Urban water demand management in Ulaanbaatar, Mongolia

PhD thesis submitted by

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Abstract

In many parts of the world, water resources have been decreasing in urban areas where resources are unable to meet ever-increasing demands, even though water is considered a renewable resource. Supply side factors for increasing water scarcity in urban areas are shrinking or changing natural – hydrological - resources due to human activities, as well as climate change. Climate change exacerbates increased stress on water resources. Population growth, particularly rapid urbanisation with improving living conditions has been increasing water demand and furthermore, has been an influential factor that contributes to water scarcity in urban areas. Traditional solutions for water scarcity in urban areas have been to expand and to improve water supply through the construction of dams, and desalination and recycling plants that are costly and expensive options for developing countries. However, developing countries also have to address issues of water access equity and to achieve the Millennium Development Goal (MDG). For this reason, these urban areas are concerned with how to improve the efficiency of water end use and the efficacy of the water supply system.

Industrialised countries have proven that better urban water management, particularly demand side policies, can alleviate problems of urban water scarcity. Urban water demand side management policies aim to provide sufficient and safe water to all users through improving the efficiency of water use. Better urban water management policies are also needed in developing economies to meet the two main issues of inadequate water resources and the inequitable distribution of water. Increasing water scarcity, coupled with hydrological and financial limitations to the development of new resources, have catalysed a shift to demand management, which is a relatively new branch of the urban water resource management. These policies not only focus on inducing users' water consumption directly but also indirectly influence water saving habits for improving efficient water use.

There are no comprehensive studies available to provide precise and accurate information about the potential effectiveness of urban water demand side management in developing and transit economies. Ulaanbaatar, the capital city of Mongolia, faces a growing problem of water scarcity. Ulaanbaatar is typical of cities that are currently experiencing high and urbanising population growth, poorly regulated industrial expansion and associated increases in demand for domestic and industrial water. However, Mongolia's climate is characterised by low precipitation and high evaporation; groundwater supplies are diminishing, and the capital city is likely to face water scarcity problems in the next few years. Moreover, the city needs money to invest in essential infrastructure that would help address issues, such as the inequity of supply services between Ger and formal living areas and the fact that an estimated 20.4% of water is 'lost' through leakage. The aim of this study is to explore the potential efficacy of water price and non-price policies as a partial solution to some of these problems. The study looks at how to assess the

sensitivity of water demand to price changes and to learn more about the water saving habits of residential and non-residential users. Furthermore, the investigations comprehensively involve various user groups: non-residential users including manufacturing, commercial and government user groups, and residential users including formal 'apartment' and informal 'Ger' settlement households.

The study area is data poor, which is quite typical of developing countries. Therefore, data had to be collected and in this study questionnaire surveys were used. After the first year's (2010) data collection, two water policy events occurred in the city. The price of water for apartment area users was increased and the government announced that 2011 would be a 'water year' with a concerted media campaign. For this reason, data were collected again in 2011 to check the effectiveness of the Government media campaign and for collecting more data from non-residential users.

The contingent behaviour method (CBM) – commonly used to estimate the non-market values of individuals – was adapted to business settings. It uses data that were collected from more than 375 non-residential water users in Ulaanbaatar, and estimates the price elasticity of water demand for three different user groups (manufacturing, commercial and governmental users). Non-residential water demand is shown to be relatively price inelastic with values ranging between -0.186 and -0.24. This inelasticity implies that prices would have to increase substantially to generate any significant reduction in water use (e.g. doubling prices would result in a 3.6 % reduction in water use), but that significant revenues could potentially be raised. The results also indicate that attempts to influence water saving habits (e.g. introducing water saving technologies or encouraging water conserving activities) through non-price policies may reduce non-residential water demand more than would increases in price.

This study also demonstrates also the potential efficacy of pricing and non-pricing policies on residential water demand. It uses data that were collected from a survey of nearly 960 residential water users from formal and informal settlement areas in Ulaanbaatar. The data collected in 2010 provide a pre-increase base and those from 2011 follow an observed increase in price. Water consumption in metered and non-metered homes was estimated using both the direct indication and conditional demand approaches and a CBM was then used to estimate the price elasticity of water demand for different types of users (formal settlement – apartment areas and informal settlement – Ger areas). The CBM indicates that consumption is relatively sensitive to small price changes among the households and that informal settlement households are likely to react to price changes much more. This study found that residential price elasticities, which were between -0.941 and -0.099 for non-metered households in 2011, were closer to observed responses when respondents had experienced actual recent price increases.

Relationships between water saving habits and attitudes about various policies for promoting efficient water use and supply are investigated for different user groups. The attitudes of residential and non-residential users about different policy approaches, including demand side (pricing) policies, operational-technical policies (which comprise retrofitting and installing and/or fixing water using appliances and equipment strategies), socio-political policies (comprising public information and education campaigns, and the auditing of water use strategies (Herrington, 2006)), and supply side policies are assessed for 2010 and 2011. There is a positive relationship between water saving habits and attitudes for both user groups (non-residential and residential). Assessments of the potential of urban water policies to influence water saving habits indicated that operational-technical policies are likely to be the most effective for residential users, while supply side policies are likely to be the most effective for non-residential users. The government media campaign was effective for convincing users about the benefits of pricing and operational-technical policies for residential users, and the benefits of socio-political policies for non-residential users. The campaign was found to be an effective means of changing attitudes and could play an important role in the development and implementation of water management policies in Ulaanbaatar.

Overall, urban water management policies are likely to be effective for alleviating problems of water scarcity in Ulaanbaatar – although it will not 'solve' the problem unless demand can be reduced by more than supply. For non-residential users, higher prices are unlikely to have much water-saving impact but would support greater revenue collection. For residential users, higher prices could reduce water demand, up to a certain point (when demand is likely to become inelastic). For both residential and non-residential users, non-price policies are likely to be better able to encourage water conservation. Overall, investigations found that (a) better urban water management policies may be able to help alleviate problems of water scarcity in urban areas; (b) the CBM is a useful method for estimating the price elasticity of non-market goods and that (c) a variable capturing water saving habits is a useful addition to the list of variables commonly employed when estimating water demand..

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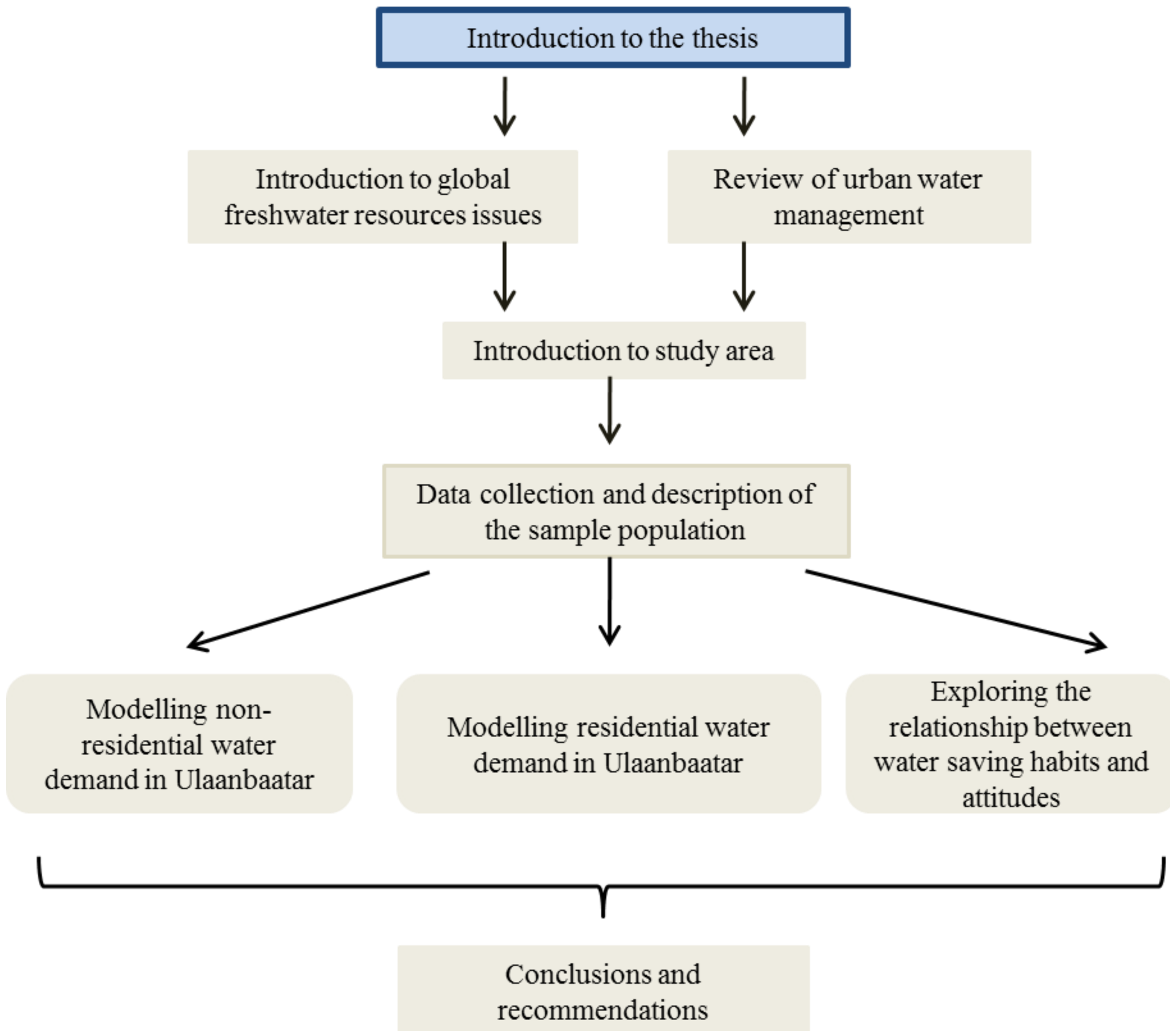
Thesis layout



CHAPTER 1 INTRODUCTION TO THE THESIS

1.1. INTRODUCTION

This thesis comprises an investigation into the potential effectiveness of demand side policies for water management in a case study of the city of Ulaanbaatar, Mongolia. The key research question addressed is: '*Can water demand management policies alleviate problems of water scarcity in Ulaanbaatar, Mongolia?*' The research draws on the experience with demand management in both developed and developing countries, and also involves the collection and analysis of primary data from both residential and non-residential consumers in Ulaanbaatar. The contingent behaviour method (CBM) – which relies on hypothetical scenarios to reveal water demand under hypothetical prices – is used to estimate urban water demand for a variety of different users, and the importance of water saving habits and of attitudes towards water management policies is explored.

This investigation into the potential effectiveness of water management policies in Ulaanbaatar provides useful information to researchers and policy makers. The purpose and objectives of the research are detailed below. Those aspects of the work that can be considered novel contributions to current knowledge on urban water demand management are also noted, as is the lack of available data in cities such as Ulaanbaatar.

Urban water demand management is introduced in Section 1.2, while the specific research objectives for the thesis are presented in Section 1.3. The research framework of the thesis is detailed in Section 1.4 and the scope of the study introduced in Section 1.5. The content and structure of the thesis is presented in Section 1.6.

1.2. URBAN WATER DEMAND MANAGEMENT

In this thesis, 'urban water demand management' is interpreted as including the interaction between demand for water and demand side management policies, including both price and non-price policies, for a city or urban area. The demand for domestic and industrial water supply is investigated in the case of Ulaanbaatar, the capital city of Mongolia. The lessons learned may also be relevant in other developing and transitional economies.

Urban water has historically been provided by centralised water infrastructure systems, most of which have been constructed in the cities of industrialised economies over the last 150 years. However, demand management approaches to the allocation of water in urban areas have only become a focus for management authorities in the past three to four decades. In industrialised countries, urban water policy is now directed far more towards sustainability through the use of demand management practices (Kolokytha et al., 2002).

The scarcity of water and limited financial resources for expanding water supply infrastructure means that demand management can improve the efficient and effective use of the available water supply (Renwick and Green, 2000). Enhancing the efficiency with which water is supplied and used also contributes to conservation efforts (Greenberg and Harshbarger, 1993). Demand management policies delay the need for large capital investment in expansion of the water sector; they seek to conserve water (quality and quantity) and to optimise water use by influencing demand. Demand management policies usually seek to promote conservation while meeting objectives that include economic efficiency, social development, social equity, environmental protection and sustainability of water supply and services (Biswas et al., 2009).

In the literature, demand side management approaches are predicated on three principal considerations:

- that demand can be influenced and modified through various policies and strategies
- that one should focus on socially beneficial outcomes in a cost-benefit context
- that the integration of water quality considerations is a part of all actions.

The issues confronting water demand and demand management initiatives may vary from region to region. International best practice may not necessarily be relevant geographically, culturally and/or economically to developing countries. Demand management can be approached in many different ways so there is no given strategy that is universally applicable, while local factors such as culture need to be considered when developing solutions (Young, 2005). Terrebonne (2005) note that programs for encouraging demand management do not guarantee that the desired outcomes will actually occur, while existing urban demand side management studies may not often be transferable to other areas (White et al., 2003b).

1.3. GOAL AND OBJECTIVES OF THE THESIS

The goal of the research reported in this thesis is to:

> *Investigate possible and appropriate solutions for alleviating problems of water scarcity in Ulaanbaatar, Mongolia through water demand management policies.*

The objectives are to:

- Investigate the potential impact of price increases on different user groups' demand for water.
- Understand perceptions of users' about the likely effectiveness of urban water management policies that seek to promote the efficient supply and use of water.
- Examine the relationship between water saving habits, water demand, and attitudes towards different water management policies.

Specific consideration of each objective is examined through sub-objectives in relation to each of these goals. Both residential and non-residential demand for water, along with socio-economic factors, water saving habits and attitudes towards different water management policies are considered. Considering these factors, and the interrelationships between them, was key to revealing the potential effectiveness of demand side management policies and understanding the relationships between water saving habits and users' perceptions.

The specific activities undertaken to meet the goal and objectives outlined above involved:

i. An investigation of the price sensitivity of *non-residential* user groups in the manufacturing, commercial and government sectors. This was done by:
    a. estimating water demand functions for different non-residential user groups; and then
    b. using coefficients from those functions to calculate
        - the potential reduction in demand for water by non-residential users in aggregate and for each specific non-residential sector if water prices were to rise; and
        - the potential revenue outcomes from the non-residential users' response to pricing policies.

ii. An investigation of the price sensitivity of *residential* water demand for apartment and Ger areas user groups. This was done by:
    a. estimating water demand functions for different residential user groups; and then
    b. using coefficients from those functions to calculate
        - the potential change in demand for water by residential users if water prices were to rise; and
        - the potential revenue outcomes from the non-residential users' response to pricing policies.

iii. An analysis of the relationships between water saving habits and attitudes about urban water management policies for non-residential and residential user groups. Here, I

a. assessed consumer’s attitudes towards different policies to promote water end use efficiency and improved water supply efficiency;
b. looked at attitudes towards urban water management policies before and after a government media campaign (aimed at increasing awareness of water scarcity); and
c. explored the relationship between water saving habits and attitudes towards water management policies for non-residential and residential user groups.

1.4. RESEARCH FRAMEWORK

The methodological framework developed for this research is shown in Figure 1Methodological framework. (which identifies the specific research questions addressed by each activity). It comprises a set of research methods drawn from various bodies of literature (mostly, although not exclusively, economic). Demand management approaches were employed to guide the development of the methodological framework and, subsequently, to investigate the effectiveness of urban water demand management approaches and to understand the attitudes of urban water users in developing and transitional countries about those approaches. A general overview of the methods used to collect data is provided in Chapter 5; subsequent chapters provide a more detailed review of the methods specific to the research questions addressed in each.

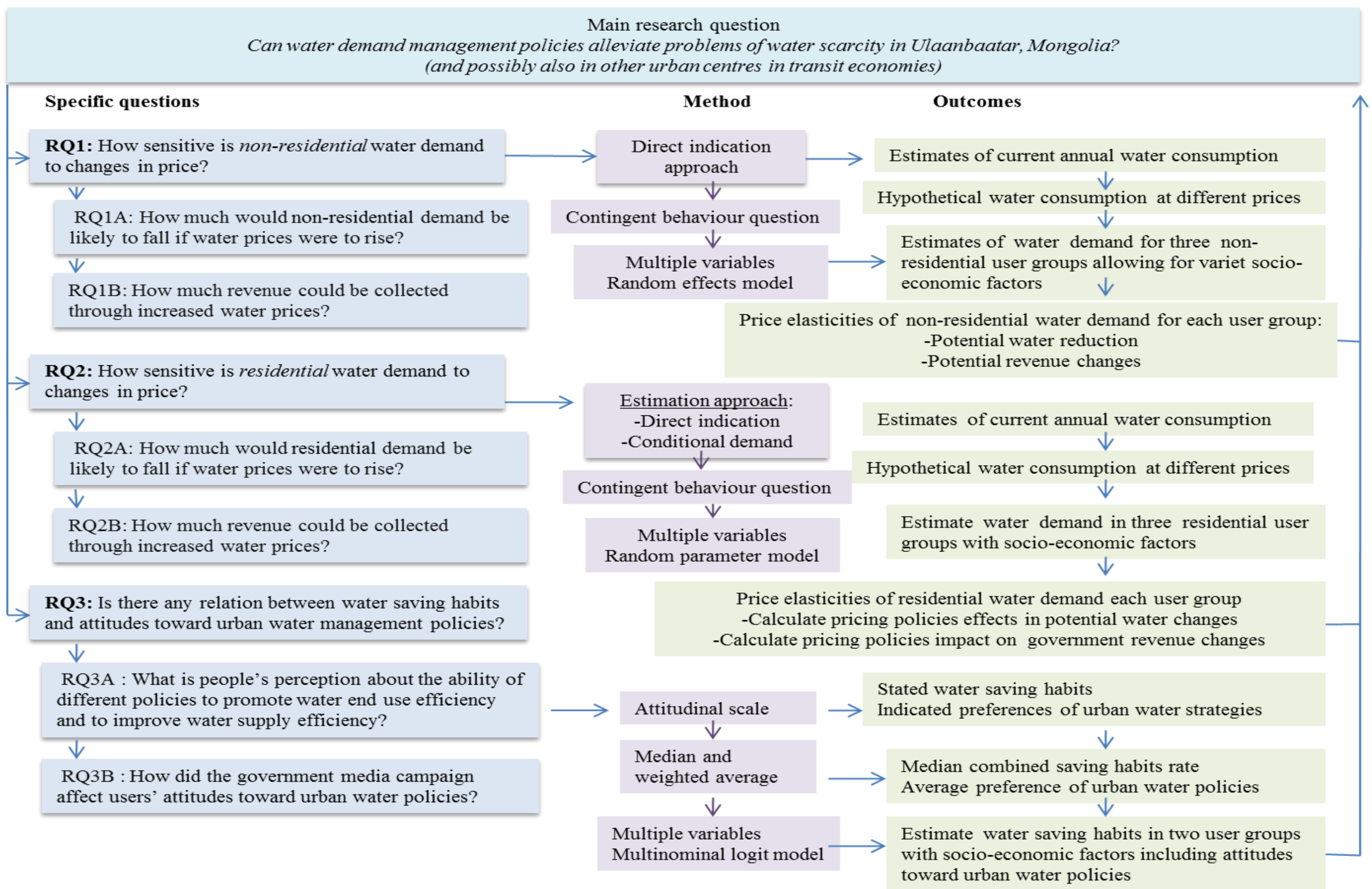


Figure 1 Methodological framework.

1.5. SCOPE OF RESEARCH

The scope of the research varies for each specific objective and is dependent on the availability of suitable data. This scope may be defined as temporal, spatial and sectoral, as outlined in Table 1. The primary spatial scope of this research is Ulaanbaatar, Mongolia. The rationale behind the spatial and sectoral differentiation is that the implementation of water policy occurs at the Water Supply and Sewerage Authority (USUG) level. Therefore, it is more realistic to analyse policy implications at the user groups' level in line with USUG practices.

Table 1 Scope of analysis.

Specific Activity	Research method	Temporal	Spatial	Sectoral / User group
1	Direct indication (to estimate current levels of water use) Contingent behaviour (for estimating demand functions)	2010 2011	Formal settlement	Manufacturing Commercial Government
1A&B	Calculation based on USUG's real data and coefficients from the demand functions	2012	Ulaanbaatar	USUG's users
2	Direct indication & conditional demand (to estimate current levels of water use) Contingent behaviour (for estimating demand functions)	2010 2011	Formal settlement Informal settlement	Ger areas residential Metered apartment residential
2A&B	Calculations based on USUG's real data and coefficients from the demand functions	2012	Ulaanbaatar	USUG's users (real data)
3A	Attitudinal scale Median & average	2010 2011	Formal settlement	Non-residential Residential
3B	Attitudinal scale Weighted average	2010 2011	Formal settlement Informal settlement	Non-residential Residential
3C	Attitudinal scale Weighted average	2010 2011	Formal settlement Informal settlement	Non-residential Residential

1.6. CONTENT AND STRUCTURE OF THE THESIS

This thesis is contained in nine chapters. Chapter Two, *Global issues of water scarcity*, comprises a review of factors affecting water resources in urban water supply and water demand and also includes a discussion of water scarcity indicators and projection. Practices and knowledge about methods of solving water scarcity in urban areas of developed countries, including applications of possible urban water management policies to developing countries, are detailed in Chapter Three. Universal concerns about water scarcity and the meeting of the Millennium Development Goals (MDG) means that there is an extensive literature in this area, particularly for highly populated and rapidly growing urban areas in developing countries (WWAP, 2006). In most developing countries supply side management policies dominate, yet many face real budget constraints and several have already met hydrological scarcity. Consequently, the focus of the discussion in Chapter Three concerns the practices of industrialised economies during the last three decades, and particularly the adoption of demand side management approaches. It is noted that there is little evidence about the potential effectiveness of these approaches in developing and transitional economies.

The case study area – Ulaanbaatar, Mongolia – is described in Chapter Four. Ulaanbaatar is faced with an increasingly scarce water supply in the face of a growing population and increasing demand for water. Introduction of the study area including the main factors for increasing urban water demand and biophysical environment are reviewed, and consumers divided into residential and non-residential users. The problem of data scarcity in estimating water usage by end users is also outlined, and the consequent difficulties in using traditional estimation techniques highlighted. The chapter presents a conceptual framework, including urban water management challenges and literature gaps on urban water management, along with an appropriate research methodology, are introduced

Chapter Five, *Data collection and description of the sample population*, contains information about the training of research assistants, sampling, and data collection processes and also provides some descriptive statistics about respondents in this study. The researcher had a limited time frame and budget for data collection, thus, administrative support from the mayor’s office of Ulaanbaatar and USUG was used to help collect data from households and businesses. Data were initially collected during 2010, but in 2011 the price of water for apartment users was changed (for the first time in many years) and the government also announced 2011 to be a ‘water year’ – with media campaigns occurring after the data collection in 2010. It was therefore decided to return to the study area in 2011, collecting more data, so that results could be compared between 2010 and 2011.

The main ‘analytical’ parts of the thesis are presented as a series of (three) chapters formatted for publication in peer-reviewed journals. Chapter Six focuses on non-residential water demand (thus addressing research question 1); Chapter Seven focuses on residential water demand (and thus research question 2); whilst Chapter Eight focuses on attitudes (before and after the media campaign) and on the relationship between attitudes and water saving habits. Authorship of chapters for publication (Chapters Six–Eight) is shared with members of my thesis committee, Natalie Stoeckl and David King. Additional supporting analyses of estimating non-residential and residential water demand are provided in the appendices.

To be more specific, Chapter Six, *Modelling non-residential water demand in Ulaanbaatar, Mongolia*, explores the potential efficacy of water demand policies in the city, with a focus on non-residential water pricing. The potential demand changes that result from price increases and the resulting effects on revenue from non-residential users are explored. The reasons for using a conditional demand function approach, including the measurement of dependent and explanatory variables of the model for demand estimation, are outlined. The relationship between non-residential water demand and the water saving habits of these user groups is also explored.

Publication:

Modelling non-residential demand for water in Ulaanbaatar, Mongolia, Altai, Z; Stoeckl, N and King, D. Water Resource Research, In review

In Chapter Seven, *Modelling residential water demand in Ulaanbaatar, Mongolia*, the potential apartment and Ger areas’ household demand changes resulting from changes in water prices are explored. Estimates of the current water consumption of each individual end user are generated. Significant differences in water use between formal and informal area households are found. Residential water demand estimation, based on a random parameter model, is presented in this chapter. More information about the price sensitivity of apartment and Ger areas’ household water demand and the impacts on revenue following the implementation of price policies is provided.

