Urbanised and rural city shows the different amount of WTP accordingly to residents' income and education level.

5.3 Recommendation for WWM scheme in different characteristic cities

Recommended WW charge rate

WW charge should levy in cities where WWTPs are available and WWM scheme should be differentiated by city characteristic. This includes rate of WW charge, collection method, WW charge collection spending activities and effective target of each different city. In urbanised city rate recommended is in between 50-65 Baht monthly or 2.00 Baht/m^3 of water consumption and the effective target is ones who live In detached house. In coastal city, WW charge recommend in between 50-110 Baht per month or 3.50 Baht/m^3 of water consumption. The effective target is property owner, and this shows that WW charge could be in the form of tax and paid via civil tax annually. In rural city, WW charge is possible to be as or "fixed rate" or "pay as you go". The recommended rate is in between 10-30 Baht monthly or 1.00 Baht/m^3 of water consumption.

Billing method

The billing WW charge together with water tariff bill is the most preferable method of all cities. This not only facilitates the payment, but also increase collection efficiency. However, this require cooperation between department in charge for water supply and the department in charge for WWM of each local municipality (e.g. BMA and MWA in Bangkok). This is the strength of small size municipality where all department is normally are in the same area and allow convenience for cooperation. On the other hand, this is one of a big challenge in a large city (e.g. Bangkok) where department are far apart and work independently. Moreover, the main place where WW charge should be spent for is O&M. This is because limited budget allocation directly affects operation performance and water quality as a consequence. Once WW charge can be collected fully, and expand the financial capacity for WWM, it could possibly use for other projects such as constructing new facilities, improving advance technology for recycling treated WW.

The Polluter pays in the form of WW charge as an economic-based instrument could play an important role in WWM in Thailand not only to gradually help local government to be independent from central government fiscal budget allocation for WWM, but also incentivise consumers to change their behaviour to reduce water consumption and pollution because the more water consumption, the more WW charge apply.

Appendix A summarise information of all WWTPs available in Thailand for more details.

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
1	CM	Chiang Mai	55,000	20,000 - 30,000	20	50	Department of Public Works and Town & Country Planning	1995	WMA	No	Malfuction
2	TM	Phayao	9,700	-	2.2	24.2	Department of Public Works and Town & Country Planning	1998	WMA	No	Normal
3	CM	Lampang	12,300	4,800	6.72	33	Ministry of Science and Technology	2005	WMA	No	Normal
4	CM	Mae Sod	11,000	6,000	10.88	40	Ministry of Science and Technology	2003	WMA	Yes	Normal
5	TM	Kamphaeng Phet	13,500	4,952.76	4.7	31.54	Ministry of Science and Technology	1995	WMA	No	Normal
6	CM	Udon Thani	45,000	12,000	8.3	17.4	National Environmental Fund	2010	WMA	in process	Normal
7	TM	Kalasin	14,000	8,700	6.8	40	N/A	2008	WMA	No	Normal
8	TM	Pak Chong	12,000	4,939	10	70	(phase1) (1) Office of Natural Resources and Environmental Policy and Planning and (2) Ministry of Science and Technology (phase2) (3) Local government	(1) 2002 (2) 2004	WMA	No	Normal
9	TM	Buri Ram	13,000	5,855	4.2	70	Department of Public Works and Town & Country Planning	2002	WMA	Yes	Normal
10	CM	Ubon Ratchathani	22,000	8,610	15	52	Ministry of Interior	1998	WMA	No	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
11	TM	Amnat Charoen	12,800	7,500	N/A	61	Local government	2006	WMA	no	Normal
12	TM	Mukdahan	8,500	6,039.03	8.4	24	Ministry of Science and Technology	2007	WMA	Yes	Normal
13	TM	Sriracha	18,000	11,088	2.153	80	Department of Public Works and Town & Country Planning	1997	WMA	In process	Normal
14	TM	Saensuk (South)	9,000	5,522.45	6.42	31.67	Department of Public Works and Town & Country Planning	1994	WMA	Yes	Normal
15	TM	Saensuk (North)	14,000	10,353.36	9.06	44.7	Department of Public Works and Town & Country Planning	1995	WMA	Yes	Normal
16	SM	Bang Saray	5,400	3,800	5.61	71	(1) Department of Local Administration and (2) Local government	2011	WMA	Yes	Normal
17	SM	Ban Phe	8,000	800-1,0000	9	30	(1) Department of Public Works and Town & Country Planning and (2) Department of Local Administration	1999-2011	WMA	Yes	Malfunction
18	TM	Map Ta Phut	15,000	1,900	30	20	Department of Public Works and Town & Country Planning	2001	WMA	No	Malfunction
19	TM	Cha-Am	17,000	2,173	10	9	(1) Department of Public Works and Town & Country Planning and (2) Ministry of Interior	2001	WMA	N/A	Normal
20	TM	Krabi	12,000	7,000	9.7	N/A	Department of Public Works and Town & Country Planning	2003	WMA	Yes	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
21	CM	Hat Yai	138,000	51,900	16.8	80	Local government and National Environmental Fund	2000	WMA	Yes	Normal
22	CM	Songkhla	35,000	15,000	7.42	90	(1) Department of Public Works and Town & Country Planning (2) Ministry of Interior and (3) Office of Natural Resources and Environmental Policy and Planning	2004	WMA	Yes	Mulfuction
23	TM	Sing Buri	4,500	1,500	4	51	Department of Public Works and Town & Country Planning	2001	WMA	No	Normal
24	TM	Ban Pong	5,000	3,000	3	N/A	Department of Public Works and Town & Country Planning	N/A	WMA	No	Mulfunction
25	TM	Kanchanaburi	24,000	8,000-10,000	7.32	80	Department of Public Works and Town & Country Planning	1996	WMA	N/A	Mulfunction
26	TM	Prachuab Khiri Khan	8,000	6,429.90	12	86	Ministry of Interior	1998	WMA	No	Malfunction
27	CM	Phitsanulok	25,000	N/A	13	N/A	Ministry of Interior	2003	WMA (63)	N/A	Malfunction
28	SAO	Ao Nang Phi Phi island	400	1,500-2,000	2	N/A	Denmark government	2004	WMA (63)	Yes	Malfunction
29	TM	Uthai Thani	5,000	4,768	6.2	85	Local government and Ministry of Natural Resources and Environment	1996	local	in process	Malfunction