Publications:

Impacts of water demand side policies on Mongolian residential users. Altai, Z. Stoeckl, N and King, D, International conference on Integrated Water Management, February 2-5, 2010, Murdoch University, Western Australia

Impacts of water demand side policies on Mongolian residential users. Altai, Z. Stoeckl, N and King, D, 2012, Water Practice and Technology 7-2: 1-10

Modelling residential water demand using contingent behaviour method: a case study of Ulaanbaatar, Mongolia, Altai, Z; Stoeckl, N and King, D. Regional Science and Urban Economics, ready for submission.

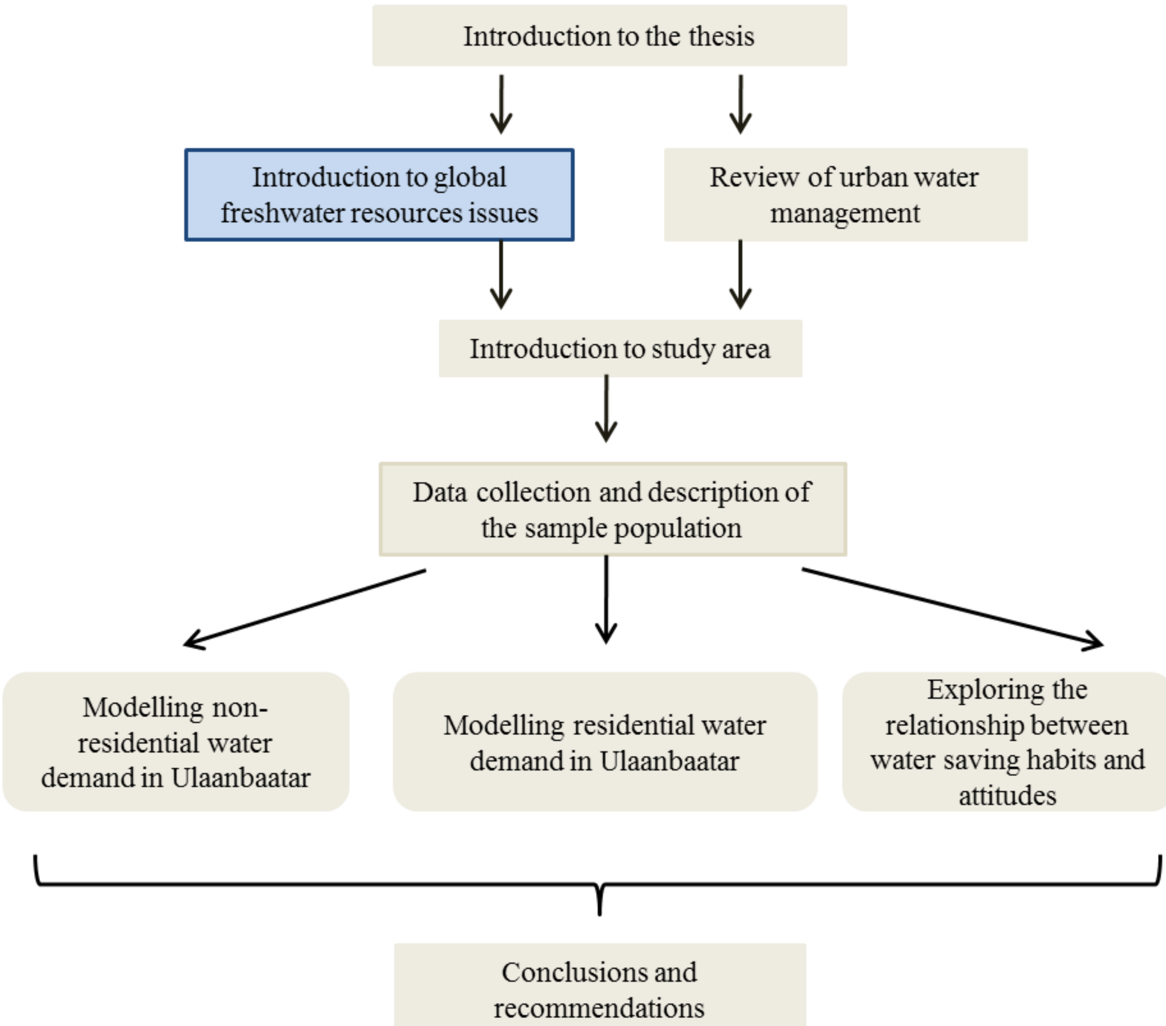
The relationships between water saving habits and the attitudes (towards various water management policies) of both non-residential and residential user groups are investigated in Chapter Eight, *A relationship between water saving habits and attitudes towards urban water management policies*. First, the water saving habits of non-residential and residential users are outlined. Consumer's perceptions about the ability of different policies to promote water end use efficiency and to improve water supply efficiency are investigated, as is the impact of a government sponsored media campaign on perceptions, attitudes and behaviours. Water saving habit models (developed using multinomial logistic regression) are presented, and interpreted in this chapter.

Publication:

Water demand management research: the relationship between water saving habits and attitudes towards urban water management policies, Altai, Z; Stoeckl, N and King, D, International Journal of Water Resources Development, In progress

The principal conclusions of the research are presented in Chapter Nine. The potential effectiveness of demand side pricing policies for water, and their impacts on revenue are discussed. The perceptions of consumer groups about urban water policies and the effectiveness of the government media campaign are also discussed. Importantly, conclusions are drawn about the relationships between water saving habits and the attitudes prevailing within the two main user groups; these conclusions are based on the empirical and methodological work undertaken. The results provide useful information about demand management policies under alternative scenarios, such as whether the government prefers to collect more money or needs to reduce demand for water by different user groups. This information is valuable not only to decision makers in Mongolia, but also to those in other developing countries. The methodological findings are likely to be useful for further non-market services/goods demand estimations and, subsequently, for improved environmental and public policy development.

Thesis layout



CHAPTER 2 INTRODUCTION TO THE GLOBAL FRESHWATER RESOURCES ISSUES

This chapter introduces global freshwater resource issues detailing supply and demand side pressure factors, which are driving the water scarce problems in urban areas. Figure 2 Structure of Chapter Two. shows the structure of this chapter. Urban water scarcity has been caused by supply side pressures including global climate change and poor infrastructure and demand side pressures include population and urbanisation growth and economic development. Population growth, particularly rapid urbanisation with improved living conditions, has been increasing water demand. Increasing and improving water supply through construction of dams, desalination and recycling plants are costly and expensive solutions for developing countries. These are often not appropriate solutions for developing countries particularly in semi-arid regions, which face water scarcity. Developing countries also have to address issues to achieve the Millennium Development Goal (MDG) of safe and equitable water access to all users, through urban water resource management. Climate change and implementation of the MDG may affect the demand side of the balance as well as the supply side. This chapter summarises the real problems in urban water resource management in developing and transit countries.

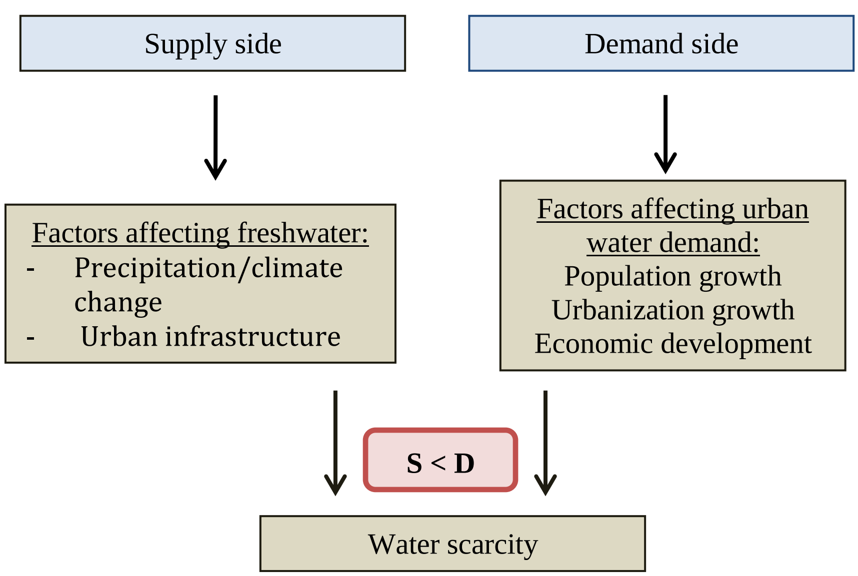


Figure 2 Structure of Chapter Two.

2.1 FACTORS AFFECTING WATER RESOURCES FOR URBAN WATER SUPPLY

In many parts of the world, water resources have been decreasing in urban areas where resources are unable to meet ever-increasing demands, even though water is considered a renewable resource. Supply side factors for increasing water scarcity in urban areas are "shrinking or changing natural – hydrological – resources" due to human activities, as well as climate change. Climate change exacerbates increased stress on water resources still further. Figure 3 simplistically shows a pattern of urban water scarcity due to supply side factors. Most urban areas, particularly in arid and semi-arid regions, belong to groundwater resources, which have been shrinking due to human activities including over-extraction (extraction of water is faster than the capacity to recharge aquifers) and degradation/pollution, while an unmanageable factor may be climate change. These pressures are illustrated as a curve for water availability shifting leftwards, which represents a reduction of the natural water resource.

The traditional method for providing water to domestic users is expanding infrastructure such as constructing dams, recycling plants and desalination plants, and drilling deeper. Urban supply side management policies are discussed in Section 3.2 and 3.3. Many parts of the world, particularly semi-arid and arid regions (which covered 30% of the earth's land area in 2000) and developing countries, need to predominately control supply side management policies. These countries need to supply water to achieve MDG as every person has to have a basic amount of water for human needs. This is one of the most fundamental conditions of human development. However, expanding supply is not a long term solution for domestic users. Figure 3 (P-price and Q-quantity) shows that urban water supply must not be in excess of natural resources – supply side management solutions are no longer relevant, especially as groundwater levels in key aquifers are falling rapidly.

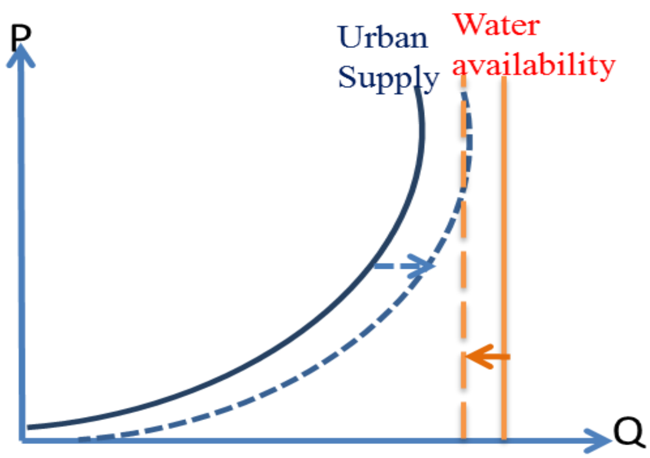


Figure 3 Supply side pressure factors to water scarcity in urban areas.

2.1.1 GLOBAL WATER RESOURCE AND CLIMATE CHANGE

Even though water is the most widely distributed and abundant resource on earth, fresh water is still scarce. Of all the water that is available on earth, 97.5 % occurs as salt water in the oceans, while there is around 35 million km^3 of freshwater, 69% of which exists in the form of ice and permanent snow cover in mountainous regions and the Antarctic and Arctic regions (Figure 4 Global freshwater resource. *Source:(BGR, 2011)*). About 31% of freshwater is available in the form of groundwater, surface water and in the atmosphere (Baumann et al., 1998, Boland and Baumann, 2009, WWAP, 2006). At the global level, if all freshwater was divided equally among the world's population, there would be 5,000 – 6,000 m^3 of water available for every person per year (UN-Water, 2007). Both populations and freshwater resources are distributed very unevenly over the globe (Kummu and Varis, 2011), both across and between regions.

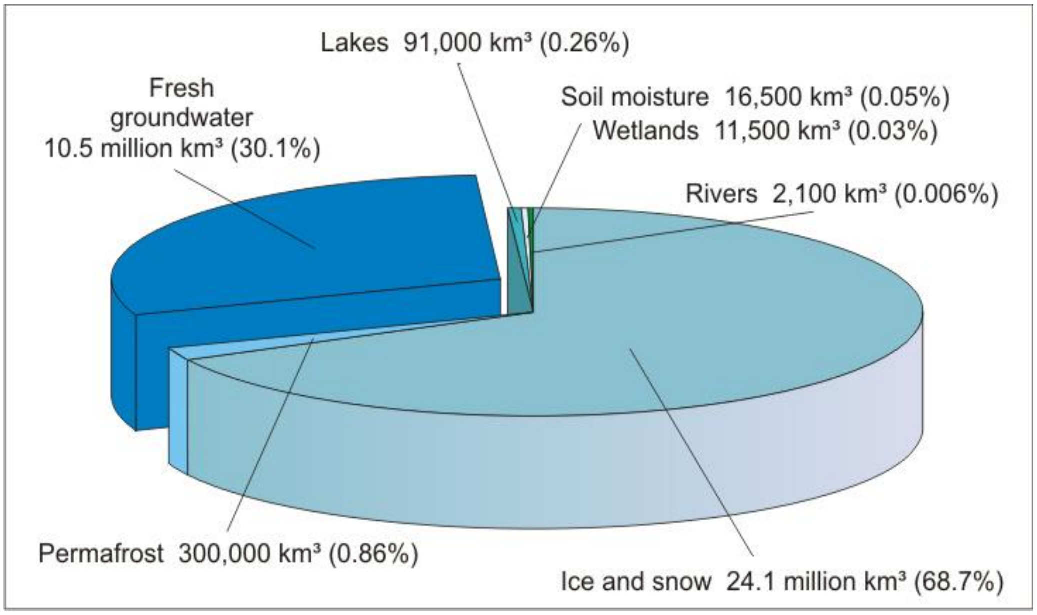


Figure 4 Global freshwater resource. *Source:(BGR, 2011)*

Global surface temperature from 1906 to 2005 has increased by 0.74°C, ranging from 0.56 to 0.92°C, with a more rapid warming trend over the past 50 years (Bates et al., 2008). This global warming impacts on the hydrological cycle and has long-term implications through temperature increase and lower precipitation, which have significant impacts on water demand (Arnell, 1999). Although water is a renewable resource, the extent to which increasing demands can be met is finite. As population increases, water demand increases and the available supplies per person inevitably decline.

Global warming has started playing a major role in the water scarcity of the world. Observational evidence – the twelve warmest years since 1850 occurred between 1995 and 2006 – confirm that global warming impacts on global average temperature (UN-Water, 2007). UN (2007) reported that in this century global warming is expected to account for an increase of around 20% of water scarcity in the world with global average temperatures increasing more than 5°C. Changing climates, particularly global warming, have been altering precipitation, and melting mountain glaciers, which affect bulk water sources, and worsen the extremes of drought and floods around the world (UN-Water, 2007, UNDP, 2007).

The increase in global temperature by even a small amount can cause changes in the seasons, which can lead to a decrease in rain and changes in the balance of rain and snow that fall over the Earth.

Decreasing natural water storage capacity from glacier/snow cap melting reduces long-term water availability for more than one-sixth of the world's population that lives in glacier – or snowmelt –fed river basins. For example, Central Asia, Northern China and the northern part of South Asia face immense vulnerabilities associated with the retreat of glaciers—at a rate of 10–15 metres a year in the Himalayas. Seven of Asia's great river systems will experience an increase in flow over the short term, followed by a decline as glaciers melt. More than one-sixth of the world's population lives in glacier or snowmelt-fed river basins (Bates et al., 2008).

UNDP (2007) predict that global temperature increases of 3–4°C could result in 330 million people living in Bangladesh, Lower Egypt, Viet Nam, and the island countries of Caribbean and Pacific may be permanently or temporarily displaced through flooding and in addition one billion people living in urban slum areas may face acute vulnerabilities also. A few studies of climate change impacts on groundwater for individual aquifers have been undertaken. In the Ogallala Aquifer region, USA, projected natural groundwater recharge decreases more than 20% in all simulations with warming of 2.5°C or greater (Rosenberg et al., 1999).

Drought attributable in significant part to climate change is already causing acute water shortages in large parts of Australia, Asia, Africa, and the United States.(AGPC, 2011)

2.1.2 URBAN WATER SUPPLY

In most countries, agriculture is one of the largest users of water (World Water Council, 2000), but that is in rural settings. Urban settings are somewhat different such as daily safety water requirement and water supply. Water supply enhancement has been a priority of urban water resource management in the modern era and recently new water supply opportunities became a reality with desalination, which is geographically and financially a limited option. Desalination appeared during the late 20th century but is still in use in certain limited areas. The traditional supply driven management policies lead to over-use of the resources, over-capitalization and other problems of varying severity (Hunt, 2009). Urban water suppliers must do more than pump and transport and deal with water quality, treatments and deactivation of contaminants. However, the world particularly in developing countries is facing increasing problems in providing water services.

Water supply systems get water from a variety of locations, including groundwater, surface water, conservation and the sea through desalination. In 2010 about 85% of the global population had access to piped water supplies through house connections and standpipes, water sellers, protected springs and protected wells (WHO and UNICEF, 2010). The rest of the globe did not have access to an improved water source and had to use unprotected wells or springs, canals, lakes or rivers for their water needs. Many of the 3.5 billion people having access to piped water received a poor or very poor quality of service, especially in developing countries where about 80% of the world's population lives. A clean water supply is the single most important determinant of public health and sewage disposal infrastructure after major catastrophes such as earthquakes, floods, etc. Once water is used, wastewater is typically discharged in a sewer system and treated in a sewage treatment plant before being discharged into a river, lake or the sea or reused for landscaping, irrigation or industrial use.

Lawrence et al. (2002) developed the water poverty index (WPI), which is measured by taking into account both physical and socioeconomic factors such as resources, access, capacity, use and environment associated with water scarcity, and ranked 140 countries (about 26% of which are in a medium WPI range, 17% in a high WPI range, and 25% in a severe WPI range). The World Water Day report in 2007 emphasised that one in three people face water shortages; around 1.2 billion people live in areas of physical (no safe water delivery systems) scarcity and 500 million people are approaching this situation. Another quarter of the world's population faces economic water shortages due to a lack of the necessary infrastructure to utilise water (UN-Water, 2007). Millions of people in developing countries cannot meet their basic needs for water of 20 litres of water per person per day: 5 litres for drinking water for survival, 10 litres for preparing food, and 5 litres for cleaning and sanitation (Gleick, 1996, UNESCO, 2003).

In general water supplies in cities/urban areas are usually supply driven, meaning whenever there is a 'shortage' the solution relies on capital investment for supply enhancement strategies/policies such as building/enlarging dams, deeper drilling/improving wells, repairing leaky infrastructure and building desalinisation plants. The traditional supply side solution with its engineering and technical approach has been successful in providing water to the urban areas, but still many people do not have access to safe water resources and some people waste the water service. These urban centres have financial and managerial problems for providing water related services, and urban water management needs to reallocate water use among the users for securing equity of water use. Thus the management show a shift to demand management approaches (Rijsberman, 2006).

2.2 FACTORS AFFECTING URBAN WATER DEMAND

Agriculture is one of the largest water users in most countries, often accounting for around 80% of total consumption (World Water Council, 2000). The drivers of demand in urban settings are, however, somewhat different than those in the agriculture sector. The major demand side factors in urban areas are population growth, urban growth, and economic development. The demand curve shifts outwards (D to D^1 in Figure 5) without urban water policies because of population growth, income growth, economic development, and climate change. Quantity (Q) for water then increases from Q to Q1 at the same price (P1) in Figure 5.

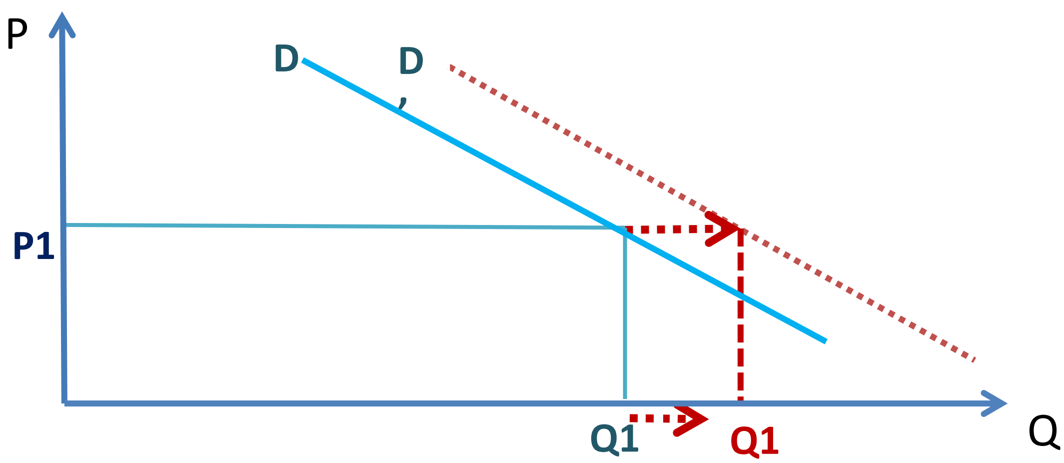


Figure 5 Demand side drivers and water scarcity in urban areas**.**

The demand for water is growing fast due to rapid population growth and increased economic activity, but water availability is not growing at the same rate because of serious financial and physical limitations for supply augmentation.

A lack of available water and an uneven water demand resulting from population growth in concentrated areas are the main causes of water scarcity in urban areas where rapid growth of population, mainly through urbanisation and economic development, are short term reasons while global warming is the long term threat. Global water use has been increasing steadily over the past decade, partly because of rising population growth, although during the last century the world's population has increased fourfold, while water use has increased by a factor of six (UNDP, 2004)(Leete et al., 2003). Population growth and global warming mean that water stress will continue to be a challenge for governments, businesses and society.

2.2.1 POPULATION GROWTH

Global freshwater sources are adequate for all people. However, the resources are distributed very unevenly amongst the world's population. The areas of most severe physical water scarcity are those where high population densities converge with low availability of freshwater. The impacts of changes in population size on water shortage are roughly four times more important than changes in water availability as a result of long-term climate change (Kobayashi and McAleer, 1999).

Access to safe water, in terms of the percentage of the total population having such access, is presented in Figure 6. The lack of access to clean water is of particular concern for many of the poorest countries. Less than 65% of the population of most sub-Saharan African and south Asian countries have access to water from improved sources; Romania remains well behind other European countries, while Mongolia lags behind its Asian neighbours (WHO and UNICEF, 2000).

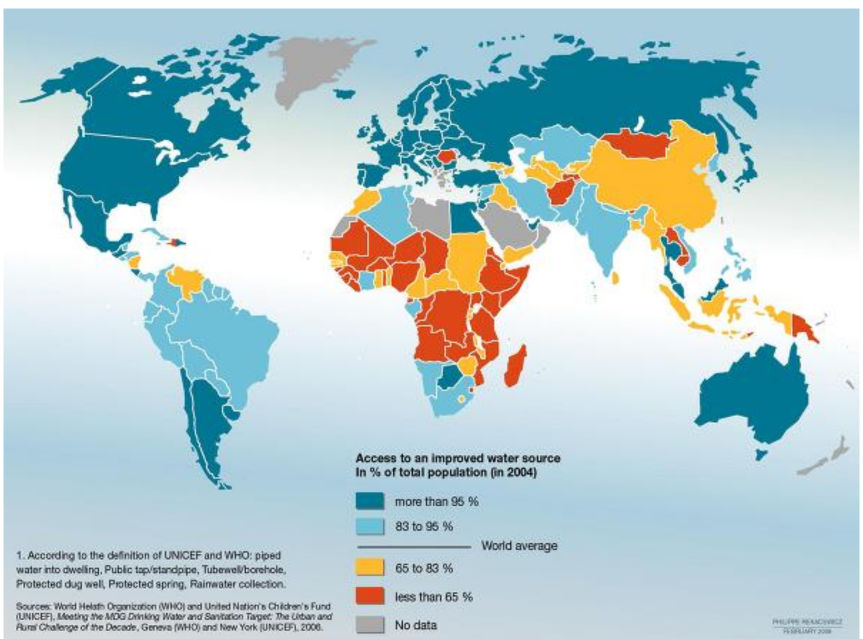


Figure 6 Total population: access to an improved water source. *Source: (WHO and UNICEF, 2000)*

The number of people living in urban areas is expected to double to more than 5 billion by 2025, with 90% of the increase occurring in developing countries from 1990 to 2025 (Ahmad and Prashae, 2010),. Population growth is the fastest in urban areas, by about 13 times in the 20th century, a trend that is set to continue, particularly in Africa and Asia where the urban population is expected to double between 2000 and 2030 (WWAP et al., 2009). By 2030, it is anticipated that the urban population in developing countries will have increased to 3.9 billion, nearly four times the number in developed countries (UN -

Habitat, 2010, UNDP, 2006). Population division of UN projections of urban and rural population by development group are shown in Figure **7** where, again, growth is seen to occur predominantly in developing countries. Urban population is expected to increase from 3.6 billion in 2011 to 6.3 billion in 2050 worldwide and from 2.7 billion to 5.1 billion for less developed regions (Altai et al., 2012). WHO and UN - Habitat (2010) forecast that 7 out of every 10 people will live in urban areas by 2050 (WHO and UN - Habitat, 2010). Urbanisation will therefore be concentrated in nations with limited resources to provide services to their urban populations (UNDP, 2006).

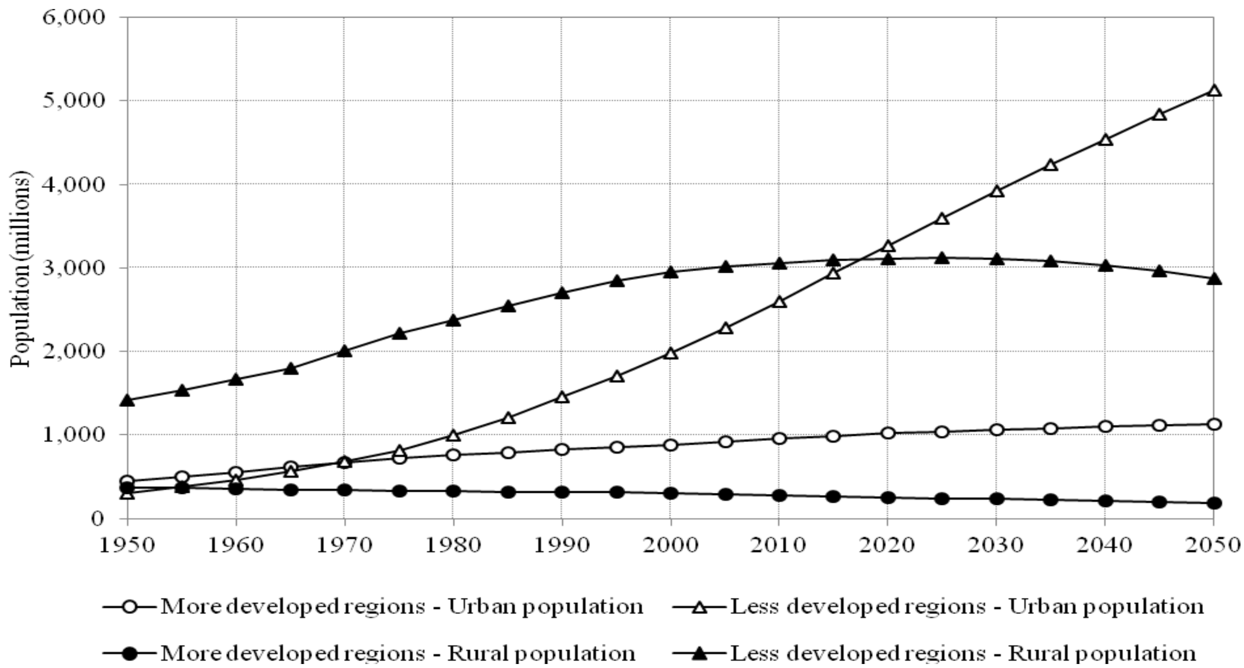


Figure 7 Global population growth to 2050. *Source: (UN, 2012)*

Challenges associated with water scarcity are more acutely felt in those countries where most of the world's new population is born each year (UNEP FI and SIWI, 2005). Many water scarcity predications assume a rapidly increasing water use per capita usually related to increasing living standards and rising incomes (Alcamo et al., 2000). Furthermore, increasing incomes and economic development will have a large influence on future water consumption, and therefore on water withdrawals and water stress.

2.2.2 URBANISATION GROWTH

Rapid growth of the world's population has been one of the most visible and dramatic changes in the last century. This population growth has huge impacts for water resources. Populations, demand and freshwater resources are distributed very unevenly over the globe (Kummu and Varis, 2011) and, therefore, high population density urban areas face and will experience water scarcity. The world's population, particularly in developing countries, is rapidly becoming increasingly urbanised and concentrated in large cities. Cities in developing countries generally face substantial challenges in providing shelter, infrastructure and services and most also confront insufficient water supply, deteriorating sanitation and environmental pollution. Urban water use is different from rural. Urban water is supplied by water pipe systems and water is lost via leakages from the system so that growing urbanisation places greater pressures on resources. Urban water scarcity is at crisis level in many developing countries. Water stress conditions also exist in many urban areas of developing countries; not only because of limited water resources and poor distribution networks, but also because of disproportionately rising water demand per capita and inequalities in water service provision between the rich and poor.

In 2004, around 827 million people lived in slums, often lacking adequate drinking water and sanitation facilities (WHO and UN - Habitat, 2010, Camplell et al., 2004) and by 2013 this number has reached more than 1 billion. Figure 8 shows the strongest affected regions, including 303 million people living in Eastern Asia and 288 million in Sub-Saharan Africa. Moreover, it has been suggested that every year in developing countries an estimated 3 million people die prematurely from water-related diseases (WWAP, 2006).

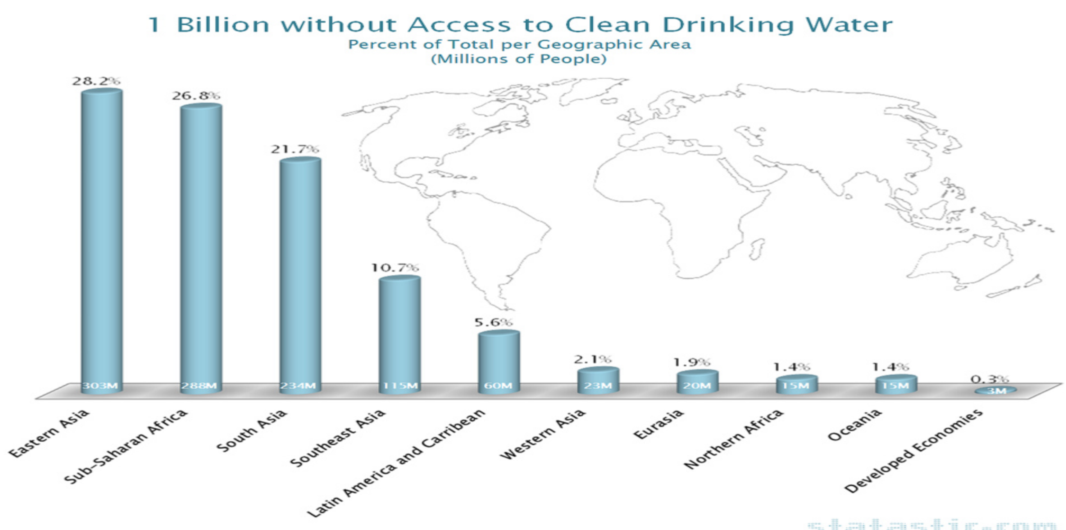


Figure 8 Pattern of not safe drinking water access. *Source: (WHO and UN, 2010)*

From 2000 to 2050, the urban population in Africa and Asia is set to almost double (UN, 2012). Asia's urban population will reach 2.6 billion and Africa will go from 294 million in 2000 to 742 million in 2030. Latin America and the Caribbean will see its urban population rise from 394 million to 609 million. Furthermore, the percentage of urban population in the world was 29% in 1950, 49% in 2007 and is expected to be 60% in 2050 (see

Figure **9**) and 79% of the world's urban dwellers will live in developing countries (UN and WWAP, 2003).

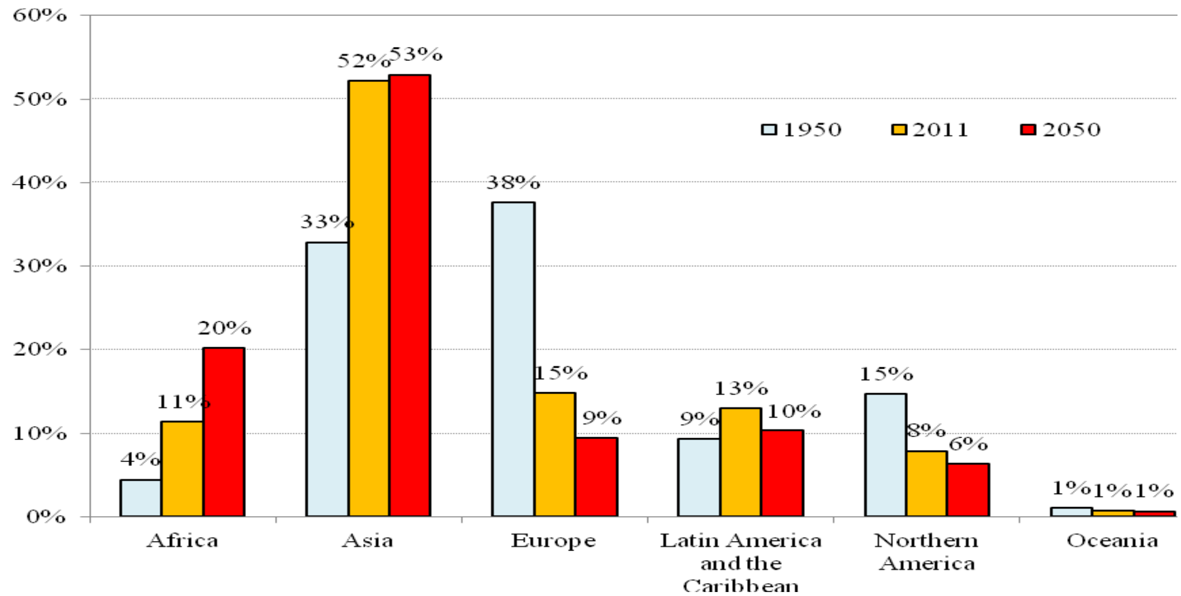


Figure 9 Distribution of the world's urban population by major area. *Source: (UN, 2012)*

People in developing countries, especially those in urban areas that lack access to water supply and sanitation, are not directly affected by water scarcity. Today more than 1.2 billion people use less water than the basic water requirement per capita per day, and many lack access to safe water and affordable water (UNICEF and WHO, 2012). Water service delivery is poor, because they do not have access to sufficient financial resources either to avail themselves of the services or to live in sufficient urban water management areas.

The Millennium project (2005) noted that the urban population in developing countries will grow dramatically, generating demand well beyond the capacity of already inadequate water supply and sanitation infrastructure and services (UNMP, 2005).

Water scarcity issues and the way they are addressed will affect the successful achievement of most MDGs. The Millennium Declaration of the United Nations draws attention to the importance of water for development and poverty reduction, with Target 10 of the MDGs being to '*Halve, by 2015, the proportion of people without sustainable access to safe drinking water'.* The aim is to make available at least 20 litres per person per day from a source within 1 kilometre of the person's dwelling.

In Asia, up to 50% of the urban population lacks adequate provision of water, while up to 60% lacks adequate sanitation (UNESCO et al., 2012). Despite the MDG target noted above, about 800 million people will not have safe water access by 2015 and about 1.8 billion people will be without sanitation. By 2030, an estimated three billion people will be without access to sanitation and/or water for producing food (UNDP, 2004). This means almost one quarter of the world's population face economic water shortage, which is defined as where countries lack the necessary infrastructure to take water from rivers and aquifers for their own use.

2.2.3 ECONOMIC DEVELOPMENT

Vorosmarty et al. (2000) found that the global water crisis is largely the result of population growth and also economic development rather than global climate change. One of the key factors of urban transition is that the nature and direction of urban change is more dependent on the global economy than ever before. Water use is not just governed by population growth. While, the world becomes rapidly urbanised and industrialised in order to provide jobs and food, so too will domestic and industrial demands rise in developing countries. Population growth of developing countries, and the associated water scarcity, has become a major factor impeding economic development and also business operations (UN and WWAP, 2003). Thus, industrialisation and business growth appears directly dependant on scarce resources in those countries, while water scarcity is likely to bring an increasing business risk. Water scarcity constraints on economic growth may be that there will be less likelihood of fresh water available, which could be problematic for key sectors such as global food security and reduced production growth in some countries (Barbier, 2004). Water scarcity also affects reduction in the per capita income of countries. (Molden, 2004) identify economic development threats to increasing demand, which developing and transit economies are more likely to experience due to physical water scarcity.

Furthermore, an increase in income following from economic growth leads to greater household water use per capita in order to achieve higher living standards, which are multiplied by the increasing number of people in developing countries. Economic growth leads to a large increase in water demands for industry due to expansion of electricity demand and industrial output. Alcamo et al. (2000) predicted industrial and business water demand will increase around 15% from 1995 to 2025.

2.3 WATER SCARCITY

Water scarcity occurs at the point where the aggregate demand for water by all users cannot be satisfied fully (UN, 2010). Water scarcity is thus a relative concept and depends upon both supply and demand. The main factors influencing water scarcity are climate variability, combined with population growth and economic development. Commonly used water scarcity indices have been developed in the last two decades.

Water scarcity induces competition for water between users, between sectors of the economy, and between countries and regions sharing a common resource, as is the case for international rivers.

Water scarcity in urban areas is defined as the imbalance between water supply and water demand via problems either of a limited supply, which relates to aridity and lack of financing for developing additional water resources, or increasing demand, which is the unsustainable management of the resource and lack of a demand management capacity of a society.

2.3.1 CORRELATIONS BETWEEN WATER SUPPLY AND DEMAND

Previous sections discussed supply and demand driven factors affecting water scarcity. Simplistically, the pattern of water scarcity in urban areas is presented in Figure 10. The figure shows water availability is shrinking due to climate change, domestic water demand increasing via population and economic growth, while urban water resource management still dominates supply side policies. In the figure, the shifted curves almost meet at one point, which represents 'absolute water scarcity'. In theory, these factors bring physical water scarcity to urban centres.

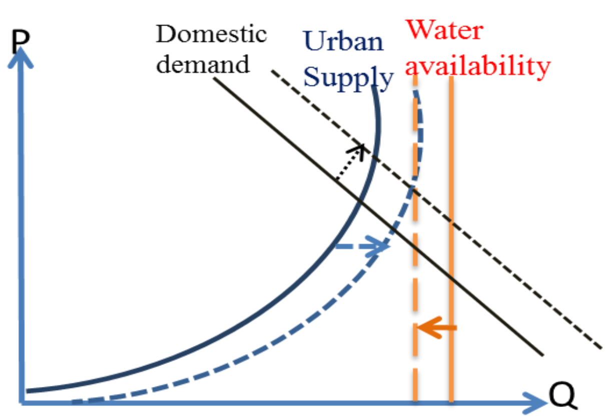


Figure 10 Factors affecting water scarcity in urban areas.

Demand for water has been increasing with urban population growth, while fresh water supplies from both surface and groundwater sources for domestic use are becoming increasingly scarce. The combination of growing populations, increasing demand for resources associated with improving standards of living, and various other external forces are increasing demand pressures on local and regional water supplies required for domestic purposes and industrial uses. Water scarcity is becoming more closely aligned with economic capacity, especially as there is typically a correlation between household water scarcity and poverty in developing countries. While households in informal settlements use less than half the amount of water used on average in the same cities – owing to poorer availability and access – they also face greater costs: the median water price in informal settlements is almost five times the average price (UN - Habitat, 2010).

2.3.2 INDICATORS OF WATER SCARCITY

The appropriate scale for understanding water scarcity is at the local level within a river basin rather than at a national or global level. Kummu et al. (2011) examined water stress indices for 284 sub-basins throughout the world over 200 years (Kummu and Varis, 2011). They found that water shortages became significant in the early 1900s, when 2% of the world population faced chronic water shortages (defined as <1000 m^3/capita/year). By 1960 this percentage had risen to 9% and by 2005 35% of the world's population lived in areas typified by chronic water shortages.

In 1999, approximately one-third of the world's population lived in countries experiencing moderate to high water stress. Maplecroft (2010), employing the Water Stress Index, identified the Middle East and North African countries of Egypt, Kuwait, UAE, Libya and Saudi Arabia as the most exposed to water stress (Figure 11). However, Australia, India, China, the USA, and African and South Asian countries have all been rated as facing 'extreme stress' because demand is exceeding 80% of total renewable water resources. The Asia-Pacific region, for example, is home to 60% of the world's population but holds only 36% of its water resources (APWF, 2009). The region is undergoing rapid urbanisation, economic growth, industrialisation and extensive agricultural development, affecting its capacity to meet its socio-economic water development needs.

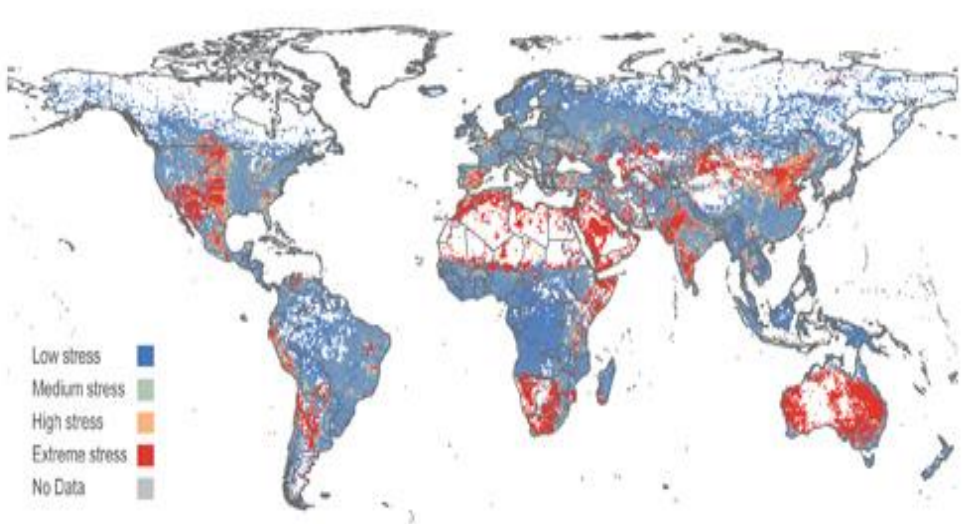


Figure 11 Water stress sub national map for high risk countries in 2010.*Source: Maple croft, 2010.*

Water scarcity can be measured using physical (Falkenmark, 1997, Rijsberman, 2006); (Falkenmark et al., 2007) and/or socio-economic (Shiva, 2002, Alcamo et al., 2007) indicators.

Around one-third of the global population is living in physical scarcity – water shortage and stressed – areas (Rijsberman, 2006). Physical water scarcity is commonly measured by the water crowding index, which uses the Falkenmark index, and the water stress index. A common measure of water scarcity combines information about available water resources and population, with physical scarcity driven by demand. The Falkenmark index is the most influential measure of water, with a scarcity threshold – the cut-off point for water stress – of 1,700m^3 per person per annum (Gleick, 2002). The World Bank's Bench indicator for scarcity is 1,000m^3 per person, while Falkenmark (1997) referred to a level below 500m^3 as absolute scarcity (Falkenmark, 1997).

Falkenmark's water scarcity indicators and found that they were easy to apply and understand but did not help to explain the true natural scarcity such as it relates to water for food, domestic, industrial and environmental requirements (Rijsberman. R. F., 2006). Thus, Raskin et al. (1997) developed the water resource vulnerability index. This index measures a ratio of annual withdrawals and annual supply; where annual withdrawals are between 20% and 40% of annual supply it is a water scarce country, while over 40% represents a severely water scarce region.

Ohlsson (1999) developed the 'social water stress index', which is indicated by UNDP's Human development index to weight the Falkenmark's index. This index has improved on the Water Poverty Index (WPI). Water poverty is a relatively new concept that has been defined as 'a situation where nation or urban centre cannot afford the cost of sustainable safe and clean water to all people at all times', where 'all times' implies that water is available for future generations also (Feitelson and Jonathan, 2002).

Later, Lawrence et al. (2003) improved the WPI, which measures household welfare with water availability and indicates the degree to which water scarcity impacts humans. In contrast, the index links to Human Development Index (HDI), so, it measures water scarcity with associating physical and socio-economic factors such as resources, access, capacity, use and environment. (Lawrence et al., 2003). The Centre for Energy and Hydrology estimated the water poverty index, which assesses actual and potential water stress for particular communities and how changes in water availability and provision will contribute to poverty elimination by the sub-national map, which presents water poverty and shows that it is dominated by African and Asian countries in 2011 (see Figure 12).

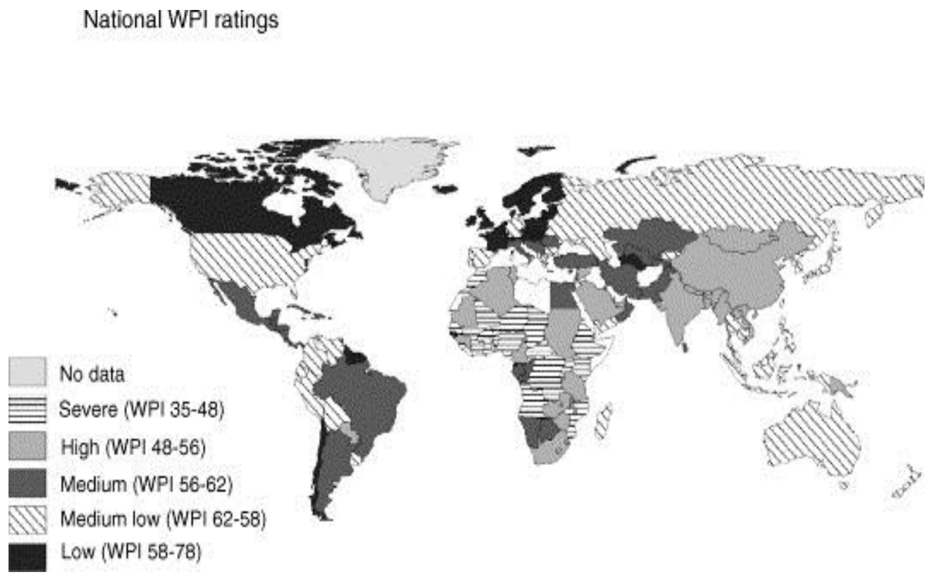


Figure 12 The indicated water poverty of the global in 2000.*Source: (Wallace, 2000)*

The International Water Management Institute developed a physical scarcity index using the proportion of renewable freshwater resources available for human requirements (taking into account existing water infrastructure), from a nation's main sources of water supply (Rijsberman, 2006); this is shown in Figure 13. The analysis labels countries as 'physically water scarce' when more than 75% of river flows are withdrawn for agriculture, industry and domestic purposes. Countries are defined as having 'adequate renewable resources' when less than 25% of water from their rivers is withdrawn for human purposes.

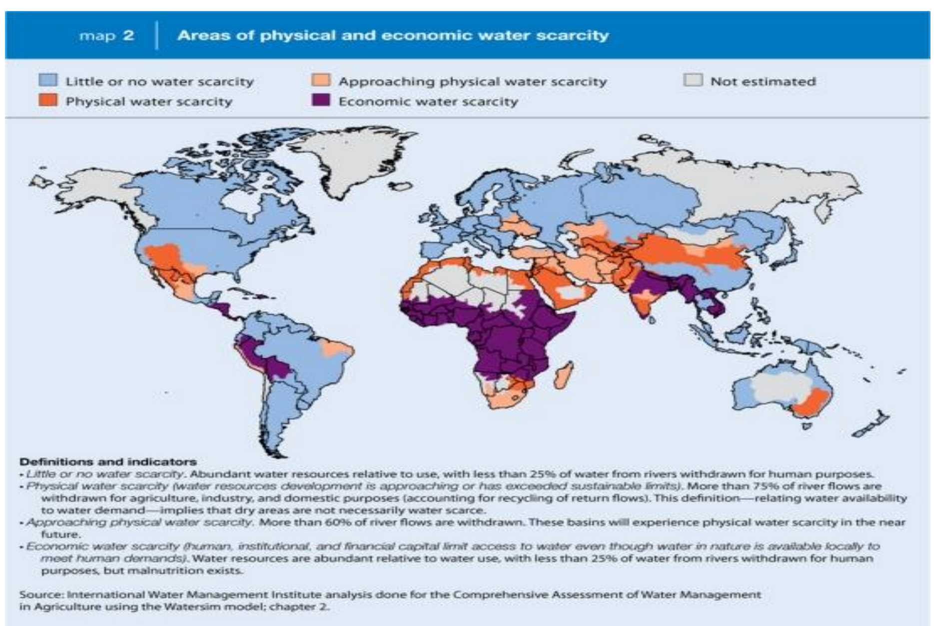


Figure 13 Areas of physical and economical scarcity. *Source: (GRID, 2008)*

Countries that have sufficient renewable resources, but would have to make very significant investment in water infrastructure to make these resources available to people, are defined as ‘‘economically water scarce’’(Seckler et al., 1998).