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
30	TM	Lamphun	10,000	2,500	N/A	N/A	Ministry of Science and Technology	2003	revise	N/A	Malfunction
31	CM	Rayong	41,000	N/A	12	73	Department of Public Works and Town & Country Planning	1999	N/A	N/A	Broken down
32	SAO	Cherngtalay	2	557.83	4	10.781	National Environmental Fund	2017	Private	No	Malfunction
33	SAO	Cherngtalay	3	4765.6	5.24	14.119	National Environmental Fund	2017	Private	No	Malfunction
34	TM	Hua Hin (Phase 1)	8,000	6,200-6,500	1.1	3.7	Department of Public Works and Town & Country Planning	1991	Local	1.2 million/year	Broken down
35	TM	Hua Hin (Phase 2)	17,000	12,000 - 15,000	2.6	3.7	Department of Public Works and Town & Country Planning	2002	Local	N/A	Broken down
36	TM	Chum Saeng	1,650	200-250	1.2	50	National Environmental Fund	1998	N/A	No	Malfunction
37	TM	Taphan Hin	7,164	1,700	4.0731	78.29	(1) Ministry of Natural Resources and Environment and (2) Local government	2006	N/A	No	Malfunction
38	CM	Trang	17,700	4,218.25	10.27	60	N/A	1998	Local	No	Malfunction

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
39	SM	Salokbat	500	40-60	3.12	17.6	Department of Public Works and Town & Country Planning	2006	Local	Yes	Malfunction
40	TM	Khlung	4,500	2,500	2.4	80	Ministry of Science and Technology	2001	Local	No	Malfunction
41	SM	Tha Rae	2,054	831	1.49	67	National Environmental Fund	2000	Local	Yes	Malfunction
42	SM	Kosumphisai	1,500	200-300	1.5	N/A	N/A	N/A	Local	Yes	Malfunction
43	TM	Pattani	27,000	N/A	4.78	N/A	Local government	N/A	Local	No	Malfunction
44	CM	Nakhon Pathom	60,000	20,000	5.28	N/A	Department of Public Works and Town & Country Planning	1994	Local	No	Malfunction
45	CM	Laem Chabang	7,500	1,000	9.3	10	Department of Public Works and Town & Country Planning	1999	Local	No	Malfunction
46	TM	Yasothon	7,246	292.6	6.5	67	Local government	2006	Local	No	Malfunction
47	TM	Suphanburi	11,400	8,000	5.858	65	Department of Public Works and Town & Country Planning	2001	N/A	No	Normal
48	TM	Saraburi	9,000	6,000-8,000	5.6	33.7	Department of Public Works and Town & Country Planning	2013	Private	No	Normal
49	TM	Pa Tong	30,000	22,000	9.02	55	(1) Department of Public Works and Town & Country Planning	1988	Private	Yes	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
							and (2) National Environmental Fund				
50	SM	Karon	6,000	10,106	5	25	National Environmental Fund	2003	Private	Yes	Normal
51	CM	Phuket	36,000	26,580	10.8	85.99	(1) Department of Public Works and Town & Country Planning and (2) Ministry of Natural Resources and Environment	(1) 1997 (2) 2003	Private	No	Normal
52	CM	Sakon Nakhon	16,000	8,871	19.25	35	(1) Department of Fisheries (2) Royal Irrigation Department (3) Department of Public Works and Town & Country Planning	2004	N/A	N/A	Normal
53	CM	Nakhon Sawan	36,000	27,000	22.29	80	(1) Ministry of Natural Resources and Environment and (2) Local government	1979	N/A	In process	Normal
54	CM	Nonthaburi	38,500	17,000	11.2	28.8	Department of Public Works and Town & Country Planning	1998	Local	No	Normal
55	TM	Ratchaburi	15,000	7,000	8.26	19.4	Department of Public Works and Town & Country Planning	2001	Local	No	Normal
56	TM	Photharam	5,000	2,500-3,000	2.51	95	Department of Public Works and Town & Country Planning	1998	Local	No	Normal
57	TM	Petchburi	10,000	4,800	5.4	100	Local government	2010	Local	N/A	Normal
58	TM	Chachoengsao	24,000	16,000	11.56	90	(1) Department of Public Works and Town & Country Planning And (2) Ministry of Science and Technology	1998-2005	Local	N/A	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
59	CM	Khon Kaen	78,000	45,000	36	80	Ministry of Science and Technology	2002	Local	N/A	Normal
60	TM	Nan	8,259	5,000-6,000	5.4	71.05	Ministry of Science and Technology	1997	N/A	N/A	Normal
61	TM	Chaiyaphum	5,000	3,000-3,500	5.4	18	Department of Local Administration	2010	N/A	No	Normal
62	SM	Bang Khla	5,000	2,000	6.53	100	Local government	2008	N/A	No	Normal
63	TM	Chai Nat	7,200	4,200	4.12	67	(1) Department of Public Works and Town & Country Planning (2) Local government and (3) National Environmental Fund	1999, 2011, 2017	N/A	No	Normal
64	TM	Ang Thong	8,200	4,000	1.2	19.35	Local government	1992	N/A	No	Normal
65	Pattaya	Pattaya city (South)	43,000	19,897	12	22.5	Local government	2014	Private	Yes	Normal
66	CM	Samui Island (Chaweng)	6,000	5,225	1.5	0.6	Department of Public Works and Town & Country Planning	2004	Private	No	Normal
67	TM	Pathum Thani	11,000	1,200	11.8	N/A	Department of Public Works and Town & Country Planning	2002	Private	No	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
68	PAO	Chonburi	22,500	7,352	36	N/A	Local government	2001	Private	No	Normal
69	Pattaya	Pattaya City (North)	65,000	77,540	28.3	53	National Environmental Fund	2000	Private	Yes	Normal
70	CM	Samui island (Lamai beach)	8,600	7,143	2.9	1.15	Department of Public Works and Town & Country Planning	2004	Private	No	Normal
71	CM	Samui Island (Nathon beach)	2,400	2,358	1.6	63	Department of Public Works and Town & Country Planning	2003	Private	No	Normal
72	TM	Chanthaburi	17,000	8,000	6.15	60	Local government	1996	Local	No	Normal
73	TM	Tak	5,400	2,088	N/A	20	(1) Office of Natural Resources and Environmental Policy and Planning and (2) Ministry of Science and Technology	1999	Local	No	Normal
74	TM	Maha Sarakham	4,200	4,200	N/A	N/A	(1) Ministry of Natural Resources and Environment and (2) Local government	2008	Local	No	Normal
75	SM	Tha Tum	500	350	1.8	80.35	(1) Office of Natural Resources and Environmental Policy and Planning and (2) Ministry of Science and Technology	2013	Local	No	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
76	TM	Panas Nikom	4,200	1,800	N/A	90	(1) Local government and (2) National Environmental Fund	2019	Local	In process	Normal
77	SM	Ban Tai ((Pha-ngan island)	300	120-180	3	3.75	Tourism Authority of Thailand	1998	Local	No	Normal
78	CM	Nakhon Si Thammarat	33,700	20,000	11	50	Local government	2014	Local	No	Normal
79	CM	Thung Song	10,000	7,000	3.5	48	Office of Natural Resources and Environmental Policy and Planning	2009	Local	No	Normal
80	CM	Phra Nakhon Si Ayutthaya	24,000	12,000 - 15,000	8	54	(1) Department of Public Works and Town & Country Planning and (2) Ministry of Science and Technology	1998	Local	No	Normal
81	SM	Phra in Thra Cha	3,000	72,000	1.17	28.96	Ministry of Science and Technology	1999	Local	No	Broken down
82	TM	Ban Mi	1,000	600	0.47	70	Local government	1993	Local	No	Normal
83	SM	Kutchik	400	240	4	70	National Environmental Fund	2014	Local	Yes (10Baht/ month)	Normal
84	TM	Surin	13,600	11,000	6.8	60	Local government	2008	Local	No	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
85	TM	Nakhon Phanom	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
86	CM	Nakhon Ratchasima	75,000	35,000	33.3	89	Ministry of Natural Resources and Environment	1990	Local	No	Malfunction
87	SM	U Thong	5,500	900	1.3	76	Department of Public Works and Town & Country Planning	2991	Local	No	Malfunction
88	CM	Yala (Wat Yala Thammaram)	4,600	3,060	2.45	12.89	Local government	2008	Local	No	Malfunction
89	CM	Chiang Rai	27,200	15,000	9	15	(1) Department of Public Works and Town & Country Planning and (2) Ministry of Natural Resources and Environment	2003-2004	Local	No	Normal
90	TM	Warin Chamrap	18,000	10,000	10	80	Ministry of Science and Technology	2002	N/A	No	Normal
91	TM	Bua Yai	3,000	2,700	1.2076	11	Department of Local Administration	2008	Local	No	Normal
92	TM	Sukhothai Thani	8,400	3,014	2.94	84	Ministry of Science and Technology	2002	Local	No	Normal
93	TM	Kathu	6,130	5,000	5	60	Deprtment of Environmental Quality Promotion	2008	N/A	Yes	Normal
94	CM	Yala	3,200	2,130	1.45	7.63	Local government	2008	Local	No	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
		(Rubber Plant)									
95	TM	Phichit	12,000	4,000-5,000	10.81	90	Department of Public Works and Town & Country Planning	1997	N/A	No	Normal
96	TM	Chumphon	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
97	SM	Khlong Dan	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
98	BMA	Si Phraya	30,000	12,475	2.7	N/A	BMA	1994	Local	No	Normal
99	BMA	Ratanakosin	40,000	17,173	4.1	N/A	BMA	2000	Local	No	Normal
100	BMA	Chong Nonsi	200,000	124,278	28.5	N/A	BMA	1999	Local	No	Normal
101	BMA	Thung Kru	65,000	63,796	42	N/A	BMA	2002	Private	No	Normal
102	BMA	Nong Khaem	157,000	142,170	44	N/A	BMA	2002	Private	No	Normal
103	BMA	Chatuchak	150,000	146,053.59	33.4	N/A	BMA	2005	Private	No	Normal
104	BMA	Din Daeng	350,000	221,245	37	N/A	BMA	2004	Private	No	Normal
105	BMA	Bang Sue	120,000	122,95	20.7	N/A	BMA	2013	Private	No	Normal

No.	Local Administration		WWT Capacity (m^3/d)	Avg Influent (m^3/d)	Service area (km^2)	WW collection coverage area (%)	Financial sources for capital investment	Year of completion	Operator	WW charge	WWT status
				7							

BMA = Bangkok Metropolitan Administration
WMA = Wastewater Management Authority
CM = City Municipality
TM = Town Municipality
SM = Subdistrict Municipality
PAO = Provincial Administration Organisation
SAO = Subdistrict Administration Organisation
Local = Local government
Private = Private sector

Appendix B: Questionnaire example

<u>แบบสอบถามเรื่องความยินดีที่จะจ่าย</u>
<u>ในการปรับปรุงคุณภาพแหล่งน้ำในชุมชน</u>

เป้าหมายที่ต้องการศึกษา: ครัวเรือนที่ปล่อยน้ำเสียจากการใช้น้ำประปา<u>ประเภทที่อยู่อาศัย</u>ที่อยู่ในพื้นที่ **กรุงเทพมหานคร**

เวลาที่ใช้ในการทำแบบสอบถาม: 10-15 นาที

<u>คำชี้แจงแบบสอบถาม</u>

แบบสอบถามนี้เป็นส่วนหนึ่งของงานวิจัยในระดับวิศวกรรมศาสตร์ดุษฎีบัณฑิต คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย โดยมีวัตถุประสงค์เพื่อประเมินความเต็มใจจ่ายในการปรับปรุงคุณภาพแหล่งน้ำใน**ชุมชน** ในรูปแบบ<u>ค่าธรรมเนียมการจัดการน้ำเสีย</u> ผลงานวิจัยมีเป้าหมายในการนำไปใช้เป็นแนวทางและสร้างข้อเสนอแนะในการปรับปรุง<u>ระบบการจัดการน้ำเสียส่วนกลางของชุมชน</u>ให้มีประสิทธิภาพมากขึ้นในอนาคต

ข้อมูลที่ได้จากการตอบแบบสอบถามนี้ถือว่า<u>เป็นความลับ</u> ซึ่งผู้วิจัยจะทำการประมวลผลตามแผนวิธีการศึกษาของงานวิจัย จึงขอความอนุเคราะห์จากท่านโดยช่วยให้ข้อมูลที่ตรงกับความเป็นจริง เพื่อให้ผลการวิจัยตรงกับความเป็นจริงมากที่สุด เพื่อจะได้นำไปใช้ในการพัฒนาแนวทางการแก้ไขปัญหาให้เกิดผลสัมฤทธิ์ได้จริง