2.3.3 PROJECTIONS FOR SCARCITY IN THE WORLD

Alcamo et al. (2003) present a projection of global water scarcity areas from 1995 for three decades. They noticed that demand has continually grown so that ‘severe water stress’ areas mostly in developing countries are projected to increase from 36.4 to 38.6 million km^2 for the following three decades (Alcamo et al., 2000). The United Nations (UN) predicts that the global water consumption rate will double every twenty years, a pace that is twice the rate of population growth (Leete et al., 2003).As much as 2.8 billion people in 48 countries are predicted to face water stress by 2025; this will be especially significant in Southern Africa, Western Africa, and Asia (UNESCO, 2003).

Figure 14 shows more detailed information about the prediction. Alcamo et al (2007) note that the world water situation will undergo significant changes in the coming decades, with large geographical differences in directions and causes. They predict that water stress will increase in most developing regions, but will decrease to a significant extent in industrialised regions. Moreover, the Stockholm Environment Institute estimates that, based on only a moderate climate change, by 2025 the proportion of the world’s population living in countries of significant water stress will increase from approximately 34 per cent (in 1995) to 63 per cent – some six billion people (Pachauri, 2004). This predication was based on freshwater resources and population at a national level, thus, this figure does not present water scarcity at regional and local levels, which would be the most affected by water shortage.

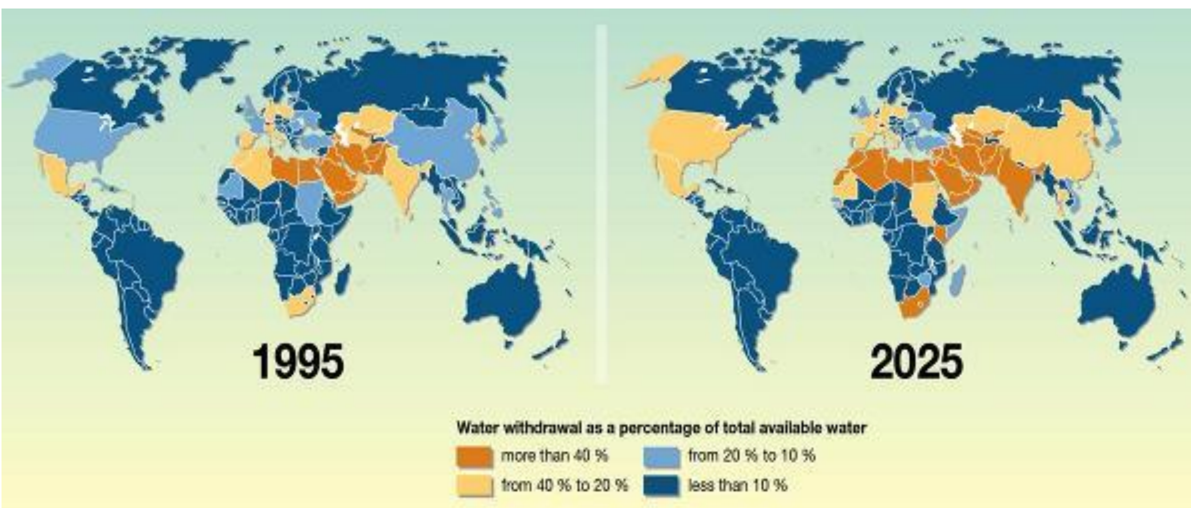


Figure 14 Increased global water stress. *Source: (WHO and UN - Habitat, 2010)*

Bates et al. (2008) showed that domestic water demand is an important factor for predicted and actual population growth in water stressed and scarce urban areas. The world's population grows by around 80 million people a year, implying increased freshwater demand of about 64 billion cubic metres every year (WWAP et al., 2009, Kjellen and McGranahan, 1997). By 2025, 1.8 billion people will be living in countries or regions typified by absolute water scarcity, while two-thirds of the world's population could face conditions of water stress (UN-Water, 2007) and about fifty countries will struggle against water scarcity in 2050 (UN and WWAP, 2003). The report noticed that by 2050, the global population could reach 9.3 billion, with an estimated urban population for developing countries around three times greater than the 1970s by 2050. The situation will be exacerbated as rapidly growing urban areas place heavy pressure on local water resources; an estimated 5 million people migrate from rural to urban areas in developing countries every month. Future demand for water is strongly related to values and lifestyles of future generations and for developing countries' water demand for food.

Figure 15 shows projected water scarcity in 2025 and the types of water scarcity. Nations with physical water scarcity are in North Africa (Sahara Desert), the Middle East (Arabian Desert), Iran, Pakistan, Afghanistan, Northern India and Northern China (Gobi Desert), and nations with economic scarcity are in Central and Southern America, Central Africa, SE Asia and Australia (Rijsberman, 2006). Furthermore, very few countries' water issues have not predicted the including of Mongolia and Romania.

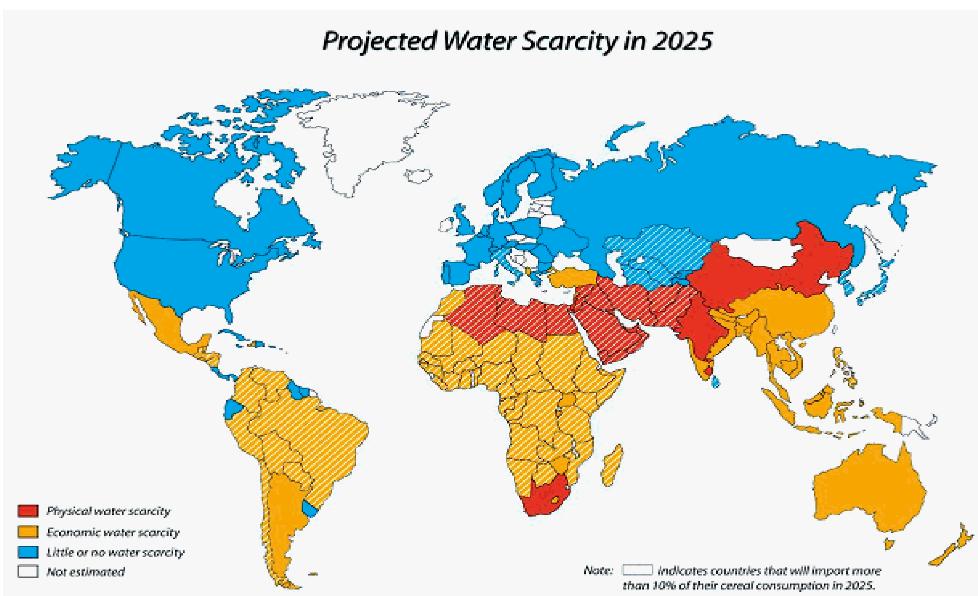


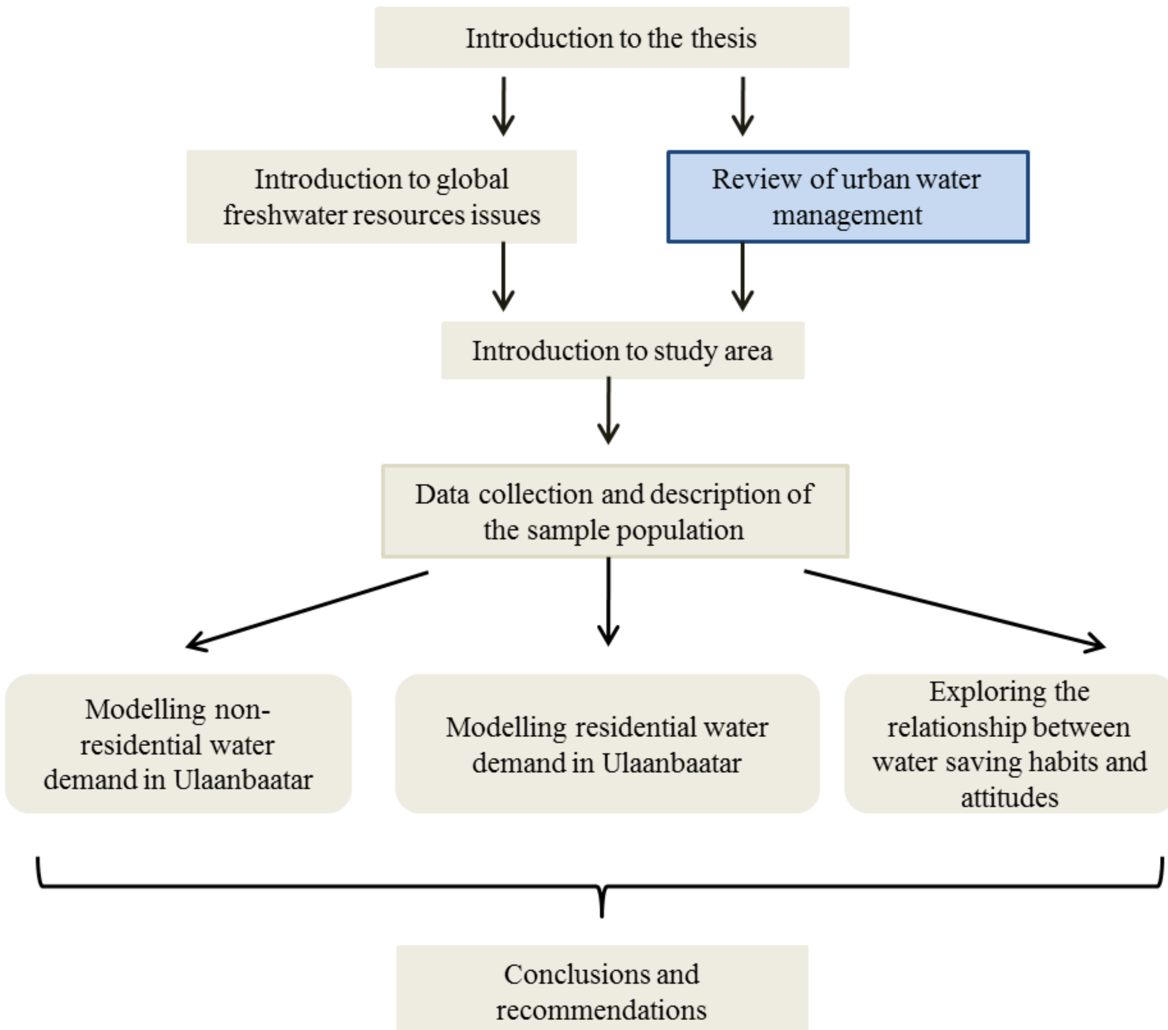
Figure 15 Projected water scarcity in 2025 by nations. *Source: (Rijsberman, 2006)*

Seckler et al. (1998) and Alcamo et al. (2000) estimate that four billion people, which is more than half the world's population, will be living in high water stressed regions by 2025. Water will be scarce in urban areas particular in Central and West Asia and North Africa with low precipitation and relatively high population density. Future water demand will depend on the amount of food, energy, industrial activities and urban water and related water services that are needed to meet the requirements of growing populations and changing socio-economic conditions. Historical techniques for meeting water demands will no longer be reliable for predicting future climate – sensitive water demand (House-Peter and Chang, 2011).

2.4 CONCLUSION

- The growth of shortages of freshwater supply has been dramatic in various parts of the world as a consequence of climate change and population growth.
- The global average temperature will increase more than 5°C in this century,
- Over 330 million people may be permanently or temporarily displaced through flooding, while one billion people living in urban slum areas may also be vulnerable to flooding
- The world population will reach 9.3 billion in the next four decades.
- The number of people living in urban areas is expected to double to more than 5 billion by 2025, with 90% of this increase occurring in developing countries.
- One hundred years ago, 2 out of every 10 people lived in an urban area. By 1970, less than 40% of the global population lived in urban areas, and around 70% of the world population will live in urban areas by 2050.
- Many urban areas rely on groundwater resources, which have declined due to human activities and climate change.
- Water demand per capita has been disproportionately rising due to improving living conditions.
- Future demand for water is strongly related to values and lifestyles of future generations.
- Population growth in developing countries, coupled with water scarcity, has become a major factor impeding economic development and business operations; industrial and business water demand has been projected to increase around 15% from 1995 to 2025.
- Economic development is associated with increased water demand, so developing and transit economies that have high rates of economic growth are likely to be particularly vulnerable to the problem of water scarcity – even if climate change does not impact water supply.
- Water scarcity problems are thus likely to get worse, particularly in the urban areas of developing countries.

Thesis layout



This chapter introduces the best or most appropriate urban water resource management policies in urban areas of developed countries and these could solve water scarcity for urban areas in other parts of the world. Urban water management policies, particularly demand side management policies, aim to provide sufficient and safe water to all users through improving efficiency of water use. Better urban water management policies are needed for urban areas in developing economies to meet two main issues in relation to water supply: inequitable distribution and inadequate natural resource. Increasing water scarcity, coupled with hydrological and financial limitations to the development of new resources, have catalysed a shift to demand management (Vairamoorthy et al., 2008), which is a relatively new branch of urban water resource management. This chapter details urban water management policies that not only focus on inducing users' water consumption directly but also indirect ways such as influencing water saving habits for improving efficient water use (Figure 16 Structure of Chapter Three.).

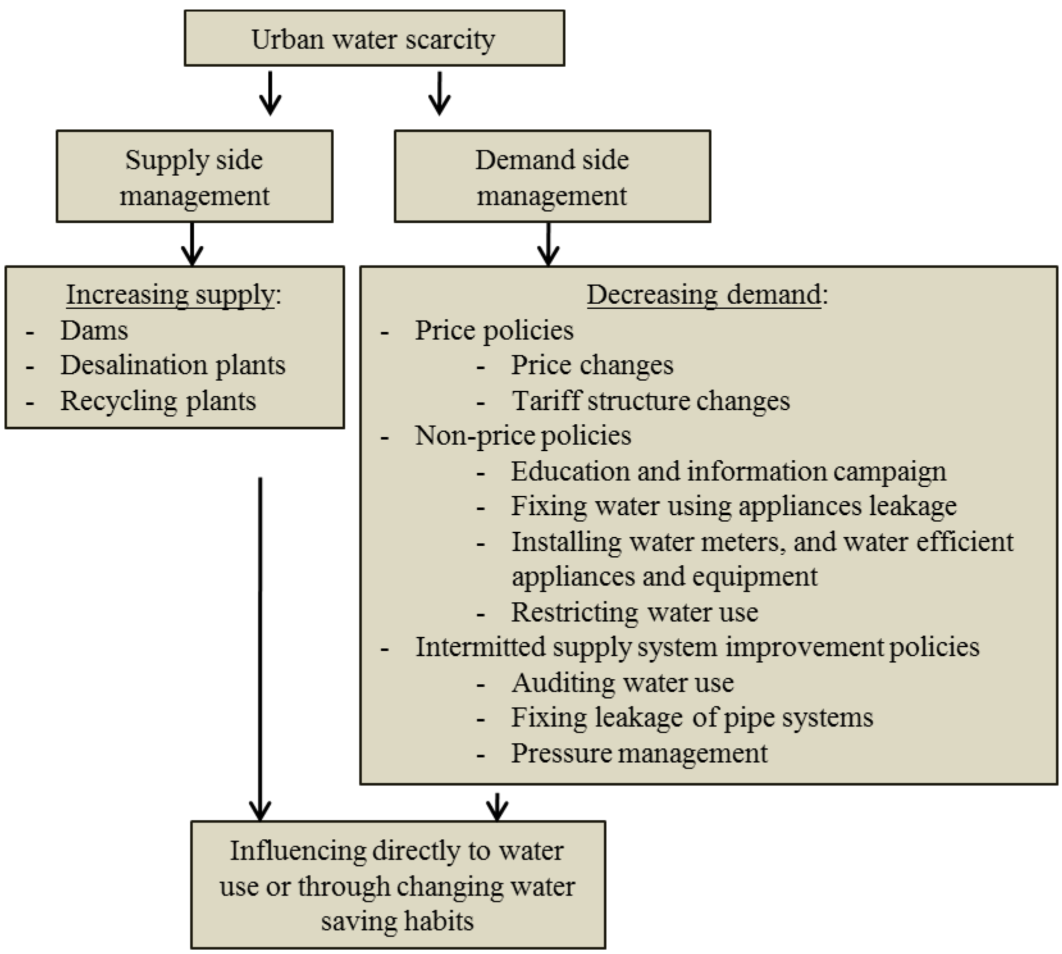


Figure 16 Structure of Chapter Three.

3.1 REVIEW OF URBAN WATER MANAGEMENT

Water scarcity in urban areas relates to the three dimensions of scarcity i.e. quantity, quality and institutional capacity. However, the literature of water resource management presents huge amount of studies on only the quality and institutional capacity dimensions, particularly in the many studies of mostly African countries. So, attention on the quantity of water is studied in developing countries fewer when compared to industrialised economies. Perhaps it relates to the availability of data to estimate water demand and to reveal the effectiveness of urban water management policies in developing countries.

The term 'urban water management' is used to describe the strategies used within urban areas and cities to manage both the supply of and demand for water. Experiences and practices of urban water demand management from Baumann et al (1997) for industrialised economies and from Butler and Ali Memon (2006) for developing countries were reviewed, with the numbers of articles about urban water demand management including price and non-price policies briefly summarised. In the 1960s, demand management studies began with estimating the effectiveness of price policy in regard to residential water demand (Howe and Lineweaver, 1967) and to non-residential water demand (Turnovsky,1969). The summary of literature (Table 2) suggests that demand management, particularly in involving residential/household water demand studies (2,308 research articles), has been developing in industrialised economies since the 1970s and more recently developing countries have given it more attention (36% of the articles related to DTEs). There are only 92 studies from 1960 to 2013 that look at the effectiveness of price policy for non-residential users, which are a lot fewer than those for residential demand.

Table 2 Number of urban water demand management studies in each decade and in each policy type.

Decade[1]	Urban water demand management		Price policies				Non-price demand management policies					
			Residential		Non-residential		Urban		Residential users		Non-residential users	
	All*	DTE*	All	DTE	All	DTE	All	DTE	All	DTE	All	DTE
1960 to1969			9	2	4							
1970 to 1979			93	20	10		3	1	3		1	1
1980 to 1989	5		128	23	4	2	6	6	6	5	5	5
1990 to 1999	50	10	212	64	13	2	25	19	29	20	22	17
2000 to 2009	344	168	1,160	449	49	20	69	50	70	45	48	36
2010 to 2013	161	84	706	278	12	6	32	19	37	21	18	11
Total	560	262	2,308	836	92	30	135	95	145	91	94	70

*All =all studies; DTE=Developing Transit Economies

[1] Studies were searched from Google scholar under the phrase: 'urban water demand management studies' or in developing countries; 'water demand estimation' or in developing countries; and "non price policies" urban water demand or in developing countries.

Urban water demand management (560 articles) has been also been more studied since the 1990s for industrialised economies and developing countries have also been paying attention to this management (262 articles) since the last decade, while most studies were concerned with residential water demand and later on non-residential water demand. Several studies present urban non-price policies (135 articles), residential (145 articles) and non-residential (94 articles) users. Most non-price policies studies considered outdoor water use, especially in efficient irrigation systems and restrictions. The summary in Table 3 shows that quite a lot of articles of non-price policies relate to developing countries, although the engineering-oriented solutions still dominate expansion of water supply with little attention to conserving water through controlling and modifying water demand in developing and transit economies.

Table 3 Summary of demand studies by user group.

	Developed countries		Developing countries	
	Residential	Non-residential	Residential	Non-residential
Price policy				
Pricing policies	√	√	√*	√***
- Identify water conservation potential from pricing policy	√	√		
- Identify revenue potential from pricing policy	√			
Installing of water meters	√	√	√	
Billing reform	√			
Non-price policies				
Education and information campaign	√	√	√	
Mapping water use –water audits		√		
Revision of plumbing, building and landscaping codes	√			
Fixing water using: - appliances - equipment	√	√		
Adoption and retrofit of water conservation technologies - Efficient showerhead - Tap aerator - Efficient toilet	 √ √ √			
Reduction of unaccounted for water: - Leak detection - Reduction of system pressures	√			
Restriction: -limit time or -limit quantity of outdoor use	√			
Moral persuasion for voluntary reductions	√			
Encouragement of recycling and/or recirculation	√	√		
Water saving habits				
Water saving behaviour	√			
Conservation activities	√			

√ - several studies; √* - few studies; √*** - very few studies

Consequently most demand management studies involve energy, agriculture, food and transport in developing countries. Thus, the literature of demand management studies in developing countries show little evidence of best practices on urban water demand management policies.

Implementation of demand side management policies are summarised for developing and developed countries by residential and non-residential users. This table shows that most demand side policies including common employed price, non-price policies and policies for increasing water saving habits are practised and targeted to residential users of urban areas in developed economies.

Water demand management encompasses two interrelated activities for improving water use efficiency: inducing water saving habits and efficient allocation of available water among competing uses through improving the supply system by leak detection and repair, and pressure reduction in distribution systems.

Dzeigielewski et al. (1993), White et al. (2003b), and Terrebonne (2005) reviewed and evaluated demand side management policies/programs that can influence urban water demand, particularly residential water demand, by reducing water consumption through pricing, regulation-institutional, restriction, technical-operational and knowledge and awareness in developed countries. Moreover, introducing adaptive demand management policies including enhanced supply by improving the efficiency of existing water supply systems, increasing water productivity and ensuring equity among users. Most studies consider price policy effectiveness of residential water demand in developed countries. Only a few studies, except for the recommendations for acceptable techniques by Koundouri et al., (2003), and Vairavamoory and Mansoor (2005), reviewed urban water conservation practices of demand side policies/programs in developing countries (Koundouri et al., 2003, Butler and Memon, 2006). The traditional way – supply side management policies – still dominates in developing countries.

3.2 URBAN WATER SUPPLY SIDE POLICIES

The world, particularly in developing countries, has been facing growing problems in providing water services. As a human right Gleick (2000) recommends that governments have to consider efficient water allocation among users to secure equitable access of water availability, whether the country is water stressed or not. Thus, developing countries still attempt to achieve MDGs that add pressure to expanding urban water supply.

Many urban areas face water stresses that will require expansion of water supply and distribution facilities. Moreover, they only have the choice to expand supply through adding new water resources. Water sources such as seawater, deep aquifers and polluted surface water are often available for domestic use when there is enough money to invest in their extraction, treatment and distribution. Current examples include:

- Beijing has to transport water from over 1,000km away from the city.
- Riyadh, in Saudi Arabia, along with Mexico City, may soon be forced to pump water 2,000m deep.
- In Amman, Jordan, the average incremental cost for groundwater supply has risen from US $0.41 to US $1.33 per cubic meter as groundwater resources become scarcer.

Increasing demand may require more expensive supply side solutions and, perhaps, an unwillingness or inability to pay for those solutions (Baumann et al., 1998). So, in the short term, water scarcity might be mitigated through expensive supply side solutions. These are not appropriate in the long term for semi-arid and land locked countries, which mainly use groundwater. Typically the rate of renewal is much slower than surface water. China and India are seeing growth limited by reduced water supplies from depleted groundwater and shrinking glaciers that sustain key rivers.

Urban areas where face water scarcity or stresses places may be necessary to augment supply methods through constructing dams, and building desalination and recycling plants.

3.2.1 CONSTRUCTING DAMS

The traditional, engineering response to water scarcity has been to construct infrastructure, particularly dams, to increase human control over water resources and make a larger share of the total renewable resources available for human use. Many urban areas of the world are supplied with water extracted from rivers stored behind low dams. A dam captures flood water, prevents flood damage and makes the excess water available during dry periods.

During the last century, large dams emerged as one of the most significant and visible tools for the management of water resources. Existing dams have reached more than 45,000, playing an important role in supporting communities and economies to harness water resources for food production, energy generation, flood control and domestic use (WCDR, 2008). However, dams fundamentally alter rivers and ecosystems, resulting in significant impacts on livelihoods and the environment; these impacts are more negative than positive. The World Commission on Dams Report (2008) reviewed experiences from 1,000 dams in 79 countries and reported that dams have physically displaced 40–80 million people worldwide, and most of these people have never regained their former livelihoods.