ด้วยความนับถือ

ขวัญมนัส มีถาวร
นิสิตปริญญาเอก
ภาควิชาวิศวกรรมสิ่งแวดล้อม คณะวิศวกรรมศาสตร์
จุฬาลงกรณ์มหาวิทยาลัย

ส่วนที่ 1 ข้อมูลของผู้ตอบแบบสอบถาม

1.1 เพศ

( ) ชาย ( ) หญิง

1.2 อายุ

( ) ต่ำกว่า 19 ปี ( ) 20-39 ปี ( ) 40-60 ปี ( ) มากกว่า 60 ปี

1.3 อาชีพ

( ) นักเรียน/นักศึกษา ( ) ข้าราชการ/พนักงานราชการ
( ) พนักงานรัฐวิสาหกิจ ( ) พนักงานบริษัทเอกชน
( ) ธุรกิจส่วนตัว ( ) แม่บ้าน
( ) เกษตรกร ( ) เกษียณอายุ/ว่างงาน ( ) อื่น ๆ.....

1.4 การศึกษาสูงสุด

( ) ต่ำกว่า ม.3 ( ) ม.3 - ม.6/ปวช.
( ) อนุปริญญา/ปวส. ( ) ปริญญาตรี
( ) ปริญญาโท ( ) ปริญญาเอก

1.5 จำนวนสมาชิกในครัวเรือน ..... คน (รวมตัวท่านด้วย)

1.6 รายได้/เดือน (ของผู้ตอบแบบสอบถาม)

( ) น้อยกว่า 8,000 บาท ( ) 8,000 – 15,000 บาท
( ) 15,001 – 25,000 บาท ( ) 25,001 – 50,000 บาท
( ) 50,001 – 80,000 บาท ( ) มากกว่า 80,000 บาท

ส่วนที่ 2 ลักษณะที่อยู่อาศัยและการใช้ประโยชน์

2.1 ลักษณะบ้าน

( ) ห้องชุด (คอนโดมิเนียม อพาร์ทเมนท์)

( ) บ้านเดี่ยว (บ้านโดด)

( ) ทาวเฮ้าส์/ทาวโฮม/บ้านแฝด

( ) ตึกแถว

( ) อื่น ๆ ระบุ.....

2.2 ความเป็นเจ้าของบ้าน

( ) เจ้าบ้าน ( ) อยู่อาศัย ( ) เช่าอยู่อาศัย ( ) อื่น ๆ ระบุ.....

ส่วนที่ 3 ค่าใช้จ่ายสำหรับน้ำประปา

3.1 ท่านมีหน้าที่รับผิดชอบค่าใช้จ่ายสำหรับน้ำประปา ด้วยตัวท่านเองหรือไม่

( ) ใช่ ( ) ไม่ใช่

3.2 รอบบิลชำระค่าน้ำประปาของท่านคือ

( ) 1 เดือน/รอบบิล

( ) 3 เดือน/รอบบิล

( ) อื่น ๆ ระบุ.....

3.3 ท่านมีค่าใช้จ่ายสำหรับค่าน้ำประปาต่อรอบบิลอยู่ในช่วงใด

( ) น้อยกว่า 50 บาท ( ) 50-100 บาท

( ) 101-150 บาท ( ) 151-200 บาท

( ) 201-250 บาท ( ) 251-300 บาท

( ) 301-400 บาท ( ) 401-500 บาท

( ) มากกว่า 500 บาท ระบุ ..... บาท

( ) ไม่ทราบ

ส่วนที่ 4 <u>ความกังวล</u>ต่อปัญหาสิ่งแวดล้อมในชีวิตประจำวัน

4.1 โปรด<u>เรียงลำดับ</u>ความกังวลในประเด็นต่อไปนี้ 3 ลำดับแรก โดยใส่หมายเลข 1-3 ลงในกล่องด้านหน้า

☐ ปัญหารถติด	☐ น้ำท่วม
☐ น้ำเสีย/มลพิษทางน้ำ	☐ มลพิษทางเสียง
☐ มลพิษทางอากาศ	☐ ขยะ/หลุมฝังกลบขยะ
☐ การตัดไม้ทำลายป่า	☐ อื่น ๆ ระบุ.....

ส่วนที่ 5 <u>ความรู้</u>เกี่ยวกับการจัดการน้ำเสียจากภาคครัวเรือน

5.1 โปรดแสดงความคิดเห็นโดยใส่เครื่องหมาย ✓ ลงในช่องว่างตามรายการด้านล่าง จาก 1 (ไม่เห็นด้วยอย่างยิ่ง) ถึง 5 (เห็นด้วยอย่างยิ่ง)

ความคิดเห็น	ระดับความคิดเห็น				
	5 เห็นด้วยอย่างยิ่ง	4 เห็นด้วย	3 เฉย ๆ	2 ไม่เห็นด้วย	1 ไม่เห็นด้วยอย่างยิ่ง
5.1.1 น้ำที่ผ่านการใช้งาน เป็นน้ำเสียควรได้รับการบำบัดก่อนปล่อยสู่แหล่งน้ำสาธารณะ					
5.1.2 ระบบบำบัดน้ำเสียช่วยทำให้แม่น้ำลำคลองมีคุณภาพดีขึ้น					
5.1.3 ระบบบำบัดน้ำเสียมีค่าใช้จ่ายในการสร้าง และดำเนินงานสูง					
5.1.4 การประหยัดน้ำเป็นการช่วยลดปริมาณน้ำเสียที่มาจากภาคครัวเรือน					
5.1.5 การแก้ปัญหาการจัดการน้ำเสียอย่างยั่งยืนเกิดจากการมีส่วนร่วมของประชาชน					

5.2 ชุมชนของท่านอยู่ในพื้นที่รับบริการการบำบัดน้ำเสียส่วนกลางใช่หรือไม่

( ) ใช่ ( ) ไม่ใช่ ( ) ไม่ทราบ

ส่วนที่ 6 พฤติกรรมที่เป็นมิตรต่อสิ่งแวดล้อมในประเด็นของการจัดการน้ำเสียจากภาคครัวเรือน

6.1 โปรดแสดงความคิดเห็นโดยใส่เครื่องหมาย ✓ ลงในช่องว่างตามรายการด้านล่าง จาก 1 (น้อยที่สุด) ถึง 5 (มากที่สุด)