3.2.2 CONSTRUCTING DESALINATION PLANTS

With the growing shortage of freshwater resources, desalination of seawater could be an option, but it is often a very expensive water supply augmentation method and is obviously not an appropriate solution for land locked countries.

The production capacity of all desalination plants worldwide was 44.1million m^3/d in 2007 with a prediction that the capacity would be doubled by 2015. The largest producer of desalinated water in Gulf countries produces 19.4 km^3/d, which is 25% of worldwide seawater desalination capacity.

Figure **17** presents the global desalination in sub-regions and their daily capacity (Lattemann, 2010), with the top 10 countries of the largest desalination being industrialised economies.

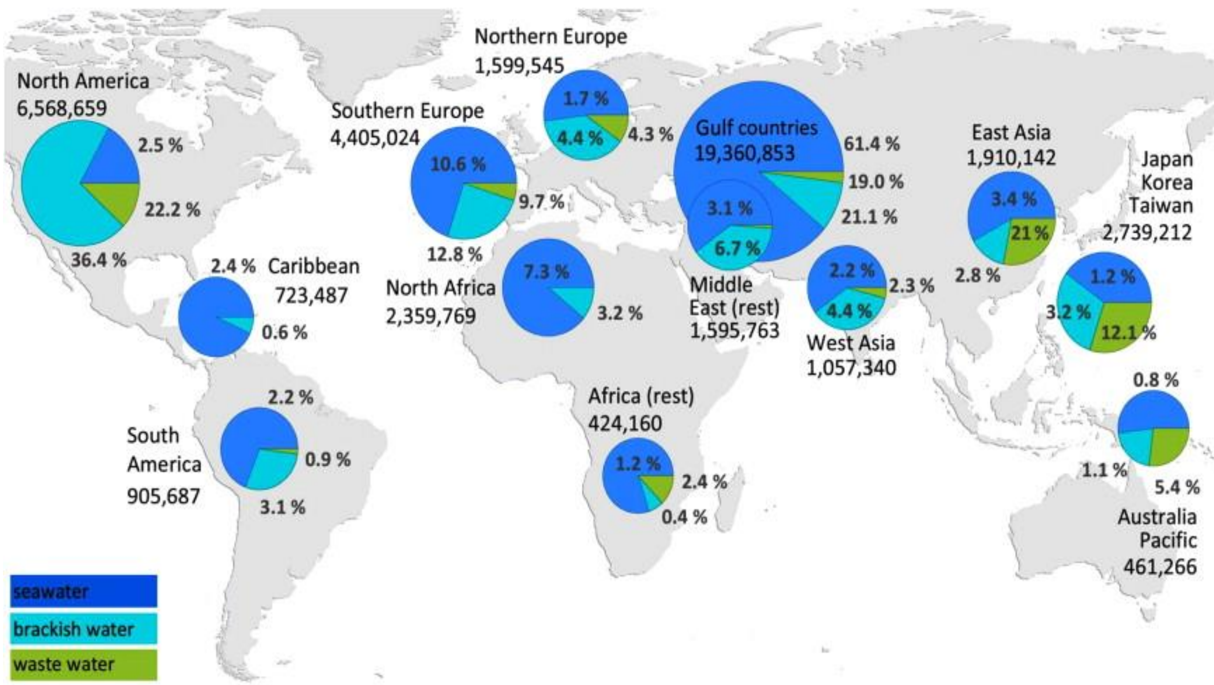


Figure 17 Global desalination capacity in m^3/d and percentage. *Source: (Lattemann, 2010).*

Figure 17 shows that there is less evidence of desalination in developing countries. The current political barrier to water suppliers and relatively high costs of desalination suggest that water demand side management might be the only option for providing current and future water in urban areas of water stressed regions. For example, the policy of the government of the Australian Capital Territory (ACT) is to avoid building further major water supply dams, with demand management targets of 12% and 25% reduction in per capita demand by 2013 and 2023, respectively (UNDP, 2006).

3.2.3 CONSTRUCTING RECYCLING PLANTS

A definition of recycling water is that of treating wastewater for recharging groundwater aquifers or industrial cooling or using for non-potable water for functions such as flushing toilets at home (Durham et al., 2005). Recycling is a key component in securing water supply for water stressed and becoming water scarce regions and areas. Recycling of grey-water reduces water usage by approximately 30–35% of Sydney' s domestic water use (Sydney Water, 2010) and in Australia, an achievable target is 20% reuse of wastewater by 2012 (Durham et al., 2005).

As Australia struggled through a 7–10 year drought, nationwide recycling effluent became a popular option (Power, 2010). Local level examples are the construction of three advanced water treatment plants in south-east Queensland, which have a capacity of producing 232 ML of purified recycled water daily in 2010 (WCRW, 2010). Another example is that of Sydney water conservation initiatives for the period 2009–2010 that saved about 116.7 GL of water during this period. The recycling program replaced 12.4 GL per year, while the regulatory measures replaced 32.8 GL per year (Sydney Water, 2010).

Recycled water, at first, appeared to be the panacea to the problem of growing water scarcity, especially in urban areas where climate change has threatened long term water security and reduced rainfall over catchment areas. Recycling wastewater has some disadvantages, such as high costs of water treatment, construction of infrastructure and waste disposal problems. There are several examples of using additional water resources in industrialised economies, but the disadvantages of the solutions are expensive investment and high costs of maintenance and operation of the plants for developing countries. Developed countries have refocussed on demand side management instead, the idea being to improve the efficiency with which water is used, thus reducing the need to use expensive supply side approaches (Griffin, 2006a).

3.3 URBAN WATER DEMAND SIDE POLICIES

In many cases the supply-driven approach to development does not take sufficient account of the limits of the water systems, much like the energy sector (although the US has been trying to manage peak demand in the energy sector since the 1970s).Thus, Falkenmark et al. (1997) recommended that decision makers should first focus on managing demand for water, with efforts to increase supply secondary to demand management. Several studies (Renwick and Archibald, 1998, Renwick and Green, 2000) have shown that water scarcity and the need for demand side management is a viable tool for managing municipal water for various reasons, including postponing a large amount of investment, decreasing operation and maintenance costs and minimising environmental impacts of increasing withdrawals (Waller and Scott, 1999). Water demand management more generally aims to increase water use efficiency. The regions, where face water shortage or stress, need to focus on the efficient use of all water sources (groundwater, surface water and rainfall) and on water allocation strategies that maximise the economic and social returns to limited water resources. Water demand side management can also be defined as any activity that reduces the amount of water used or that enables water to be used more efficiently (Brooks, 2006).

Water demand management encompasses two interrelated activities: improving water use efficiency and efficient allocation of available water among competing uses. Urban water demand management is defined by the development and implementation of policies/strategies focused on influencing demand for achieving more desirable allocations and sustainable use of water. Furthermore, demand management is focused on making better use of existing supplies, rather than developing additional ones (Winpenny, 1997). Demand management will, thereby, contribute to water conservation (Greenberg and Harshbarger, 1993).

The principal goals of water demand management are: the efficient allocation of scarce water resources; and improvements in efficiency of use through changes in end users' behaviours or via improved efficiency of water using appliances and equipment. Demand side management policies influence demand directly and indirectly by inducing water saving habits. Increasing price policies could reduce demand in the short run and encourage adoption of water efficient technologies and water saving habits in the medium to long run. Water saving habits could be identified by behaviour change (shorter showers) and technical change (efficient showerheads) of water use. Behavioural change can be promoted by providing information and implementing education strategies, applying economic instruments and socio-political strategies. Technical change of water saving habits relate to engineering solutions through adopting water efficient devices.

Demand side policies are divided into two main groups of policies: price and non-price policies. Water price policies may also play an important role in technology adoption and in changing water saving habits. A review of demand side management policies found that lower income households contribute a greater share of a city's aggregate water consumption reduction than they do under non-price demand management policies (Olmstead and Stavins, 2008). They also found that increasing price policies influence reduction in demand and increases in total revenue, while mandatory (when well enforced) polices are more effective than voluntary policies such as information and education programs (Olmstead and Stavins, 2007).

3.3.1 PRICING POLICIES

The most cost effective tool for solving water scarcity in urban areas is better pricing for water. Analysing and forecasting urban water demand to gauge the effectiveness of price policies is complex. As a theory, price policies seek to cause movement along the curve (e.g. from A to B in Figure 18), although water pricing is often much more complex than this because it involves the use of different price structures such as block tariffs.

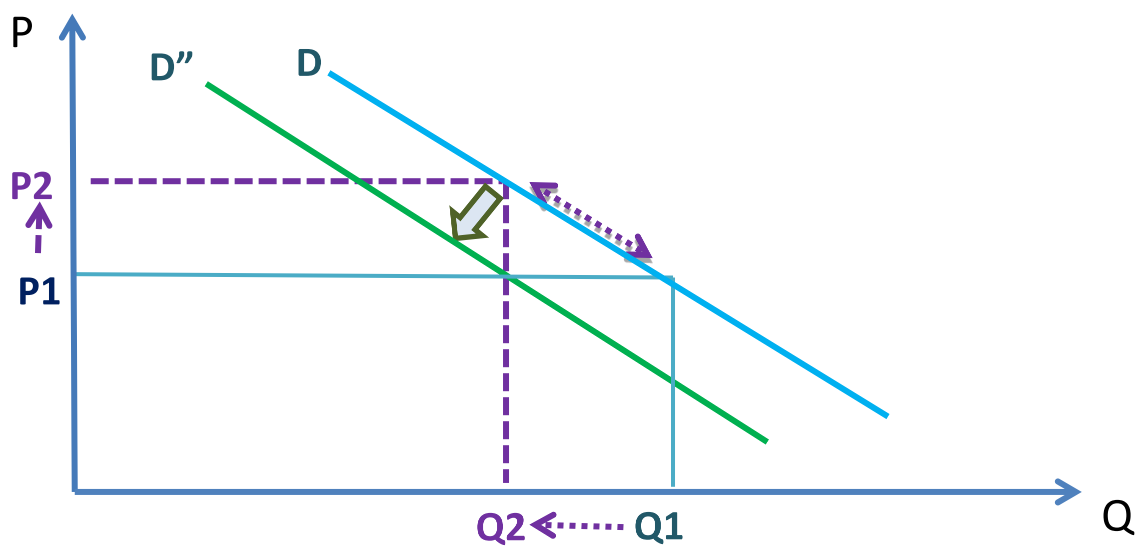


Figure 18 Interrelationship between price and quantity.

There are a variety of different ways of pricing water in urban environments, all of which require authorities to install water meters. In the literature, many examples confirmed that the metering installation programs are an effective means of reducing demand – even when users are not charged for their consumption (Renwick and Archibald, 1998). The price policy in urban areas is to charge a price that increases or decreases according to a scarcity price in drought periods and in using single and two part rates or fixed rate to uniform rate (Figure 19). A comprehensive discussion about the pricing of water and water tariffs in developing countries is provided in Whittington and Boland (2001) and a brief summary is provided below:

- The single rate approach consists of a fixed charge (flat rate) irrespective of how much water is used.
- The two part rate uses both a fixed fee and a volumetric charge, which requires water metering to end users. The volumetric charges can be uniform, where the same tariff is applied to each cubic metre of water used, independent of the level of consumption, or can use block structures (either decreasing block tariff (DBT) or increasing block tariff (IBT)).
- A DBT means that the price falls as consumption rises and an IBT results in the opposite. In an examination of low water tariffs and tariff structures in the USA, decreasing-block rates, under which the unit rate decreases with consumption, were found to offer minimal incentives for water conservation (USEPA, 2002).
- Whittington and Boland (2001) suggested that cities in developing economies should use an IBT. When low water tariffs and inappropriate tariff structures were employed, they do not encourage water conservation. Residential monthly water consumption between 1976 and 1985 in a study in Denton, Texas found that a significant price affects the block rate (Nieswiadomy and Molina, 1989b), in particular that an increasing block rate is more conservation oriented (Nieswiadomy and Cobb, 1993). This circumstance suggests that the city needs to adapt tier block tariffs for water that are more manageable for a seasonally scarce source.
- Most researchers agree that IBTs are the most efficient methods for reducing water consumption.

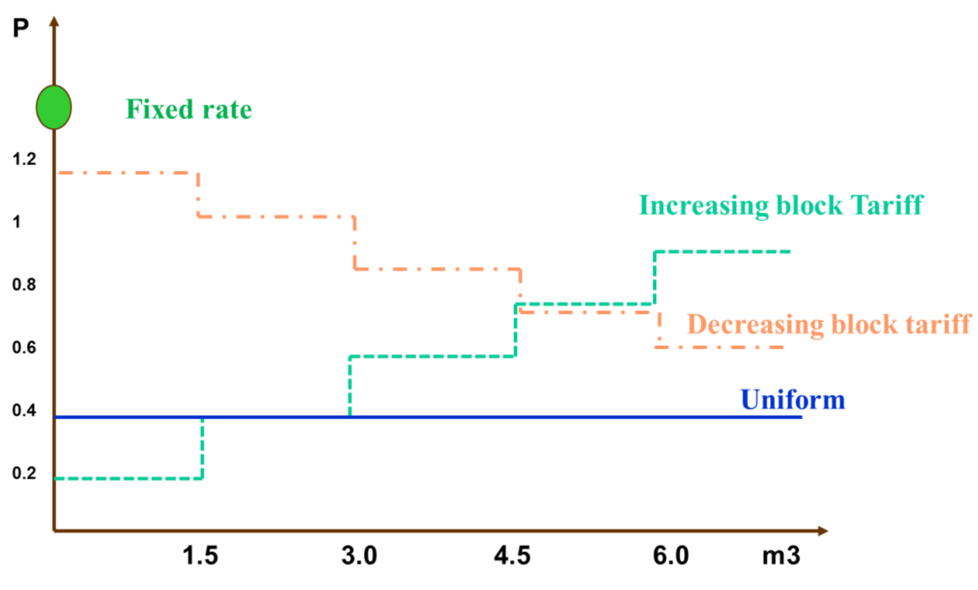


Figure 19 Tariff structure (vertical axis presents price and horizontal axis presents quantity).

In general, prices affect water use. However, it is often difficult to assess the strength and shape of the relationship between complex price structure and water consumption. Nieswiadomy and Cobb (1993) showed residential users reaction to average price under volumetric charge. In particular they showed that increasing block rate appears a more conservation oriented structure and adopting water efficient technology. Increasing price policies affects reduction of water consumption for low-income compared to high-income households (Olmstead and Stavins, 2008, Renwick and Archibald, 1998, Agthe and Billings, 1987). Renwick and Archibold (1998) found that price responsiveness varies by income group. Price policies are more effective in the short run than in the long run because capital investments are not fixed for long time periods.

Literature on urban water management shows that residential water demand is relatively inelastic compared to non-residential water demand, and will not react much when prices change (Renzetti, 2002b, Baumann et al., 1998, Espey et al., 1997).

A few studies (Espay et al., 1997; Dalhuisen et al., 2003; and Arbues et al., 2003) have performed meta-analyses of price policies' impacts on residential water demand for developed countries and developing countries cases as reviewed by Nauges and Whittington (2010). Overall, summaries of elasticity estimations show that the mean price elasticity is -0.38, with a standard deviation of 0.53 (Waddams and Clayton, 2010). Empirical estimates cover a sizeable range of values from -7.47 to 3.5and of the 1,308 price elasticity estimates, 204 of these are positive (Dalhuisen et al., 2001). Overall, summaries of elasticity estimations show that the mean price elasticity is -0.38, with a standard deviation of 0.53 (Waddams and Clayton, 2010).

The reviews of residential water demand show that price elasticity estimates are generally found in the range of zero to -0.5 in the short run and -0.5 to unity in the long run (Worthington and Hoffman, 2008) in industrialised economies and in the range for water from private connections from -0.3 to -0.6 in developing countries (Nauges and Whittington, 2010). The price elasticity should be inelastic, however, there is some evidence of elastic demand for households of Metro Manila, Philippines (-2.1) and Jakarta, Indonesia (-1.2), and very little evidence estimates and compares price elasticities of tap and non-tap residential water; surprisingly industries of Northern Taiwan (-4.37 and -0.02) and department stores of the USA (-1.33) were estimated (David and Inocencio, 1998, Rietveld et al., 2000a, Liaw et al., 2006, Williams and Suh, 1986). Few studies reviewed estimations of industrial and commercial water demand of developed economies (Renzetti, 2002a, Gispert, 2004), while very few studies estimate industrial and commercial water demand of developing and transit economies (Toteng, 2004).

A large body of empirical economic literature on residential water demand has been devoted to measuring the impact of price policies (Espey et al., 1997, Arbues et al., 2003, Nauges and Whittington, 2010, Worthington and Hoffman, 2008). The most direct economic tool for inducing water-conservation behaviour is price policy, which encourages behaviour through market signals by the law of demand because demand is inversely related to the price for water.

Very few researchers have reviewed the effect of price on non-residential water demand, which is markedly different from residential water use. In the industrial case, the elasticity obtained takes values ranging from -0.11 to -0.975, depending on the price measure being used (Schneider and Whitlatch, 1991, Gispert, 2004). In the domestic case, the values range from -0.179 to -0.483, and in the commercial case from -0.141 to -0.360 for short run and -0.92 for long run and average values for the estimated own-price elasticity for the water intake range from -0.15 to -0.59 (Gispert, 2004), and in the government case -0.438 for short term and from -0.781 for long term (Schneider and Whitlatch, 1991).

Few studies on non-residential demand reviewed the price elasticities of non-residential demand for water which are substantially higher than residential users (Worthington, 2010, Dharmaratna and Parasnis, 2010). This suggests that the non-residential demand for water is potentially more price responsive and may therefore indicate opportunities for substitutability between differing qualities of water, including recycling.

Conservation-oriented water rates are uniform, increasing-block, and excess-use rates and moreover price elasticity is higher under increasing block price than uniform prices (Corral et al., 1999). Gaudin (2006) found that price elasticity may rise by more than 30% when price information is on water bills. Urban areas in developing countries often have equity issues on water use that relate to urban planning particularly the role of land use planning regulation such as zoning and density as a tool for reducing water consumption (Shandas and Parandvash, 2010). Their study confirms that there is a significant relationship between land use and water consumption, thus zonal price policies of urban demand side management might support efficient allocation of limited resources among users.

Price policies may be necessary but are not always an efficient way to motivate users to reduce waste and use resources wisely. Price policies are often effective in the short term but are also politically very difficult. Economists emphasise the strong empirical evidence that using prices to manage water demand is more cost-effective than implementing non-price conservation programs. Unfortunately, the impact of price changes on water usage is not always considered in the determination and allocation of utility revenue requirements.

3.3.2 NON-PRICING POLICIES

Non-price policies, which are often designed to increase efficient water use, often appear more politically or socially acceptable than price increase policies. Martinez-Espinera and Nauges (2004) found that when the price for water reached an insensitive threshold, non-pricing policies are more effective in reducing consumption than an increase in price. Although non-price policies are more cost-effective than price demand management (Olmstead and Stavins, 2008), non-price policies may have a more effective impact in the long run than price policies, while behaviour change may have only transient effects (Gilg and Barr, 2006).

Non-price policies, such as public awareness and education programs, are designed to inform consumers about their conservation options, use restrictions, the distribution of or subsidies for alternative water use technology, and matters such as plumbing codes that require the installation of water conserving fixtures. Simplistically, these policies shift the demand curve – for example, from D to D" in Figure 20, which may result in reducing water quantity from Q1 to Q2. Many of these policies are based on retrofitting and/or installing water efficient appliances and equipment, so water users can capture the same value for water services while using less water.

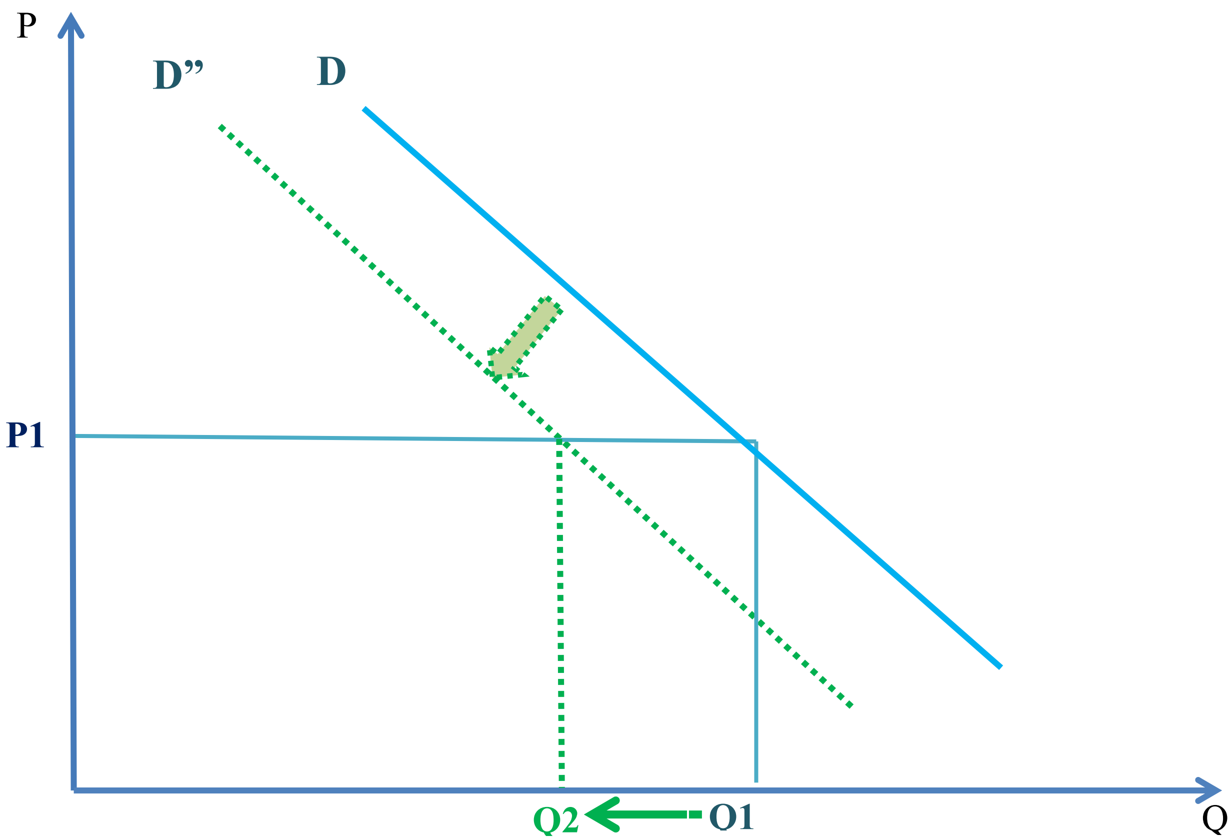


Figure 20: Interrelationship between price and quantity through demand management policies.

Most demand side policies aim to directly influence water consumption, so the technical solutions such as retrofitting water using appliances and equipment dominate in short term conservation. But, in the long term, water conservation through efficient water use is determined by consumers or users' behavioural changes, however few researchers have investigated residential water consumption effects in influencing their water saving habits, which could be the cost effective demand management policy tool that yields long term conservation.

Non-price demand side policies reduce water demand but also lead to a decline of water utility revenue, thus, the water utility from unsustainable financial losses should be prevented. In 1991, a California study showed that total use and revenue fell by more than 20% (Renwick and Green, 2000). Thus, some studies recommend implementing mixed strategies such as price and other non-price policies as more effective for conserving water from end users and for supporting financial sustainability of water utilities.

Olmstead and Stavins (2007) noticed that water saving attitudes towards non-price demand side management policies could provide a measurement of demand response, nonetheless impacts of non-price polices depend on how the policies are financed. A rebate mechanism is inversely related to household income (Renwick and Archibald, 1998).

3.3.2.1EDUCATION AND INFORMATION CAMPAIGN

Education and awareness campaigns play an important role in water conservation by influencing water users to become more willing to save water or minimise leakages and waste water through behavioural and/or technical change. The aim of an education program is to influence people’s values, attitudes and behaviour so as to build knowledge and understanding about the environment and its problems (Thompson, 1997). Public awareness campaigns are also important in spreading the message of water conservation to consumers via municipal websites, media campaigns, newspaper, posters, TV, radio, public meetings and outdoor advertising and also billing reform. Public information and education campaigns reduce water usage by around 8% (Renwick and Green, 2000).