พฤติกรรม	ความคิดเห็น				
	5 มากที่สุด	4 มาก	3 ปานกลาง	2 น้อย	1 น้อยที่สุด
6.1.1 ท่านทิ้งขยะ หรือของเสียอื่น ๆลงแม่น้ำลำคลองโดยตรง					
6.1.2 ท่านใช้น้ำอย่างประหยัด เช่น ปิดน้ำทุกครั้งหลังใช้งาน เป็นต้น					
6.1.3 ท่านใช้สุขภัณฑ์ประหยัดน้ำ เช่น โถสุขภัณฑ์ ก๊อกน้ำ ฝักบัว เป็นต้น					
6.1.4 บ้านของท่านติดตั้งบ่อบำบัดน้ำเสียเบื้องต้น ก่อนปล่อยลงคลอง/แม่น้ำโดยตรง เช่น บ่อเกรอะ เป็นต้น					
6.1.5 ท่านมีการรีไซเคิลน้ำภายในครัวเรือน เช่น นำน้ำซักผ้ามารดน้ำต้นไม้ เป็นต้น					

ส่วนที่ 7 ผลกระทบจากน้ำเสียในการดำเนินกิจกรรมประจำวัน

7.1 โปรดให้คะแนนระดับผลกระทบที่ท่านได้รับจากแหล่งน้ำสาธารณะมีสภาพเน่าเสียต่อชีวิตประจำวันของท่านในแต่ละด้านต่อไปนี้

โดยใส่เครื่องหมาย ✓ ลงในช่องว่างตามรายการด้านล่าง จาก 1 (น้อยที่สุด) ถึง 5 (มากที่สุด)

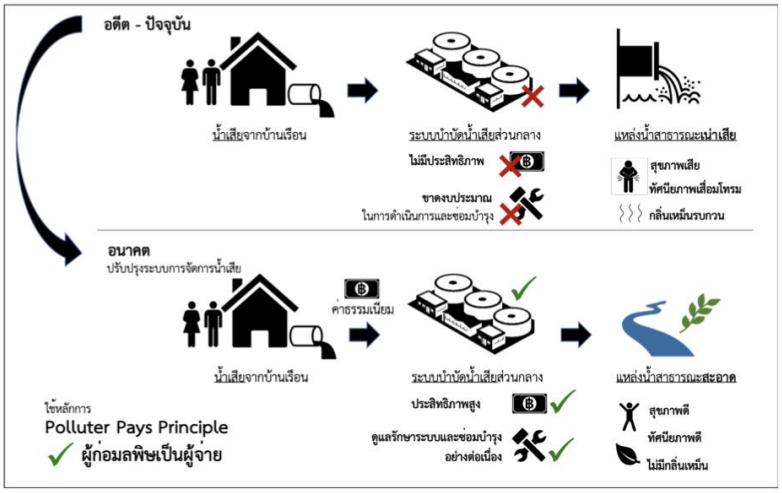
ผลกระทบ	ระดับผลกระทบ				
	5 มากที่สุด	4 มาก	3 ปานกลาง	2 น้อย	1 น้อยที่สุด
7.1.1 กลิ่นเหม็นรบกวน					
7.1.2 ทัศนียภาพเสื่อมโทรม					
7.1.3 ส่งผลเสียต่อสุขภาพ					
7.1.4 มูลค่าที่ดิน/สิ่งปลูกสร้าง					
7.1.5 การลดลงของสัตว์น้ำในแม่น้ำ					

ส่วนที่ 8 การสำรวจความยินดีที่จะจ่ายในการปรับปรุงคุณภาพแหล่งน้ำในชุมชน

คำชี้แจง

ประเทศไทยมีปัญหาคุณภาพแหล่งน้ำเสื่อมโทรมต่อเนื่องเป็นระยะเวลานานกว่า 30 ปี จึงได้มีการก่อสร้างระบบบำบัดน้ำเสียส่วนกลางของชุมชนกว่า 100 แห่งทั่วประเทศ ด้วยงบประมาณของรัฐบาลที่ใช้ในการก่อสร้างและดำเนินการไปแล้วกว่า 83,000 ล้านบาท เพื่อบำบัดน้ำเสียก่อนปล่อยลงสู่แหล่งน้ำสาธารณะ ซึ่งนำไปสู่การลดปัญหาและป้องกันการเกิดแหล่งน้ำเสื่อมโทรม

อย่างไรก็ตาม การดำเนินการจัดการน้ำเสียยังไม่เพียงพอและไม่ได้ประสิทธิภาพเท่าที่ควร เนื่องจากระบบบำบัดน้ำเสียมีมูลค่าการลงทุน และค่าใช้จ่ายในการดำเนินงานสูง ดังนั้น การนำนโยบายตามหลักการ **"ผู้ก่อมลพิษเป็นผู้จ่าย (Polluter Pays Principle)"** หรือ ผู้ใดก่อให้เกิดมลพิษ ผู้นั้นจะต้องรับผิดชอบต่อการจัดการมลพิษนั้น ๆ โดยการจ่ายค่าธรรมเนียมการจัดการน้ำเสีย จึงได้รับการยอมรับและนำมาใช้ในหลายภาคส่วน ซึ่งหลักการนี้ได้ถูกพิสูจน์ในหลายประเทศที่ดำเนินการสำเร็จ และพบว่าสามารถแก้ไขปัญหาและเพิ่มประสิทธิภาพระบบการจัดการน้ำเสียได้จริง เพราะสามารถนำค่าธรรมเนียมที่จัดเก็บได้มาใช้ในการบริการจัดการน้ำเสียได้ตรงจุดประสงค์อย่างเต็มประสิทธิภาพ เช่น การเพิ่มโครงข่ายท่อรวบรวมน้ำเสียเพื่อให้บริการทั่วถึงทุกครัวเรือน และการเพิ่มปริมาณการรองรับน้ำเสียของโรงบำบัดแต่ละแห่ง เป็นต้น โดยการจัดเก็บค่าธรรมเนียมการจัดการน้ำเสียนี้สามารถลดการพึ่งพาเงินภาษีจากงบประมาณแผ่นดินจากส่วนงานอื่นเพื่อนำมาอุดหนุนในการดำเนินการการจัดการน้ำเสีย ดังแสดงในภาพที่ 8.1



ภาพที่ 8.1 การเพิ่มประสิทธิภาพระบบการจัดการน้ำเสียชุมชนด้วยหลักการผู้ก่อมลพิษเป็นผู้จ่าย