The literature on urban water management presents billing frequency, which reminds consumers more frequently of the fact that water costs. In the short term, households, particularly high consumption households, significantly reduce their consumption by the application of simple cognitive dissonance and feedback information (Aitken et al., 1994).Price information on water bills has a significant positive influence on residential water demand elasticity (Gaudin, 2006) and also the bill provides information about non-price policies to users, such as in a case study in Winconsin, USA (Reynaud, 2012).

A comparison of demand side water management strategies study, which used disaggregated data, shows that public information campaigns with increasing price policies are a moderately effective tool for reducing water use (Coleman, 2009)(Martinez-Espineira and Nauges, 2004).

Public information and education policies/programs encourage water users to adopt and maintain long-term water conservation measures and behaviours. All these individual decisions affect the sustainability of the urban/city water resources. Thus, a public information and education program/strategy is crucial for the success of demand side management, particularly in developing countries (Butler and Memon, 2006). Public information and education programs/strategies have influenced the reduction of public water use, an annual saving of between 2 and 12.3% (Nieswiadomy, 1992) and conserving 2 to 5% of residential water (de Loe et al., 2001). Some places have been affected more. An example of a successful water conservation education program in Utah reported that approximately 27% of indoor and 8% of outdoor water use was reduced by an education program (Hasenyager, 2009). Water use was reduced by 26% by a four year information and education program in California (Dziegielewski et al., 1993). Renwick and Green's (2003) study found that a public information campaign strategy reduced residential water consumption by 8% through influencing people's water use behaviours. However, several studies show that information and education programs have a limited impact, especially in the short term (Camplell et al., 2004, Michelsen et al., 1999). Dzeigielewski et al. (1999) and Reynaud (2012) both found that implementing a mix of price and information policies is effective as consumers become aware of the price increase and more of them gain information on the best ways to reduce their water use or loss in response to price. Coleman's (2010) study confirms that a public information campaign had a statistically significant impact on water consumption but this effect appears quite small and only applies in the short term.

Sydney's water conservation initiatives for the period 2009–2010 have saved about 116.7 GL of water and especially education program for households affected to reduce over 17.2 GL of residential water use each year (Sydney Water, 2010).

3.3.2.2FIXING LEAKING WATER USING APPLIANCES

Developed countries, particularly Australia, USA, and the UK have the best practices for retrofitting programs showing that households with water efficient appliances have successfully conserved indoor water usage by between 9–50% (Mayer et al., 1999, Inman and Jeffery, 2006, DeOreo et al., 2001, Mayer et al., 2004, Ahmad and Prashae, 2010). Water savings were highest in toilets and clothes washers, faucet aerators and leakage from toilets were significantly reduced (DeOreo et al., 2001) in 12 American cities.

Maddaus's (1984) study presented field results of several demand side management strategies, such as fixing toilet leaks and installations of other water efficient appliances and kits. The results show that fixing toilet leaks saves 24 gallons per day of water per toilet. Retrofitting of water using appliances reduce water usage by approximately 20% (DeOreo et al., 2001). A retrofitting of conventional household showerheads, toilets and faucets has been shown to yield a water saving ranging from 51 to 127 litres per person per day (Vickers, 1991).

A larger sample size would assist in confirming these findings and additional local Australian examples of retrofitting investigations would assist in validating the reported conservations. For example, toilet consumption is significantly lower in Australia, with an average 6/3L to 4/3Litres per flush (White et al., 2003b) than America, which has an average 13/15Litres per flush (Mayer et al., 2004). Furthermore, a Yarra Valley study was the most accurate measurement of the efficiency of appliances in Australia and the measures of water use of each appliance shows that American water using devices for residential users are less conservation efficient than Australian (Roberts, 2005). But in the literature on urban water demand side management, there are no accurate studies on the effectiveness of retrofitting policies in developing countries.

3.3.2.3INSTALLING WATER EFFICIENT APPLIANCES AND EQUIPMENT

Installing water efficient appliances and retrofitting water demand side management programs is one of the most popular mechanisms for conserving water in urban areas. These appliances mean not only water using equipment or devices but they also include water meters, which are an essential tool for implementing demand side policies for monitoring and evaluating programs and policies. De Leo et al. (2001) confirm that installing water meters is a primary element in an efficient water demand side management policy. Madduas (1984) found that installing water meters conserves 20% of water. The De Loe et al. (2001) study in Canada provides more detailed information about meter program results, such as conserved water from universal water meters of 20% and sub-meters, which are individual water meters at home, between 20 and 40% of water consumption.

Hundreds of different demand side strategies are able to be employed to reduce water consumption and to change water use behaviour. The results of previous studies show a mix of strategies commonly employed at the end use level. For instance, when the price for water was increased, households fixed or retrofitted water use technologies such as low flow toilets, taps, and showerheads. The retrofit kits program resulted in a reduction of 4 to 7 gallons per capita per day (Maddua, 1984) and in 9% of total residential consumption of Santa Barbara, California (Renwick and Green, 2000). A low flow shower program resulted in significantly reduced water (coefficient was -1.24) from high density households, moreover, when increasing low flow showerheads household’s water demand was decreased by 24%. Also the low flow toilets program significantly reduced low density household’s water demand by 8% by increasing the number of low flow toilets available (Renwick and Archibald, 1998).

A mixture of different strategies would vary the effect on residential users but the results of conservation efforts depend on household characteristics. Several studies found that a positive relationship exists between income (higher income groups), education and water saving activities (Berk et al., 1993, De Oliver, 1999). Domestic water consumption was reduced from 165 L per capita per day in 2003 to 158 L per capita per day in 2008, with a targeted value for 2012 of 155 L per capita per day by a series of conservation programs, which are co-funding water conservation activities for residential and non-residential users and water efficient labelling scheme, of the water agency in Singapore.

3.3.2.4RESTRICTING WATER USE

One of the most effective strategies for reducing water use during drought periods is a restriction policy (Kenney et al., 2004). Thus, in most urban areas across Australia, water restriction programs are the dominant policy mechanism for restricting urban water consumption particularly in outdoor use such as watering lawns, washing vehicles and refilling swimming pools during the drought period (Chaong et al., 2009). Renwick and Archibold (1999) found that low density households (coefficient was -7.24) react more to the restriction policy than high density households (coefficient was -3.40). This result confirms that the restriction policy influences a decline not only of outdoor use but also affects indoor use. Restrictions (selected water use with rationing plan) reduce water usage by 30–65% (Renwick and Green 2000; Dziegielwki 2003).

De Oliver (1999) estimated the effectiveness of restrictions alongside public education campaigns in a drought summer in Colorado, USA, and found that mandatory restrictions saved 18 to 56% of residential outdoor water use and voluntary restrictions were between 4 and 12%. However, White and Fine (2002) noted that a mandatory restriction program might be costly to enforce, time consuming and require more information and education. An Aurora, Colorado, study showed that restrictions with free water saved 31% of water and also the effectiveness of restrictions policies varied between different classes of customers such as low, middle, and high volume water users (Kenney et al., 2008). A recent study on a restriction program with rebate programs for water efficient devices resulted also in a 50% reduction of residential water consumption between 2004–2005 and 2008–2009 in south-east Queensland, Australia (QWC, 2010). A review of restriction programs in Australia recommends that an assessment of restriction programs requires filling information gaps about cost effectiveness and location specific conditions.

3.3.3 INTERMITTENT SUPPLY SYSTEM IMPROVEMENT OR LEAKAGE MANAGEMENT POLICIES

Demand management is an alternative to increased water supply in order to meet growing demand by affecting the supplier (physical methods such as under pressure water) or the consumer to control water usage. Vairavamoorthy et al. (2007) recommend that intermittent supply systems for developing countries maintain adequate and equitable supplies under the common conditions of water resource shortage. These programs relate to improved equity in supply, and quality in intermittent systems and can be identified by leakage management including auditing/monitoring and pressure management (Butler and Memon, 2006) for industrialised economies. De Loe et al. 2001 confirm that water conservation policies should be integrated into long range water supply planning such as leakage management activities and reducing minimum peak demand pressure. Other studies review the current tools and methods for water leakage management in water distribution systems (Mutikanga et al., 2013, Lambert and Fantozzi, 2010).

3.3.3.1AUDITS WATER USE

According to a World Bank study (2006), about 48 teralitres of water costing US$14 billion is annually lost from water distribution systems (Kingdom et al., 2006). Auditing water use is able to measure leakage and to prioritise leak detection activities. Water auditing can be carried out in a wide variety of arenas. The distribution systems of public water suppliers and also buildings (interior and exterior), landscape, external commercial applications requiring irrigation, aquatic centres, material transport by water, cooling systems and non-metal manufacturing (e.g. paper manufacture) can be audited (Sturman et al., 2004). A study, which involved 153 Canadian towns, cities and regional municipalities, showed that around 22% of the respondents implement water audits of homes and business programs mostly directed to the residential sectors. Large landscape water audit demand side management strategy/measures may save 10 to 20% of water (de Loe et al., 2001).

3.3.3.2FIXING LEAKAGE OF PIPES AND SYSTEMS

Managing leakage or ‘real losses’ in water distribution networks and plumbing systems at home is an essential component of demand management in support of water conservation. Managing leakages also improves efficiency and effectiveness of water supply services.

De Loe et al. (2001) found that Edmonton's leakage program reduced unaccounted water to less than 5% of total production. Their finding showed the largest amount of reduction due to implementing leakage management in Winnipeg, Canada. In Winnipeg, calibration of pumping station meters, and a 60% reduction in water main breaks due to system improvements and renewals, reduced unaccounted-for water from 22 to 16% of total demand (de Loe et al., 2001).The International Distribution losses (leakage) in the USA are typically 10 to 15% of total withdrawals, although they can exceed 25% of total water use in older systems (Burian et al., 2000, Dziegielewski, 2003). In comparison, the level of water losses is 6% in Singapore, 7% in Germany, 19% in England and Wales, and 26% in France (WVGW, 2008). The international water association suggests that the leakage level including non-revenue water could be 1.5% of water supply (Dellow, 2011).

According to an Asian Development Bank (ADB) report in 1997, water losses including real losses and unaccounted – non-revenue – water in urban areas of developing countries reach an average of 35 to 40% of water supply (McIntosh and Yniguez, 1997, WWAP et al., 2009) due to water leakages in pipes and canals and illegal tapping of pipelines with an extreme level of 78% reached in Faisalabad, Pakistan (McIntosh, 2003).

Burn et al. (2002) found that in Australia demand management reduces costs for reticulation systems by 25% to 45%, while pressure management increases savings by a further 20% to 55%. Efficiency improvements result more from cost effectiveness; annual savings from conserved water reduced energy consumption than from reuse and harvesting.

In a Sydney case, some key achievements of water conservation initiatives for the period 2009–-2010 have saved about 116.7 GL of water. In contrast, an education program for households affected a reduction of just over 17.2 GL of indoor and outdoor water use in each year. Business water efficiency programs induced a reduction of 24.7 GL per year of business water use by leak detection, reuse, water efficient devices and business specific advice programs. Managing leak programs resulted in conservation of 29.5 GL of water by improving a report of leaks and breaks, reducing pressure and renewing water mains. Recycling programs replaced 12.4 GL per year, and regulatory measures 32.8 GL per year (Sydney Water, 2010).

3.3.3.3PRESSURE MANAGEMENT STRATEGY

Physical ways of limiting consumption such as pressure reduction and cut offs are only applicable in periods of crisis. Pressure management is not only used to reduce water leakage, to reduce costs for operation and maintenance but it is also used as a management tool (Lambert and Fantozzi, 2010). A demand side management measure ‘pressure reduction in the system’ gains water at 3 to 6%of total production, but this measure such as use of pressure reducing valves for residential users conserves 5 to 30% of water (de Loe et al., 2001) and 25 to 45% of costs for pipeline maintenance and operation (Burn et al., 2002a).

3.4 INFLUENCING WATER SAVING HABITS AND ATTITUDES

Renwick and Archibold (1998) noticed that aggregated cross sectional and time series data for determining residential water demand could not reveal water saving technologies and furthermore responsiveness of price and non-price policies are influenced by household characteristics. Urban water demand side management policies involve water use behaviour as behavioural or technical changes or infrastructure (Brooks, 2006). Thus, policymakers need to understand psychological processes of water use behaviour that underlies residential and non-residential water demand.

Few studies investigate a relationship between the effectiveness of water management policies and water saving habits. Terrebonne (2005) noted that the probability of success for water demand management strategy/programs encouraging change in water use behaviour is when one of the most important considerations in cost effectiveness comparisons of alternative water demand management programs is taken into account. The main aim of demand management is that policies/programs influence and change water using behaviour for long lasting conservation. Thus in my study, the water saving habits model is tested to demonstrate the effectiveness of water management policies by combined and separated policies.

Few studies estimate water conservation from non-residential users. Vickers (1991) reviewed implementations of water conservation programs across the USA by residential, commercial, industrial and agricultural sectors. Her study measures water conservation from over 100 large industrial and commercial users, using an auditing program she then found that water saving in commercial and industrial sectors is cooling water, which needs more than half of their use and requires replacement of cooling processes with reticulating system. Wastewater reduction program also yields water conservation from 30 to 40% (Vickers, 1991).

Some demand management policies aim to induce users' water saving habits, which bring benefits for long term water conservation, rather than to directly cut their consumption. In an earlier study Hamilton (1983) concluded that, amongst smaller users, the most effective conservation strategies were based on voluntary actions rather than economic incentives. Water use behaviour is a critical aspect of water demand management, which highlights a need for better understanding of psychological processes for conserving water from residential users (Steg and Vlek, 2009). Furthermore, behavioural intentions are generally more effective for encouraging pro-environmental behaviour when they are systematically planned, implemented and evaluated. Few studies pay attention to the contribution and potential of psychology in understanding and promoting water saving behaviours such as curtailment and efficient behaviours and the relationship between potential applications for water demand policies and water saving behaviour (Russell and Fielding, 2010, Spinks et al., 2011). A relationship between water saving technology and water conservation habits was determined by 27,000 households in Spain (Martinez -

Espineire and Garcia-Valinas, 2012). Educational campaigns had a strong positive effect on both decisions to undertake investments and decisions to adapt habits. In contrast, a positive correlation was found between the indices measuring the number of habits adopted and the investments made to conserve water and low-income families appear to have stronger water conservation habits (Martinez - Espineire and Garcia-Valinas, 2012). Furthermore, having curtailment and efficiency behaviours of households leads to water conservation (Aisa and Larramona, 2012).

Several studies have investigated how non-price polices induce water saving habits of residential users. Glig and Barr (2006) examined the social, attitudinal and behavioural composition of water saving activities of south-west Victoria, Australia, using four different behavioural characteristics of individuals, who are likely to engage in specific activities. Russell and Fielding (2010) showed that water demand policy influences environmental psychology through determinants of water conservation behaviours such as attitudes, beliefs, habits or routines, personal capabilities, and contextual factors. They then found clear evidence for policy makers that implications of demand management strategies and other conservation activities encourage water saving from residential users around the home (Gilg and Barr, 2006, Russell and Fielding, 2010). Attitudes about saving water are affected by perceptions of the abundance of water and distrust of the water authority, although attitudes differed between user groups (Graymore and Wallis, 2010). Michelle et al. (2010) found that residential users are more altruistic in their water saving habits. Spinks et al.'s (2011) study concludes that past behaviour is the strongest predictor of future intentions to engage in curtailment and efficiency behaviours and a link between past behaviour and future intentions may reflect the role of habit. In contrast, females, older than 25, and low income groups engage more curtailment behaviour, which refers to everyday water saving actions (e.g. taking shorter showers, turning tap off while brushing teeth) and also females aged between 55 and 64 years are more likely to engage efficiency behaviour such as installing low flow taps and fixtures, water wise plants and shower timers (Spinks et al., 2011). Full-time workers and large families are more likely to make this type of pro-environmental choice and also households with higher levels of education and income tend to adopt a larger number of water saving devices. Fielding et al. (2012) found evidence that good water saving habits are linked to water conservation for supporting long term cultural shifts on water use.

In the literature on urban water management, no studies put any attention on water saving habits of non-residential and, in particular, on residential and non-residential habits in developing countries.

Aitken's study found that attitudes to water conservation through an information and education campaign related poorly to actual use and is not a good predictor, but is a significant influence on changing the water use behaviour of households (Aitken et al., 1994). In this study, the residential water saving habits model provides more precise information about the relationship between residential water saving habits and attitudes. The habits relate positively to socio-political and negatively toward operational-technical and supply side policies. This shows that people would change their behaviour through information and education campaigns rather than technical solutions such as retrofitting and fixing water using appliances.

Income, education levels and age have also been correlated with environmental activities, with higher income, educated and younger persons being more involved in conservationist groups (Van Liere and Dunlap, 1980, Gregory and Di Leo, 2003). Urban water management policies may have a significant impact on urban water demand; but the exact nature of the relationships between such policies and on non-residential and residential water demand have not yet been addressed adequately in developing and transit economies.

3.5 CONCLUSIONS AND OUTLINE OF 'THE WAY FORWARD'

3.5.1 KEY FINDINGS FROM THIS CHAPTER

- Urban water management in developing and transit economies is a relatively new field of study in comparison to industrial economies.
- Water resources in urban areas, particularly in developing and transit economies, are faced with growing pressure on water scarcity due to population and urbanisation growth as well as climate change.
- The literature review highlights the fact that both supply side policies (such as constructing dams, desalination and recycling plants), and demand side policies (which seek to manage urban water resources through both price and non-price strategies) are important..
- This study attempts to develop a theoretical framework for improving our understanding of price and non-price demand side management policies that are expected to influence residential and non-residential demand for different types of user groups in a developing country case study.
- Renwick and Archibold (1998) suggest that policymakers need to understand how different types of user groups are expected to reduce their demand in response to specific policies.
- Price policies are often effective in the short term; they are also cost effective but are also politically very difficult.
- Although there is significant evidence to suggest the potential value of implementing/adopting demand side policies in developing and transit countries (White et al., 2003a), the literature on urban water demand management shows that non-price policies have heterogeneous effects in

urban areas, and there are very few examples from developing and transit economies. Consequently, the effectiveness of such policies is not well understood.

3.5.2 THESIS FOCUS

Possible solutions to postpone real water scarcity in urban areas of developing countries are investigated using the city of Ulaanbaatar, Mongolia as a case study (an overview of which, is provided in the next chapter).

Thus, the thesis will address the following research questions:

- ✓ *Can water demand management policies alleviate problems of water scarcity in Ulaanbaatar, Mongolia (and possibly also in other urban centres in transit economies)?*

The research question is answered through the following sub questions;

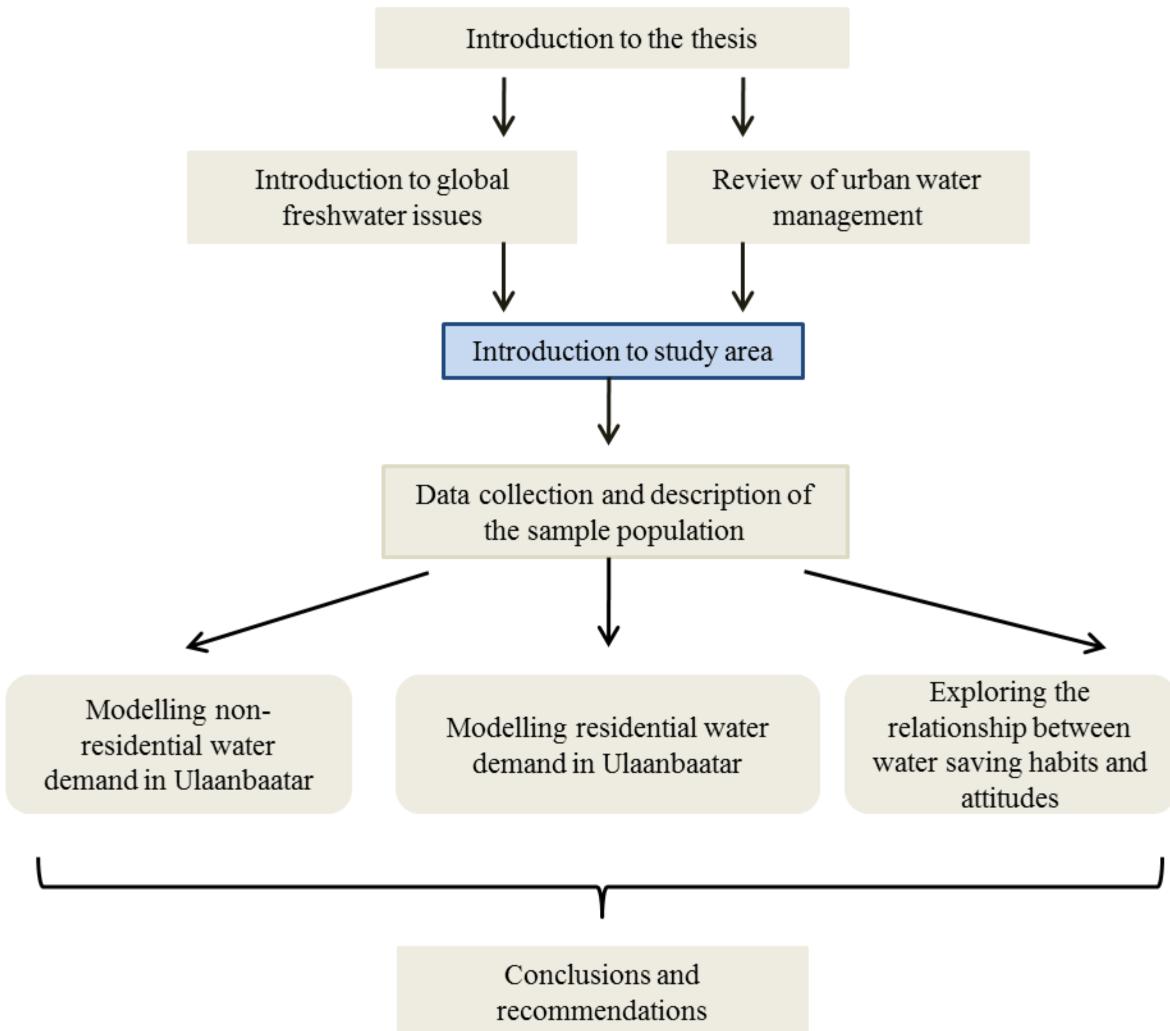
- ➢ *How sensitive is non-residential water demand to changes in price?*

  RQ1A: How much would non-residential demand be likely to fall if water prices were to rise?
  RQ1B: How much revenue could be collected through increased water prices?
- ➢ *How sensitive is residential water demand to changes in price?*

  RQ1A: How much would residential demand be likely to fall if water prices were to rise?
  RQ1B: How much revenue could be collected through increased water prices?

- ➢ *Which water management policies are perceived (by residents and businesses) as likely to be the most/least effective in promoting efficient use of water and improving efficient supply of water?*

Thesis layout



CHAPTER 4 INTRODUCTION TO THE STUDY AREA

The case study presented in this thesis is focused on the effectiveness of demand side management policies in developing and/or transit economies, particularly in Ulaanbaatar, Mongolia. The case study area, Ulaanbaatar, faces seasonal water scarcity and will face a greater water scarcity problem in the next few years. Short term problems are largely due to increasing water demand caused by population growth, urbanisation and economic development. In the longer term, Ulaanbaatar is also likely to see a decrease in its water supply as global warming melts the glaciers which provide most of the city's water (Batima et al., 2008). Consequently, Ulaanbaatar, which could represent other semi-arid urban areas in developing countries, will face a water scarcity problem in the next few years as a result of social and economic pressures and through global warming. This chapter describes the study area and its challenging issue of urban water resource management, using the following conceptual diagram to structure, and guide the discussion.