(สำคัญ)

เหตุการณ์สมมติ

หากมีการ**จัดเก็บ**ค่าธรรมเนียมการจัดการน้ำเสียเป็นรายเดือนและนำมาใช้ในการจัดการน้ำเสียโดยตรง เพื่อเพิ่มคุณภาพแหล่งน้ำสาธารณะ ไม่ว่าจะเป็นคลอง หรือแม่น้ำ มีผลให้แหล่งน้ำมี**คุณภาพดีขึ้น**และ**ได้มาตรฐาน**ตามที่กฎหมายกำหนด ทัศนียภาพโดยรอบดีขึ้น ไม่มีกลิ่นเหม็นรบกวน และไม่ส่งผลเสียต่อสุขภาพประชาชน

8.1 ท่านจะยินดีจ่ายค่าธรรมเนียมหรือไม่

( ) ยินดี (ทำข้อ 8.2)

( ) ไม่ยินดี

เพราะเหตุใดท่านถึงไม่ยินดีจ่ายค่าธรรมเนียมการจัดการน้ำเสีย (ตอบได้มากกว่า 1 ข้อ)

(ตอบแล้วข้ามไปทำข้อ 8.5)

( ) ไม่มีเงินจ่าย

( ) ค่าการจัดการน้ำเสียรวมอยู่ในภาษีอื่น ๆ แล้ว เช่น ภาษีโรงเรือน เป็นต้น

( ) การจัดการน้ำเสียควรเป็นหน้าที่ของรัฐบาล

( ) ไม่เชื่อว่าเงินที่จัดเก็บจะนำไปปรับปรุงประสิทธิภาพการจัดการได้จริง

( ) ไม่ได้คิดว่าน้ำเสียเป็นปัญหา

( ) มีความเป็นห่วงเรื่องประสิทธิภาพ/ความโปร่งใสของการใช้งบประมาณ

( ) อื่น ๆ ระบุ.....

8.2 อัตราค่าธรรมเนียม**สูงสุด**ที่ท่านเต็มใจจ่ายค่าธรรมเนียมการจัดการน้ำเสีย ในการปรับปรุงคุณภาพแหล่งน้ำในชุมชน โดย**เพิ่มจาก**ค่าน้ำอุปโภค/บริโภค (น้ำประปา) เป็นจำนวนเงิน .....บาท/เดือน/ครัวเรือน

8.3 เพราะเหตุใดท่านถึงยินดีจ่ายค่าธรรมเนียมการจัดการน้ำเสียด้วยจำนวนเงินข้างต้น (ตอบได้มากกว่า 1 ข้อ)

( ) ระบบบำบัดน้ำเสียมีความสำคัญในการแก้ปัญหาน้ำเสียหรือมลพิษทางน้ำ

( ) เป็นความรับผิดชอบต่อการก่อให้เกิดน้ำเสียจากกิจกรรมในครัวเรือน

( ) อยากมีส่วนร่วมในการปรับปรุงคุณภาพแหล่งน้ำสาธารณะ

( ) เป็นการอนุรักษ์ทรัพยากรน้ำเพื่อใช้ในอนาคต

( ) อื่น ๆ ระบุ.....

8.4 การแจ้งการจัดเก็บค่าธรรมเนียมการจัดการน้ำเสียควรอยู่ในรูปแบบใด (เลือก 1 ข้อเท่านั้น)

( ) บิลเดียวกันกับค่าน้ำประปา (แจกแจงรายการ ค่าน้ำประปา และค่าจัดการน้ำเสีย)

( ) แยกบิลกับค่าน้ำประปา

( ) รวมไปในค่าน้ำประปา (น้ำประปาราคาสูงขึ้น)

( ) รวมไปในการเรียกเก็บภาษี เช่น ภาษีโรงเรือนและที่ดิน เป็นต้น

( ) อื่น ๆ ระบุ.....

8.5 หากมีการจัดเก็บค่าธรรมเนียมการจัดการน้ำเสียตามปริมาณการใช้น้ำประปาของท่าน ท่านจะใช้น้ำ**ประหยัด**ขึ้นหรือไม่

( ) ใช่ ( ) ไม่ใช่ ( ) ขึ้นอยู่กับค่าธรรมเนียม

8.6 ข้อเสนอแนะอื่น ๆ ในการเพิ่มคุณภาพแหล่งน้ำสาธารณะ (หากมี)

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ขอบพระคุณเป็นอย่างสูงค่ะ

Appendix C: Water tariff and Wastewater charge of Residence (Tha Rae Municipality, Sakon Nakhon)

Table C-1: Water Tariff and Wastewater charge, Tha Rae, Sakon Nakhon

Water Tariff of Residence (Tha Rae Municipality, Sakon Nakhon) *(ref. from memorandum of water supply department, Tha Rae, Sakon Nakhon)*		
Water usage (cu.m.)	Water tariff (Baht/cu.m.)	Wastewater charge (Baht/cu.m.)
0 - 15	6.00	1.00
16 - 30	7.00	
31 - 45	8.00	
46 - 60	9.00	
61 - 75	12.00	
75 - 100	15.00	
> 100	20.00	
Metered-Service fee = 10.00 Baht		

Table C-2: wastewater charge schedule of Tha Rae, Sakon Nakhon

B.E.	Rate of wastewater charge (Baht/m^3.)			
	Residential	Commercial	Hotel	Industrial
2550-2554	1.00-2.50	1.50-3.00	2.00-3.00	3.00-3.50
2555-2559	1.50-3.00	2.00-3.50	2.50-3.50	3.50-4.00
2560-2564	2.00-3.50	2.50-4.00	3.00-4.00	4.00-4.50

Appendix D: List of Highly urbanised city

No.	Local Administration System	Name of local administration/ WWTPs	Province
1	BMA	Si Phraya	Bangkok
	BMA	Chong Nonsi	Bangkok
	BMA	Ratanakosin	Bangkok
	BMA	Thung Kru	Bangkok
	BMA	Nong Khaem	Bangkok
	BMA	Chatuchak	Bangkok
	BMA	Din Daeng	Bangkok
	BMA	Band Sue	Bangkok
2	City Municipality	Chiang Rai	Chiang Rai
3	City Municipality	Chiang Mai	Chiang Mai
4	City Municipality	Lampang	Lampang
5	City Municipality	Phitsanulok	Phitsanulok
6	City Municipality	Mae Sod	Tak
7	City Municipality	Nakhon Sawan	Nakhon Sawan
8	City Municipality	Sakon Nakhon	Sakon Nakhon
9	City Municipality	Udon Thani	Udon Thani
10	City Municipality	Khon Kaen	Khon Kaen
11	City Municipality	Nakhon Ratchasima	Nakhon Ratchasima
12	City Municipality	Ubon Ratchathani	Ubon Ratchathani
13	City Municipality	Laem Chabang	Chonburi
14	City Municipality	Rayong	Rayong
15	City Municipality	Nakhon Si Thammarat	Nakhon Si Thammarat
16	City Municipality	Thung Song	Nakhon Si Thammarat
17	City Municipality	Trang	Trang
18	City Municipality	Hat Yai	Songkhla
19	City Municipality	Songkhla	Songkhla
20	City Municipality	Yala (Rubber plant)	Yala
	City Municipality	Yala (Wat Yala Thammaram)	Yala
21	City Municipality	Nakhon Pathom	Nakhon Pathom
22	City Municipality	Nonthaburi	Nonthaburi
23	City Municipality	Phra Nakhon Si Ayutthaya	Phra Nakhon Si Ayutthaya
24	PAO	Chonburi	Chonburi

Appendix E: Lists of Seaside city

No.	Local Administration System	Name of Local administration/WWTPs	Province
1	Pattaya City	Pattaya city (South)	Chonburi
	Pattaya City	Pattaya City (North)	Chonburi
2	Town Municipality	Saensuk (South)	Chonburi
	Town Municipality	Saensuk (North)	Chonburi
3	Subdistrict Municipality	Ban Tai (Pha-ngan island)	Surat Thani
4	City Municipality	Samui island (Lamai beach)	Surat Thani
	City Municipality	Samui Island (Nathon)	Surat Thani
	City Municipality	Samui Island (Chaweng beach)	Surat Thani
5	Subdistrict Municipality	Karon	Puket
6	City Municipality	Phuket	Puket
7	Town Municipality	Pa Tong	Puket
8	Town Municipality	Kathu	Puket
9	SAO	Cherngtalay (Surin beach)	Phuket
	SAO	Cherngtalay (Bang Tao beach)	Phuket
10	SAO	Ao Nang (Phi Phi island)	Krabi
	SAO	Ao Nang ((Khlong Chak)	Krabi
11	Town Municipality	Cha-Am	Petchaburi
12	Town Municipality	Hua Hin (Phase 1)	Prachuab Khiri Khan
	Town Municipality	Hua Hin (Phase 2)	Prachuab Khiri Khan
13	Subdistrict Municipality	Ban Phe	Rayong

Appendix F: Lists of Rural city

No.	Local Administration System	Name of local administration/WWTPs	Province
1	Subdistrict Municipality	Salokbat	Kamphaeng Phet
2	Subdistrict Municipality	Tha Rae	Sakon Nakhon
3	Subdistrict Municipality	Kosumphisai	Maha Sarakham
4	Subdistrict Municipality	Kutchik	Nakhon Ratchasima
5	Subdistrict Municipality	Tha Tum	Surin
6	Subdistrict Municipality	Bang Saray	Chonburi
7	Subdistrict Municipality	Bang Khla	Chachoengsao
8	Subdistrict Municipality	U Thong	Suphan Buri
9	Subdistrict Municipality	Phra in Thra Cha	Phra Nakhon Si Ayutthaya
10	Subdistrict Municipality	Khlong Dan	Samut Prakan
11	Town Municipality	Lamphun	Lamphun
12	Town Municipality	Phayao	Phayao
13	Town Municipality	Sukhothai Thani	Sukhothai
14	Town Municipality	Phichit	Phichit
15	Town Municipality	Nan	Nan
16	Town Municipality	Taphan Hin	Phichit
17	Town Municipality	Chum Saeng	Nakhon Sawan
18	Town Municipality	Tak	Tak
19	Town Municipality	Kamphaeng Phet	Kamphaeng Phet
20	Town Municipality	Uthai Thani	Uthai Thani
21	Town Municipality	Nakhon Phanom	Nakhon Phanom
22	Town Municipality	Maha Sarakham	Maha Sarakham
23	Town Municipality	Chaiyaphum	Chaiyaphum
24	Town Municipality	Kalasin	Kalasin
25	Town Municipality	Bua Yai	Nakhon Ratchasima
26	Town Municipality	Buri Ram	Buri Ram
27	Town Municipality	Surin	Surin
28	Town Municipality	Warin Chamrap	Ubon Ratchathani
29	Town Municipality	Yasothon	Yasothon
30	Town Municipality	Amnat Charoen	Amnat Charoen
31	Town Municipality	Mukdahan	Mukdahan
32	Town Municipality	Panas Nikom	Chonburi
33	Town Municipality	Sriracha	Chonburi
34	Town Municipality	Map Ta Phut	Rayong
35	Town Municipality	Chanthaburi	Chanthaburi
36	Town Municipality	Khlung	Chanthaburi

No.	Local Administration System	Name of local administration/WWTPs	Province
37	Town Municipality	Chachoengsao	Chachoengsao
38	Town Municipality	Chumphon	Chumphon
39	Town Municipality	Krabi	Krabi
40	Town Municipality	Pattani	Pattani
41	Town Municipality	Chai Nat	Chai Nat
42	Town Municipality	Suphan Buri	Suphan Buri
43	Town Municipality	Sing Buri	Sing Buri
44	Town Municipality	Ang Thong	Ang Thong
45	Town Municipality	Pathum Thani	Pathum Thani
46	Town Municipality	Ban Mi	Lopburi
47	Town Municipality	Saraburi	Saraburi
48	Town Municipality	Ratchaburi	Ratchaburi
49	Town Municipality	Ban Pong	Ratchaburi
50	Town Municipality	Photharam	Ratchaburi
51	Town Municipality	Kanchanaburi	Kanchanaburi
52	Town Municipality	Petchburi	Petchaburi
53	Town Municipality	Prachuab Khiri Khan	Prachuab Khiri Khan
54	Town Municipality	Pak Chong	Nakhon Ratchasima

Appendix G: Statistical data of respondents

Gender						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	243	37.1	227	40.4	171	37.5
Female	412	62.9	335	59.6	285	62.5
Total	655	100	562	99.5	456	100
Missing	0	0	3	0.5	0	0
Total	655	100	565	100	456	100