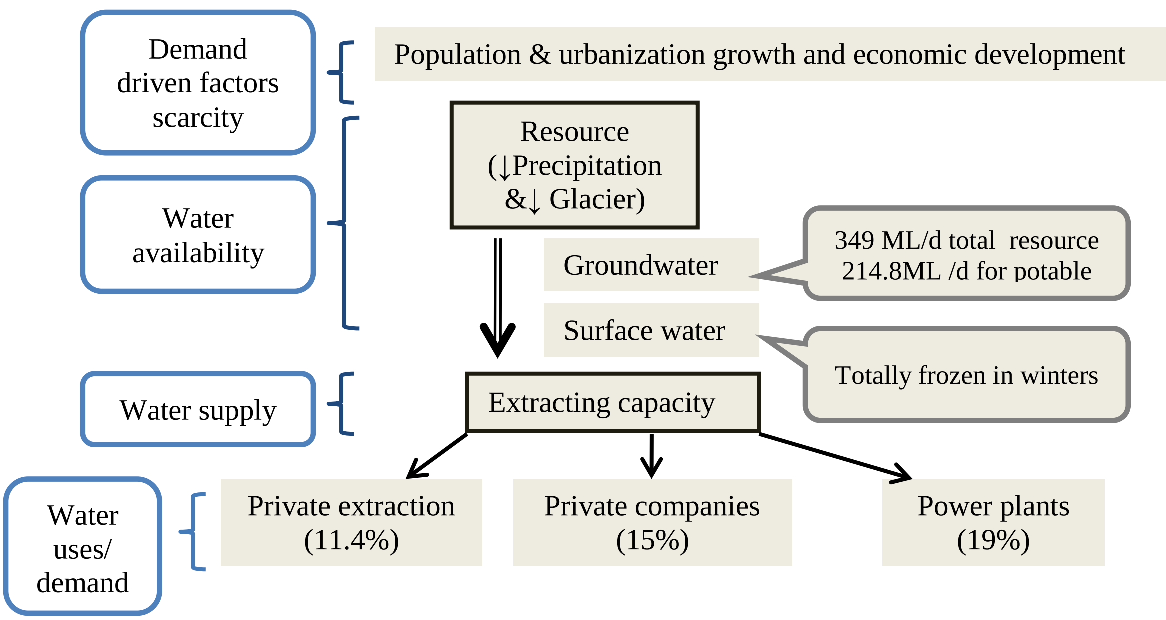


Figure 21 Structure of chapter four

4.1 THE POPULATION AND BUSINESS DEMOGRAPHIC

Ulaanbaatar is the capital city of Mongolia, and was established in 1639. However, urbanisation of Ulaanbaatar has been a recent phenomenon; it is just 100 years since nomadic people lived in wooden and mud houses, and the city has grown from 10 000 people in 1935 to 100 000 in 1956 to 650 000 in 1998 (UBSO, 2007a) and was 1 240 000 in 2010 (UBSO, 2011c). The Mongolian Population and Housing census -2010 reported Ulaanbaatar city had approximately 302 242 households and was home for 43.6 %

of the Mongolian population (NSOM, 2011a). Although Ulaanbaatar's annual population growth rate was less than 1% before 1992, it jumped from 3 to 4.5 % p.a. between 1993 and 2009; significantly this growth rate excludes migration from rural areas. Figure 22 presents population and population growth of Mongolia and Ulaanbaatar.

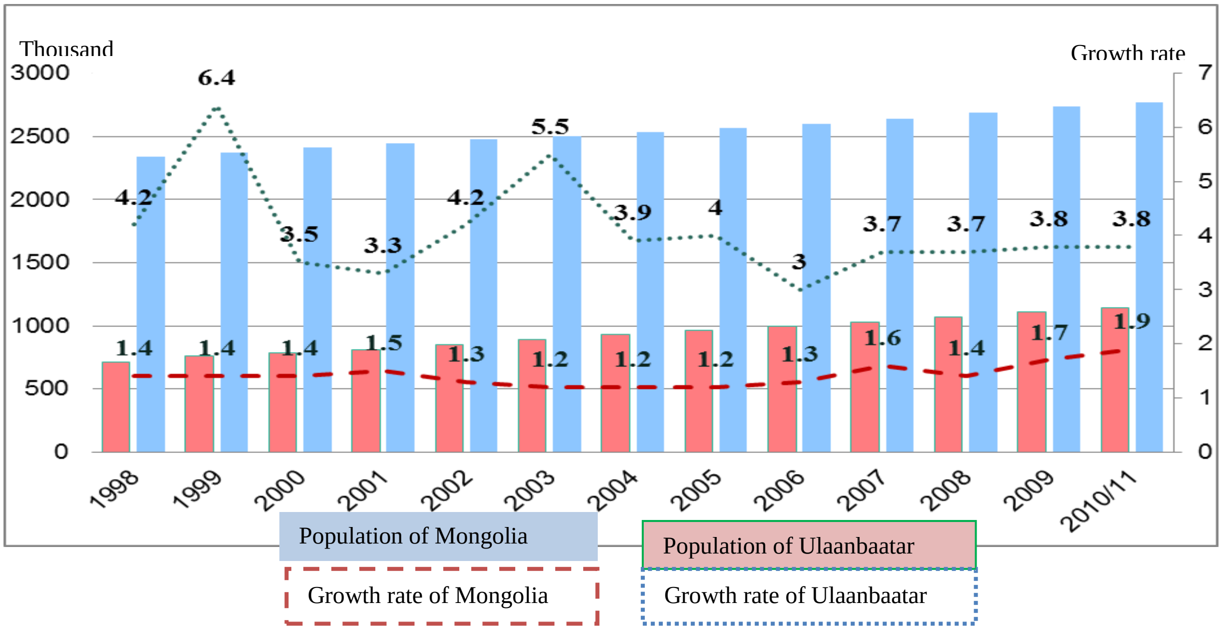


Figure 22 Population and population growth for Mongolia and Ulaanbaatar

According to the census (2010) , over 60% of the Mongolian population lives in urban areas, of which nearly 44% in the capital city, Ulaanbaatar (UBSO, 2011b). Since 1993, about half a million people emigrated from rural areas. Every year approximately 7,500 households (approximately 5 to 6 people per household) from rural areas settle in Ulaanbaatar. The migrants leave the countryside to reach the capital city, hoping to find a job or better living conditions. Some of this migration may be a consequence of severe weather conditions such as extreme winters that devastate livestock and crops. There have also been land privatisation[2] policies, which firstly began with 0.7 hectare for a family from 2002 to 2008 and secondly the policy updated the same amount of land for each head until 2016. That provided strong incentivises for people to move into Ulaanbaatar. This rapid urban migration of the rural poor, especially since 1990, is constantly adding pressure to urban services including water and sanitation (NDICMG, 2010)

Ulaanbaatar is thus an important hub for commerce and industry. In 2009 and 2010, 59.4% and 62.1% respectively of Mongolian GPD was produced in Ulaanbaatar. Nearly 70% of national production comes

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[2] Some provinces (aimag) have been privatizing two to three time larger than the size of the maximum plot land - 0.07 ha of Ulaanbaatar since 2006 (TUMENBAYAR, N. 2006. Land privatization option for Mongolia).

from the city, which accounts for 48% of industrial output, 52% of construction, 41% of trade, 75% of hotels and restaurants, and 56% of transportation and communication services (Emerton et al., 2009). In 2011, there were 45,600 registered businesses, 68.6% of which were located in Ulaanbaatar (NSOM, 2011a), including major manufacturing enterprises, which produce textiles and related goods, leather and footwear, soap, paper, iron castings, cement, glassware, beer and spirits, and processed foods. Also located in the city are three thermal power stations that supply electricity and hot water to its residents. About 89% of Ulaanbaatar's businesses are small sized business, that employ between one to nine people (NSOM, 2011a). Around 65% of the businesses are privately owned, 28.1% are public and 7% NGOs. Ulaanbaatar businesses dominate services, with around 57% of businesses being retail and wholesale shops and stores. Moreover, the number of businesses in the trading sector increased by about 5.5 times from 2,697 in 1997 to 14,774 in 2010, and the sector's share of all businesses increased from 36% to 56.5%. The manufacturing sector declined in relative terms from 16% to 6% of the total. Nowadays, the next largest economic sector is about 7% for personal and other services (NSOM, 2011a).

4.1.1 THE URBANISATION AND LIVING ENVIRONMENT

The urbanised area of Ulaanbaatar is just over 59 km^2, which is three times larger than pre land privatisation policy (JICA, 2008), more details of urbanisations is presented in Table 4. Administratively, the Ulaanbaatar Municipality consists of 9 districts; six central districts (see in Table 4) make up the heart of the city and three remote cities/districts, which are located 45 to 110 kilometres from the city centre. The districts are subdivided into khoroos; between 4-25 khoroos, in each district giving a total of 152 khoroos[3] in Ulaanbaatar in 2012 (UBSO, 2012). There are between 460 and 63 500 household in each.

Table 4 Households and population of Ulaanbaatar by district and by living areas

	District			Apartment area		Ger area	
	Name	Household	Population	Households	Population	Households	Population
1	Baganuur	7092	25875	3181	10479	3911	15396
2	Bagakhangai	976	3615	516	2030	460	1585
3	Bayanzurkh	63483	250241	20621	82145	42862	168096
4	Bayangol	46545	174851	31829	129682	11716	45169
5	Nalaikh	8527	30215	2155	7131	6372	23084
6	Chingeltei	31648	141243	6939	28096	24709	113147
7	Khan Uul	27808	104166	9710	37239	18098	66927
8	Sukhbaatar	34503	135103	15712	59583	18791	75520
9	Songino khairkhan	55600	241410	15323	62746	40277	178664
	Ulaanbaatar	273182	1106719	105986	413191	167196	687588

Source: Ulaanbaatar statistical office in 2010 (shaded areas are involved in this study)

[3] Khoroo- the smallest administration unit only for the Ulaanbaatar city

Geographically, Ulaanbaatar is divided into two main areas (see Figure 23**Figure 23**View of Ulaanbaatar): the city centre area and the Ger areas. The city centre area contains commercial and administrative buildings and high rise apartments, most dating from the time of communism, and newly constructed buildings which have only appeared in the past 5 years as a consequence of the 40,000 units housing program, which was approved by the Mongolian government in 2007 and was updated in 2011 with a second phase, the '100,000 units housing program' between 2011 and 2035.

Figure 23 View of Ulaanbaatar

The city areas are equipped with all urban infrastructure for water supply and wastewater disposal: hot and cold water, a sewerage system (collection network and treatment), and a central heating system and internet connection. In 2010, the city centre was occupied by 108,345 households, or 35.8 % of the total Ulaanbaatar population (NSOM, 2011b), a decrease of 40.1% from 2007 (UBSO, 2007b). Most people live in apartments (83.8%); some live in workers' accommodation, some in individual houses or townhouses (NSOM, 2011b). In 2010, 69.7% of the total Ulaanbaatar population (UBSO, 2010) lived in their own built, detached, wooden or brick houses in Ger areas (NSOM, 2011b).

In the capital, the most rapidly growing area is the Ger areas, where over 60% of the Ulaanbaatar households live (see Table 4). Geographically, the Ger areas account for 70% of Ulaanbaatar's residential area (Margaret and Onon, 2003). Ger areas are informal unplanned peri-urban settlements, spread over a wide region stretching from the city centre to its outskirts and into the outer suburbs that surround the major cities of Mongolia including Ulaanbaatar. Ger areas generally do not have basic infrastructure – while the majority of households living in the Ger areas have access to electricity they do not have indoor running water and sewerage services, and have to rely on communal standpipes and individual outhouses.

Ger areas consist of rows of streets with wooden fences surrounding plots of different sizes, between 450 and 2000m^2 depending on location. In 2010, the Ger areas were occupied by 193,897 households, or 64.2% of the total Ulaanbaatar population (NSOM, 2011b). People live in self-built, primarily one-storey detached (wooden and brick) houses or 'Ger's. In 2010, 54.85% of Ger areas' households lived in one-storey detached houses, 43.4% in gers, and only 1.29% in modern individual houses (connected to some infrastructure); 0.47% of the areas' population was homeless (UBSO, 2011c, NSOM, 2011b).

Official data show that the registered population of the total Ger area grew by 96% between 2000 and 2009, mainly because of households migrating from rural areas and because newly married couples can settle easily and cheaply in Ger areas. Moreover, land privatization also impacted Ger area growth,with a program of land privatisation (700m^2 per household) beginning in 2002.Through the provision of private entitlements over land plots settlers have identified as their own, and this has contributed to the formalisation of residences in the Ger areas.

Overall, Ger areas are characterised by inadequate infrastructure including solid waste collection and water supply and sanitation (including bathing facilities). Almost all of the households in the Ger areas collect their water from different kinds of off-site water supply services of which USUG constructed and operated water kiosks, serve the major part of the population. Approximately one-third of the kiosks, mainly placed in the central Ger areas, are connected to the piped water supply system, whereas the other two-thirds of the kiosks in 2012 are filled by water trucks. Water consumption by Ger residents is low by any international standard at 7-10 lpd, which compares to the basic water requirement of 20lpd for WHO (1996) and 50ldp for Gleick (1996), and access is difficult with on average 1,000 persons per kiosk and an average walking distance to the nearest source of water being 350m. Sanitation in the Ger areas is based on simple on-site solutions and bathing relies on a limited number of public showers and relatives' apartments in the formal settlement areas.

4.2 THE BIOPHYSICAL ENVIRONMENT

Ulaanbaatar is the capital of Mongolia, and the centre for administrative, commercial and financial activities of the country. The city covers an urban area of approximately 12.5% of Ulaanbaatar – 4,704 km^2, which is 0.3% of Mongolian total territory. The city lies on the Tuul River which is 704 km long and flows southwest through Ulaanbaatar. Ulaanbaatar's water supply depends wholly on groundwater (Batima. P. et al., 2004, Batima et al., 2008) drawn from an alluvial aquifer extending along the bed of the Tuul River. Davaa and Erdenetuya (2007) estimate the annual composition of runoff and recharge of the Tuul River to comprise about 68% rainfall water, 6% snow melt and 25% groundwater (Davaa and Erdenetuya, 2007, Miguel and Medina, 2007).

Ulaanbaatar has a semi-arid climate, with hot dry summers (reaching 34°C) and cold winters (sometimes down to -39.5°C) and the Tuul River is completely frozen from December to February. Further, in 2010, Buyankhishig's study confirmed that the Tuul River's groundwater levels dropped by 2.8m from 2001 to 2009, see Figure 24 (MOUB and SAM, 2010).

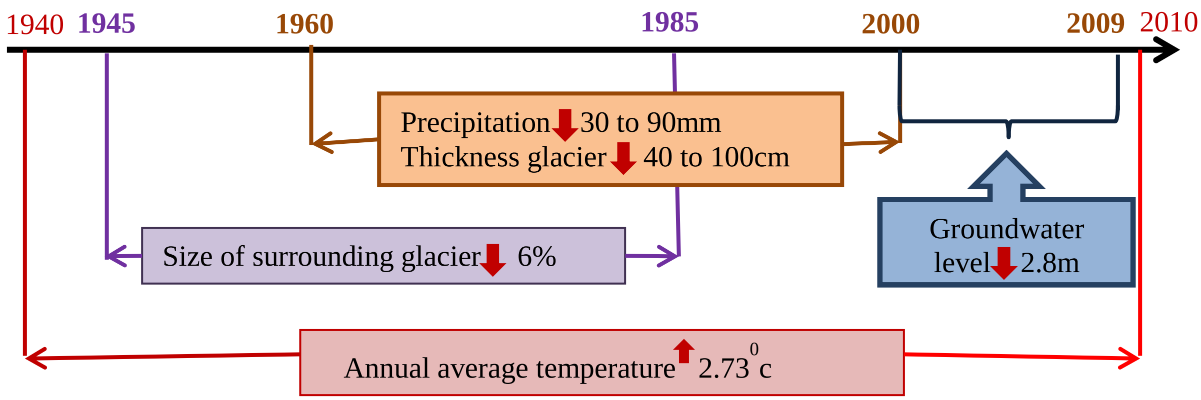


Figure 24 Summary of climate change impacts to water resources of Ulaanbaatar

The annual average precipitation varies from just 243 mm to 402 mm in Ulaanbaatar and its surrounds (Sarantuya et al., 2002) 90% of which occurs in the warm seasons, in particular, between April and September (Basandorj and Davaa, 2005). The number of hot days increased and cold days and days with precipitation decreased. Annual precipitation has decreased by 30-90mm and the ice thickness of surrounding glaciers has decreased by 40-100cm from the 1960s to 2000. The reason for the decreasing size of the glacier is the climate: Baast (1988) confirmed that 6% of the size of the glaciers decreased between 1945 and 1985. During the period 1940-2009, the annual average temperature increased by 2.73°C and annual precipitation decreased by 9.97 mm in the city. These changes are high compared with the national average(UN - Habitat, 2010).MARCC (2010)suggests that there is a high probability that the snow cap, which has a depth of up to 50 metres, would have completely melted by 2040. Ulaanbaatar is also likely to see a decrease in its water supply as global warming melts the glaciers, which provide most of the city's water (Batima et al., 2008). Ulaanbaatar is thus likely to face a water scarcity problem in the next few years. Short term problems are largely due to an increasing demand for water, caused by population growth, urbanisation and economic development (WRG, 2009).

Seasonality is also a significant problem, and the city often faces water supply shortages during the springtime (late April and May) when groundwater levels drop (Namkhai, 2004) and the snow covering the Khentei Mountain range has not yet melted (Batima et al., 2008).

4.2.1 WATER RESOURCE OF ULAANBAATAR

Water resources, water infrastructure and usage of Ulaanbaatar details follow Figure 25. The main water resource of Ulaanbaatar is the Tuul River, particular its basin's groundwater. The Tuul River drains from the south-western slopes of the Khentii Mountain and into the Orkhon River (about 650km from where it merges) which is one of the main tributaries of the Selenge River - the main artery of the Baikal Lake in Russia. The Tuul River is 704 km long in total, 45-50 m wide (in the dry the width falls to 8-18m), 0.9-12m deep, with an average velocity of 0.31-2.24m/sec (maximum 4m/sec) and the total catchment area is 50,400 km2. The catchment area consists of four sub basins, Terelj, upper Tuul River, middle Tuul River and lower Tuul River as illustrated in Figure 25. (Namhai, 2004, UBSO, 2008, UNWAAP, 2006).

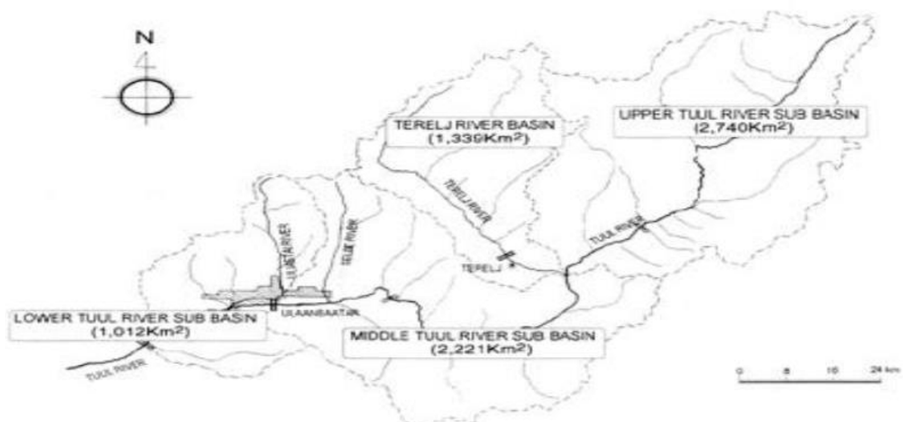


Figure 25 The catchment area with its sub basins. *Source:(Sarantuya et al., 2002)*

The basin elevation ranges between 1200 and 2700 metres above sea level as illustrated in Figure 26 (Miguel and Medina, 2007).

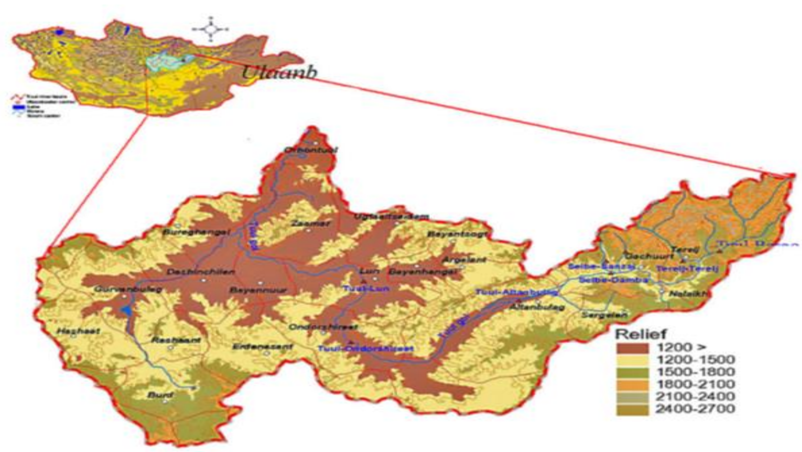


Figure 26 Tuul River basin and elevation. *Source: (Emerton et al., 2009)*

Surface flow is formed by rain, snowmelt water, and discharges of springs. The average annual discharge and average specific discharge for Ulaanbaatar are 28.41m^3 and 4.5$l/s/km^2$ respectively. The discharge reaches a peak in July or August and the flood occurs in these two months. The river's daily discharge is between 0 and 721m^3/s, which is maximum during the rainy season, (Sarantuya et al., 2002) depending on the season and the atmospheric precipitation. Other factors influencing discharge include evaporation of the surface water table, atmospheric pressure as well as human activities. The average composition of the river flow is about 69% from rainfall in the warm period (April to September), 6% from snowfall and subsequent melting; and 25% of flows are sustained by groundwater. The annual average precipitation varies from 243mm to 402mm in Ulaanbaatar and its surrounds (Sarantuya et al., 2002). The river is completely frozen from December to February.

Table 5 Maximum and minimum daily mean discharges in Ulaanbaatar

	Daily mean discharge (m3/s)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Maximum	0.76	0.73	15.3	134	406	618	721	498	565	131	19.6	35
Minimum	0	0	0	0	1.57	3.19	3.45	6.84	5.2	2.12	0	0

Source: (UNESCAP, 2003)

60% of the Mongolian population use groundwater resources for drinking and 90% of the urban population of Mongolia, including those in Ulaanbaatar city, use groundwater for other uses (Tdashi and Maki, 2004). The city depends on groundwater resources (Batima. P. et al., 2004, Batima et al., 2008) in the alluvial aquifers which extend along the Tuul River bed - stretching into upper Ulaanbaatar. Indeed, 96.6% of the water used by residents of Ulaanbaatar is drawn from groundwater resources (JICA, 2008). Urban development has altered much of the surface water regime as well as the drainage pattern in the area and disturbed the interaction between surface and groundwater (Janchivdorj, 2011, Namkhai, 2004). As a consequence, the groundwater tables have dropped from 1.6 to 3.1 metres from 1948 to 1998 as shown in Table 6. The groundwater that is available from wells at different times of the year is shown in Table 6 where supply clearly declines in the winter and spring months, when the precipitation is lowest, and returns to its average during the spring thawing and the first rains.

Table 6 Changes in Tuul River groundwater table levels in metres

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Ave(m)
1948	1.0	1.4	1.7	1.9	1.8	1.4	0.9	0.5	0.3	0.5	0.5	0.8	1.1
1960	2.0	2.4	2.8	3.0	2.4	2.0	1.5	1.0	0.7	1.3	1.3	1.5	1.8
1979	3.2	3.7	4.0	4.3	3.6	2.8	1.9	1.5	1.7	2.4	2.4	2.7	2.8
1998	3.7	4.0	4.1	4.3	4.1	3.5	3.3	2.2	1.7	2.0	2.0	2.7	3.1

Source:(Sarantuya et al., 2002)

4.3 WATER SUPPLY INFRASTRUCTURE OF ULAANBAATAR

During 1977-1979 and 1980-1982, a team of Russian hydro geologists (from PNIIIS of the former Soviet Union) conducted a detailed hydro geological study of Ulaanbaatar's groundwater resources for the city's drinking water supply and industrial use. The groundwater resources in the Tuul River valley were evaluated in three river segments, 'Upper source', 'Central source' and 'Lower source', as alluvial aquifers. Proven groundwater resources for each segment is daily from 89.7 to 125.1 ML for potable water and the total is 349.0 ML (Sarantuya et al., 2002). But recent studies show that the proven groundwater source is estimated about 4% less than the previous study (Janchivdorj, 2011). Table 7 shows the sources with usable types and extracted groundwater in 1997, 1999, 2006 and 2009.