Age						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
19 and lower	25	3.8	120	21.2	23	5.0
20-39	249	38	230	40.7	165	36.2
40-60	266	40.6	174	30.8	189	41.4
greater than 60	115	17.6	24	4.2	79	17.3
Total			548	97.0	456	100
Missing	0	0	17	3.0	0	0
Total	655	100	565	100	456	100

Occupation						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Student	67	10.2	131	23.2	37	8.1
Government officer	55	8.4	57	10.1	31	6.8
Public enterprise	24	3.7	46	8.1	11	2.4
Private company	160	24.4	129	22.8	31	6.8
Business own	175	26.7	118	20.9	138	30.3
Agriculture	0	0	56	9.9	85	18.6
Housewife	67	10.2	8	1.4	62	13.6
Retirement	85	13	13	2.3	35	7.7
Others	22	3.4	5	0.9	26	5.7
Total	655	100	563	99.6	456	100
Missing	0	0	2	0.4	0	0
Total	655	100	565	100	456	100

Education						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Lower than M3	153	23.4	85	15.0	200	43.9
M3-M6	182	27.8	234	41.4	156	34.2
Certificate	29	4.4	70	12.4	25	5.5
Bachelor	137	36.2	145	25.7	66	14.5
Master	51	7.8	24	4.2	7	1.5
Doctoral	3	0.5	2	0.4	2	0.4
Total	655	100	560	99.1	456	100
Missing	0	0	5	0.9	0	0
Total	655	100	565	100	456	100

M3 = 9 years of schooling (Matthayom3)

M6 = 12 years of schooling (Matthayom6)

Income (monthly)						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
less than 8000	81	12.4	125	22.1	224	49.1
8000-15000	197	30.1	128	22.7	144	31.6
15001-25000	172	26.3	149	26.4	46	10.1
25001-50000	143	21.8	121	21.4	33	7.2
50001-80000	29	4.4	18	3.2	5	1.1
Greater than 80000	33	5	9	1.6	4	0.9
Total	655	100	550	97.3	456	100
Missing	0	0	15	2.7	0	0
Total	655	100	565	100	456	100

Number of household member						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
1	20	3.1	62	11.0	30	6.6
2	91	13.9	67	11.9	70	15.4
3	142	21.7	86	15.2	81	17.8
4	166	25.3	112	19.8	123	27.0
5	121	18.5	53	9.4	78	17.1
6	49	7.5	22	3.9	36	7.9
7	21	3.2	14	2.5	19	4.2
8	13	2	2	0.4	12	2.6
9	4	0.6	1	0.2	4	0.9
10	5	0.8	2	0.4	2	0.4
11	2	0.3	0	0	0	0
12	1	0.2	0	0	0	0
13	1	0.2	0	0	0	0
14	2	0.3	0	0	1	0.2
15	2	0.3	0	0	0	0
16	1	0.2	0	0	0	0
Total	641	97.9	421	74.5	0	0
Missing	14	2.1	144	25.5	0	0
Total	655	100	565	100	456	100

Type of residence						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Condominium/Apartment	91	13.9	105	18.6	4	0.9
Single house	237	36.2	189	33.5	425	93.2
Townhouse	111	16.9	84	14.9	5	1.1
Shop house	215	32.8	187	33.1	19	4.2
Others	1	0.2	0	0	3	0.7
Total	655	100	565	100	456	100

Residence ownership						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	226	34.5	131	23.2	189	41.4
No	316	48.2	165	29.2	246	53.9
Rent	113	17.3	269	47.6	21	4.6
Total	655	100	565	100	456	100

Water bill costs (monthly)						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
less than 50	8	1.2	5	0.9	18	3.9
50-100	31	4.7	16	2.8	99	21.7
101-150	57	8.7	38	6.7	139	30.5
151-200	83	12.7	52	9.2	73	16.0
201-250	82	12.5	87	15.4	36	7.9
251-300	117	17.9	66	11.7	38	8.3
301-400	98	15	81	14.3	20	4.4
401-500	93	14	78	13.8	21	4.6
>500	62	9.6	105	18.6	3	0.7
No information	24	3.7	36	6.4	9	2.0
Total	655	100	564	99.8	456	100
Missing	0	0	1	0.2	0	0
Total	655	100	565	100	456	100

WW service perception						
	Bangkok		Pattaya		Tha Rae	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	64	9.8	157	27.8	356	78.1
No	87	13.3	133	23.5	48	10.5
Don't know	504	76.9	275	48.7	52	11.4
Total	655	100	565	100	456	100

Appendix H: WW charge schedule of Bangkok, Pattaya and Tha Rae

Table H-1: wastewater charge schedule of Bangkok

Type of wastewater source	Rate of wastewater charge (Baht/m^3)
Type 1: Living residence	2.0
Type 2: Government organisation Religion place Hospital School/Educational institutes Apartment/Condominium Commercial building (WW<2,000 m^3/month)	4.0
Type 3: Hotel Commercial building (WW>2,000 m^3/month)	6.0

Table H-2: wastewater charge schedule of Pattaya

WW concentration BOD (mg/L)	Rate of wastewater charge (Baht/m^3)		
	Residential/ Religion place	Small commercial building /hospital/government building	Industry/Bank/Large commercial buildings
< 200	3.50	4.00	4.50
201-300	4.50	5.00	5.75
301-400	5.25	6.00	6.75
401-500	6.35	7.00	8.00
501-700	7.00	8.00	9.00
701-1,000	8,75	10.00	11.25

Table H-3: wastewater charge schedule of Tha Rae, Sakon Nakhon

B.E.	Rate of wastewater charge (Baht/m^3)			
	Residential	Commercial	Hotel	Industrial
2550-2554	1.00-2.50	1.50-3.00	2.00-3.00	3.00-3.50
2555-2559	1.50-3.00	2.00-3.50	2.50-3.50	3.50-4.00
2560-2564	2.00-3.50	2.50-4.00	3.00-4.00	4.00-4.50

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VITA

NAME	Kwanmanas Meethavorn
DATE OF BIRTH	10 October 1988
PLACE OF BIRTH	Bangkok
INSTITUTIONS ATTENDED	Chulalongkorn university
HOME ADDRESS	4 Ngamwongwan 25 Ya k27 Ngamwongwan Rd., Bangkhen, Mueang, Nonthaburi 11000 Thailand