Table 7 Groundwater sources of Ulaanbaatar and extracted water

Groundwater resources	Operating capacity 10^3 m^3/day	Extracted groundwater 10^3 m^3/day			
		1997	1999	2006	2009
Central	125.2	97.2	103.7	99.0	72.0
Upper	89.7	21.8	23.9	25.2	54.0
Industrial	30.3	25.9	25.4	34.8	28.3
Meat factory	8.6	16.2	14.2	13.8	15.5
Potable total	**253.8**	**161.0**	**167.2**	**172.8**	**169.8**
Power station-2	4.9		4.5	4.5	4.8
Power station-3	41.4		39.0	33.6	30.0
Power station-4	30.0		28.8	25.2	28.0
Industrial usable total	**87.7**		**72.3**	**63.3**	**62.8**
Mobility water			2.0	3.0	3.0
Private business				52.5	50.0
Private households		1.5	1.7	25.6	38.0
Total	**330.1**	**162.5**	**243.2**	**311.4**	**323.6**

Source: Tuul River: Ecological changes, issues of water management-L Janchivdorj 2011

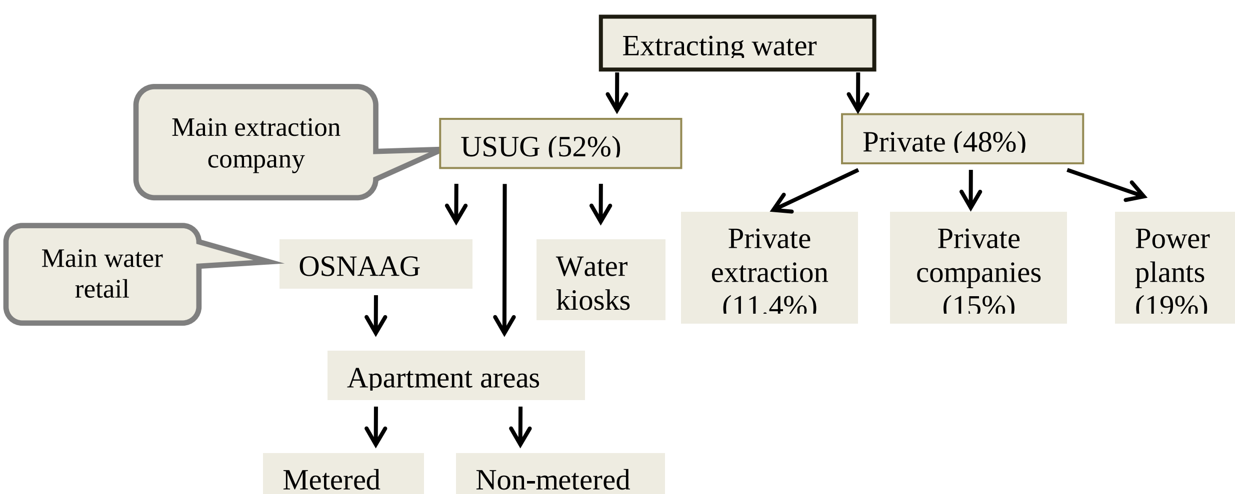


Figure 27 Diagram of Ulaanbaatar water suppliers. *Source:(Janchivdorj, 2011)*

There are several studies that have estimated Ulaanbaatar's total use and extracting water. Sarantuya et al (2002) highlighted the fact that Ulaanbaatar's large industries have their own independent water sources, of which the total proven reserve is estimated at 83ML/d (Sarantuya et al., 2002, Emerton et al., 2009). Later Janchivdorj's (2011) study estimated the reserve (91ML/d in 2009) from an estimation of Ulaanbaatar's three power plants and use by surrounding factories and 1613 private wells (EAUB, 2010). The main supplier through the central water system is USUG[4], which extracts just over 52% of total annual withdrawal for Ulaanbaatar. As Janchivdorj (2011) estimates, the rest of the withdrawal for water was extracted by self-extractors, who are not controlled in their use[5]or use type. When calculation of water usage from USUG, OSNAAG and the three terminal power plants are included, user groups comprise residential and non-residential users (70.6%), self-extractors (26.4%) and agricultural firms (3%) (Janchivdorj, 2011). Small and medium businesses, which are located in Ger areas and not connected to the pipe system, extracted approximately 18.5[6] ML/annum of water for which users paid a fee for using water resource in 2010. But, there is no data about water usage for households that obtain water from their own shallow wells or from the River. This is likely to show no control for private extraction and usage.

4.3.1 WATER SUPPLY COMPANIES AND WATER USAGE

The central supply zone, which mainly is extracted by USUG, is the main water source and it produces up to 60% (depending on withdrawal estimations) of the total water supply. A large proportion of the residential population and industries is served by the centralised water supply system, which was established in 1959, and is managed by two public owned utility companies. These are USUG and the Housing and Public Services Authority of Ulaanbaatar (OSNAAUG), which are both departments of the Municipality of Ulaanbaatar.

USUG is in charge of water sources, water collection and distribution facilities. Current water distribution facilities are characterised by 176 groundwater wells, four water supply sources/reservoirs with a total annual capacity of around 53.1 ML, three transmission stations, 384km long water distribution pipes, 24 tanks, 253 trucks, areas through kiosks (559) with 53.4% piped or supplied by 24 tanks, 253trucks, and by tanker trucks to residents and businesses in June 2010 (USUG, 2009). In 2010, the average daily production was around 166 ML/day and around 19.6% unaccounted water for USUG. USUG manages most of the city's water supplies, supplying to its customers; in the core area, USUG has over 319

[4] USUG-Water Supply and Sewerage Authority of Ulaanbaatar
[5] I investigated that only 18% of the self-extracted withdrawal water users paid fees for using water resources. Data sourced from Taxation office of Ulaanbaatar
[6] The amount of self-extracted water is calculated using data from Ulaanbaatar taxation office report – 2010.

thousand direct contracts, which consist of the apartment dwellers (67,000 apartments) and 2,700 institutional customers (USUG, 2010a).

USUG supplies in bulk, to the OSNAAUG via 61 Heat and Water Distribution Centres, which is 72.5 % of the total water demand (Emerton et al., 2009), serving apartment dwellers, industrial and institutional customers in the core area of the city. OSNAAG is one of the direct contractors of USUG and is responsible for water distribution to the apartment dwellers (76643 households) and 5315 institutional customers in September 2011 (OSNAAUG, 2011) with all the industrial and business users universally metered and only 28.5% of households having sub-water metered homes (UBCC, 2010).

Emerton et al (2009) stated about 42.2% of daily extracted water by USUG and OSNAAG is supplied to non-residential users of the city for industrial, commercial and government use. According to USUG's users structure, in 2005, the indication of base demand of USUG's users' category represented 76.2% of the total water for apartments, 18.1% for administration including government organisations and schools, 4.4% for industries, 0.53% for hospitals, 0.12% hotels and only 0.71% for kiosks (MOUB and Ltd, 2006).

According to the MDG implementation report of Ulaanbaatar (2009), 95.1% of the population, including the apartment and Ger areas, is served by the public water system (MOUB, 2009) through the central water system and kiosks with connected pipes and charging trucks.

Ger area dwellings' water consumption depends on water kiosks, whether connected to infrastructure or by trucks/water tankers by the USUG. In these areas, water access is difficult, with an average of 1,000 people per kiosk and an average walking distance to the nearest source of 350m. Moreover, in the last few years, 51 unofficial private wells with water kiosks as the likely vendor, serve some Ger area's residents but with a doubled price (USUG, 2010b). By the end of 2010, 38.2% of the total Ulaanbaatar households living in apartment areas were connected with a water system and the rest of households took water from water kiosks and tanker trucks. In addition, in 2009, 30% of Ulaanbaatar's total households obtained water from piped kiosks, and 27.4 % from non-piped kiosks and by tanker truck[7] according to the USUG (2009) operational report.

The current water metering situation is reflected by the common practice of aggregate consumption data of the different user groups such as residential and non-residential users as demonstrated in Table 8, which presents 'average' water consumption and is calculated as an aggregate of USUG's data from 2000

[7]The tanker trucks have a capacity of 5000 litres and visit kiosks twice a day on average. Each tanker truck is required to make 10-15 trips per day. The kiosks have the same official operating daily schedule of between 10.00am to 2.00pm and from 4.00pm to 8.00pm. However in reality, many of the kiosks, supplied by tankers, are closed when the storage tank is empty and the operator is waiting for a tanker delivery. During winter the tankers have difficulty reaching many kiosks because of poor road conditions and operating hours are further reduced.

to 2011. The average annual water consumption was about 8,110 m^3 for an ‘average’ manufacturing user, about 2580 m^3 for an ‘average’ commercial user and about 6,450 m^3 for an ‘average’ government user. Apartment households are divided into two groups, metered and non-metered. In contrast, the average water consumption for an apartment dweller of OSNAAG consumers is between 110 lpd for metered households and 340 lpd for non-metered households (OSNAAG, 2011), however the only available data from USUG is 257 lpd for the USUG consumers in 2010 (USUG, 2011). According to average water consumption by litres per person per day, 257.6 lpd is for apartment areas and 7.7 litres for Ger areas. Ger area residents have lower water consumption, but there is little difference depending on the source, whether they are supplied by a piped kiosk (daily about 2 litre more (USUG, 2010a)) or they are a non-piped kiosk customer.

Table 8 Water consumption of each user group between 2000 and 2010

	Residential (litres/day)		Non-residential (10^3 m^3 of annual consumption)		
	Apartment	Ger	Manufacturing	Commercial	Government
2000	402.7	4.7	11.61	5.65	13.31
2001	318	5.3	13.14	6.06	12.76
2002	287	5.7	13.54	5.39	10.22
2003	320	5.8	14.05	5.13	9.02
2004	309	5.9	12.96	5.02	8.88
2005	286	6.1	10.45	3.40	7.95
2006	291.3	7.2	8.80	3.09	8.51
2007	285.4	7.3	8.86	2.96	7.59
2008	272.3	7.4	7.88	3.08	7.65
2009	261.2	7.5	7.56	2.54	6.02
2010	257.6	7.7	8.11	2.58	6.45

Source: USUG’s internal statement

In contrast, there are very few studies showing the component of water use and water saving habits for households and businesses of Ulaanbaatar city. A Ger area household with 4 people uses 30-40 litres of water daily: 40% for food, 30% for cleaning, 20% for washing hands, face and hair, and 10% for washing dishes (UNDP et al., 2004). For the Ger area dwellers, being able to have showers depends on a limited number of public showers or having access to an apartment in the city.

4.3.2 WATER TARIFFS

In Mongolia, utilities (including water) are decentralised (Miguel and Medina, 2007) and local authorities are entitled to set and revise water tariffs. No standard pricing policy is adhered to by the public water provider. In Ulaanbaatar, the tariffs for hot and cold water are supplied separately and prices are almost the same except for a hot water service fee, which is charged at a flat rate per person per month. Metered consumers are charged at a constant uniform rate per litre for their consumed water. The water price and price schedule of the USUG is approved by the mayor's office of Ulaanbaatar. USUG serves water to six different user groups such as metered and non-metered, Ger areas, manufacturing, commercial and governmental users and very few special users[8]. The classification is based on the tariffs for water and waste water. Non-residential users are charged differently for waste water. However, most customers are charged one of the two main prices, such as residential and non-residential, which is divided into piped and non-piped customers. The greatest diversity in price is present in the non-piped customers, who belong to a small proportion of the total customers.

Water consumption data is difficult to find: in the past water has been inexpensive and there has been little incentive for water suppliers to keep strict records of water consumption. USUG implemented a five year water metering policy between 2004 and 2009. The result of the policy is that all USUG consumers had universal water meters in 2009 (USUG, 2010a). The universal meters policy of USUG was only aimed at collecting water revenue from all users of USUG, thus all of the end users were not metered in 2009 (USUG, 2010a). The Ulaanbaatar city has been implementing a water metering policy since 2010. According to the National Inspection Agency of Mongolia (NIAM) report, only 16.6% of all apartment households, which are served by a uniform rate (definition details in Section 3.3.1), had sub-water meters at their homes in 2009 and the Ulaanbaatar City Council stated 28.5% of apartment area households of OSNAAG' consumers have sub-water – individual- meters at home (UBCC, 2010). No individual meters mean there is not any recorded water use for each end user for the at time series.

According to non-residential customers, USUG's consumers are totally metered and served at a uniform rate, but there is not clear evidence about water meters of OSNAAG's consumers.

Metered apartment households, non-residential users and Ger areas dwellers are charged a uniform rate, which is based on their actual usage, for water. Ger area residents buy water direct from water kiosks, at a price significantly higher than that paid by other domestic users or industry (see Table 9). The unit tariff for water supply in Ger areas is about 4 times the tariff in the city centre, but non-metered consumers are charged a flat rate for water. This calculation is adjusted for aggregate consumption (it is mainly based before the tariff approved year and is not flexible) and the number and size of both companies' non-metered households, thus they are charged the same price, which is a flat rate for each head per month. Water revenue covered USUG's cash operational costs in 2007 but the average tariff did not provide cover for depreciation. Moreover there is not any fixed fee or connection fee for customers of either the USUG or OSNAAG. The cash margin for the water supply in Ger areas is strongly negative due to very

[8] Around 20% of apartment areas households of Ulaanbaatar stay in summer campus houses for summers. That time USUG provides water to the summer campus users by track.

high unit operating costs- in particular for the trucked water services. Moreover, the current water charges for only the immediate cost recovery are significantly less than the scarcity value of water.

Table 9 Tariffs for water between 2000 and 2010 in ₮ /m3

User group	2000	2001	2005	2007	2008	2010
Uniform rate for non-residential users		238		329.3	550	
Uniform rate for metered residential users	131.3	135.3	207.5			281
Flat rate for non-metered residential users	990	1478.3	2101.1			2910.6
Uniform rate for Ger area users from water kiosks	500			1000		

Table 9 presents tariffs for water changes in the last decade for each user group. The table clearly shows that the kiosk users pay nearly twice as much as non-residential users. The price for water was changed 13 times (not all scheduled at the same time) in the last decade. Mostly non-piped water prices had been increased due to operating costs, mostly related to rising electricity and fuel costs.

Table 10 Tariffs for water in user groups in 2011

User groups	Residential users			Non-residential users		
	Apartment metered	Apartment non-metered	Informal water kiosks	Manufacturing	Commercial	Governmental
Tariffs	0.28₮/per litre	2910.5₮/per person	1 ₮/per litre	5.5 ₮/per litre		

The current water price per user group is presented in Table 10. The water tariffs for residential users, provided by USUG and OSNAAG, operate at a flat rate for non-metered consumers and a uniform rate for metered consumers and Ger area consumers. The flat rates, which were 2101.05 ₮ in 2010 and 2910.54 ₮[9] in 2011, according to apartment consumers per person per month, do not vary with quantity consumed. According to metered apartment consumers, the uniform rate which is the amount paid per unit of consumption, the same overall units consumed, for water was 0.208₮/litre in 2010 and 0.281₮/litre in 2011 per litre, but the rate for the Ger settlement consumers was 1₮/litre. According to Ger settlement consumers, the price for water per litre was 4.8 and 3.5 times more than the uniform rates in 2010 and 2011. Water tariffs for the mining industry are about 0.125₮/litre, whereas small businesses pay 0.5₮/litre. The rate for Ger consumers is 1₮/litre – double that of small businesses. In contrast, the opposite occurs in India: commercial and industrial consumers use just 10% of the water, yet provide

[9]The price for apartment consumers was increased by the A/137 order of USUG in 23th June 2010.

80% of the total revenue with the commercial tariffs being between 7 and 38 times that of domestic consumers (Biswas et al., 2009).

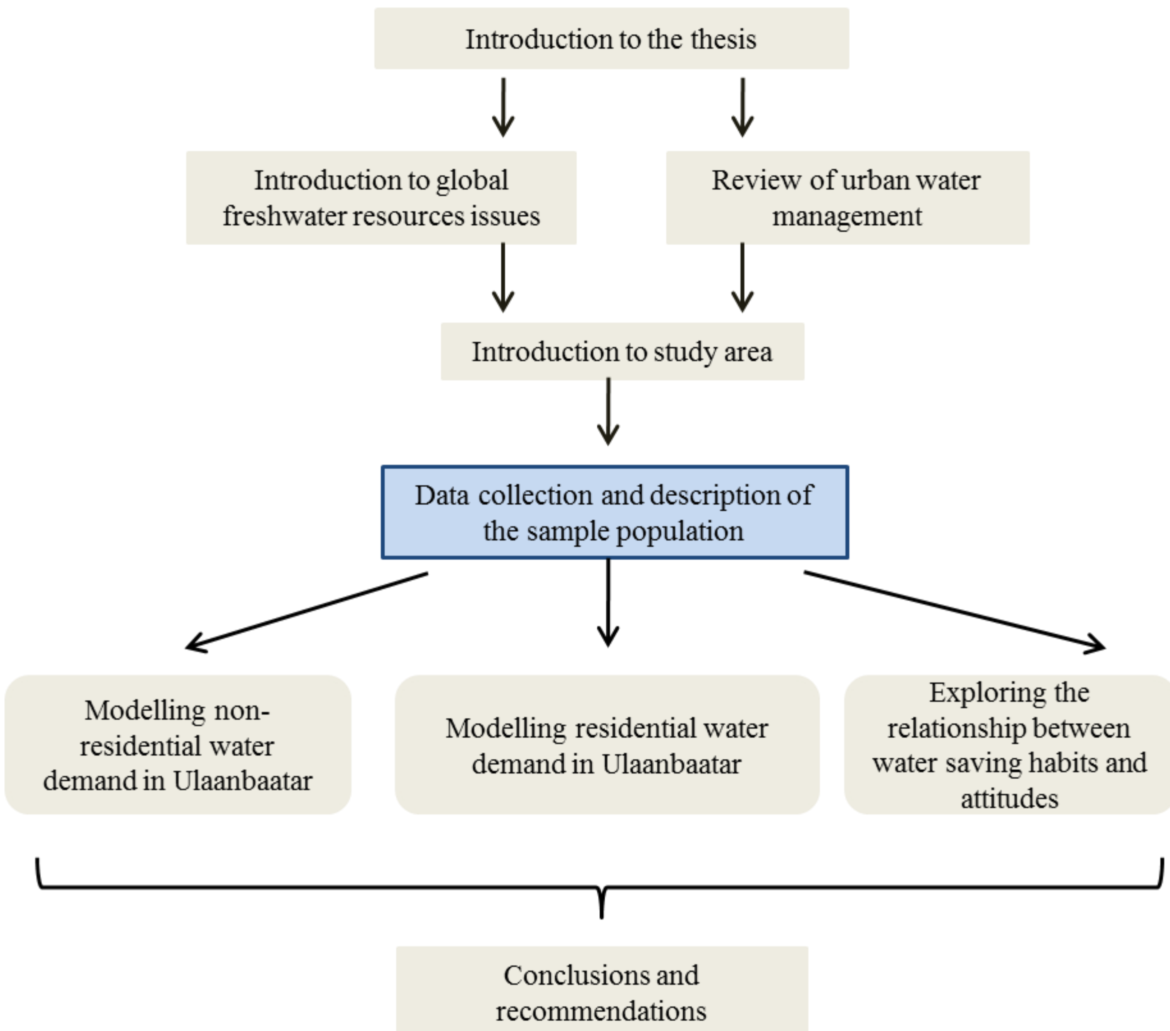
4.4 CONCLUSION

- Seventy per cent of registered Mongolian businesses and 41% of Mongolia's population reside in Ulaanbaatar.
- The population growth rate of Ulaanbaatar is higher than the national rate, while migration from rural areas to the city is very high.
- The city centre area contains commercial and administrative buildings and high rise apartments, most dating from the time of communism, and newly constructed buildings which have only appeared in the past 5 years as a consequence of the 40,000 units housing program. The program was approved by the Mongolian government in 2007 and updated in 2011 with a second phase, the '100,000 units housing program' 2011 to 2035.
- Urbanisation has been fuelled by these housing programs and by land privatization policies and is, therefore, contributing to increases in urban water demand.
- Most businesses and residents rely on groundwater from the Tuul River basin, but groundwater levels have been falling over time.
- Seasonality is also a significant problem and the city often faces water supply shortages during the springtime (late April and May) when groundwater levels drop (Namkhai, 2004). According to several forecasts, including the Urban Development Master Plan of Ulaanbaatar (UDMP) to 2025, Ulaanbaatar Water and Sewerage Master Plan (UBWSMP) to 2020, and the study of Nemer et al. (2008), Ulaanbaatar will face what is formally defined as water scarcity by 2015 if the population and water usage continues to grow at the levels observed in 2005.
- Over 26% of total extraction of water is not controlled and managed by the city.
- There is also an inequity of supply services in the Ger areas, while aging infrastructure may be contributing to water problems: an estimated 20.4% of water supplied through the urban distribution system is 'lost' through leakage.
- The city has very limited hydrological sources to augment the supply source, while the weather and location of the city also limit the options for supply augmentation; one additional source might be to construct a recycling system and plant, although this is very expensive and a technically difficult option for the city.
- The World Bank (2008) recommended adopting urban water demand side management approaches, particularly price policies, to recover operational and maintenance costs for USUG,

rather than reducing water consumption. The report, however, does not present any evidence regarding consumers' likely responses to pricing policies and how they would affect revenue flows to USUG.

- The clear evidence from the World Bank's report in 2009 is that users are willing to pay for water at more than double the current price.
    - If urban water demand is elastic over a range of prices, then pricing may help to solve the water shortage problem. But if it is not, as is the case in most countries, then increasing prices may serve to increase revenues but will only reduce demand a little. The revenues would be useful to fund expanding infrastructure and improving supply efficiency, but may not be effective at decreasing consumption.
- There are, however, no historical time series recording individual end use data for Ulaanbaatar, and there have been few price variations and no cross-sectional differences in the price for water. So it is not possible to use some of the more common econometric techniques to estimate price elasticities.

Thesis layout



CHAPTER 5 DATA COLLECTION AND DESCRIPTION OF THE SAMPLE POPULATION

5.1 INTRODUCTION

The literature review in chapters three and four indicates that, in the field of urban water resource management, there are very few studies available to provide precise and accurate information about the potential effectiveness of urban water demand side management. Thus, the objective of this study was to learn more about urban water demand and the potential effectiveness of water management policies for alleviating the problem of increasing water scarcity in Ulaanbaatar, Mongolia (and possibly also in other urban centres in transit economies). The study looks at both residential and non-residential water demand, a key aim begin to assess the sensitivity of water demand to price and to learn more about the water saving habits of residential and non-residential users.

The study area is data poor (as discussed in Chapter four), which is quite typical of developing countries. Therefore, data had to be collected and in this study questionnaire surveys were used. The main data chapter (six, seven and eight) explain how specific questions in the surveys where developed and analysed. This chapter explains how the data were collected and describes characteristics of respondents. However, the questionnaire development and structure are explained in each analysis chapter also.

After the first year (2010) data collection, the following events occurred in the city. The price of water for apartment areas users was increased. The government announced that 2011 would be a 'water year' with a media campaign. Because of this, data were collected in 2011 for checking effectiveness of the government media campaign and for collecting more data from non-residential users. Full copies of the questionnaire used for residential users from Ger and apartment areas and non-residential users are in Appendix A.

5.2 RESEARCH ASSISTANTS AND TRAINING

Administrative support from the office of the Mayor's office of Ulaanbaatar, Mongolia, and also USUG, and personal contact support from Mongolian Energy Regulatory Authority (MERA) and the Humanities University of Mongolia (HUM) were provided to gather data. Moreover, data were gathered with the help of research assistants: 26 khoroo governors, 26 technicians of USUG and 22 students from the Department of Economics of School of Business at the HUM. The research assistants were provided with printed information sheets, which contained details of the research project, and questionnaires.

The selected 26 khoroos governors were aged between 28 and 61 years old and had between 6 months and 26 years' working experience on the administration in 2010. Some governors had more than 5 years' experience conducting surveys and around 60% of the governors had at least some experience conducting surveys. Only 20 out of 26 khoroos governors, who come from formal settlements, were selected to conduct surveys in 2011. The researcher targeted to gather residential data only from apartment areas, where the price for water had changed.

Ms Tuya, the head of the customer department of USUG, was my research supporter collecting data from non-residential users. She selected 52 USUG's technicians, who often conduct surveys from their consumers, for research assistance in 2010 and 2011.

Research assistants were provided with training during a one day workshop for the khoroo governors and a half day workshop for the students and technicians in during April 2010. In 2011, the training workshop involved fewer people, who were just the governors and technicians of the 26 from the previous year, and a shorter period (just a half day).

The aim of the workshop for the governors was to introduce the interview procedure and to practice its administration. B. Munhbaatar, Deputy Mayor of Ulaanbaatar, opened the session with a presentation: "Current situation of Ulaanbaatar's water resource and consumption" that provided useful background information and served to develop a shared understanding of the issue, thus gaining support from the governors. It also encouraged participants to share their survey experience.

I then explained the research methodology, data collecting method, sampling methods and interview process with an emphasis on avoiding presuppositions. Security issues during the surveying were also discussed. In the workshop, experts of khoroo administration from the districts advised the governors- research assistants- about personal safety when conducting surveys, particularly in Ger areas (some Ger area households are not connected to electricity creating dark streets – an issue if surveyed during the evening). The treatment of dog attacks was also an issue in these areas.

After lunch, the structure of the questionnaire and the intended meaning of each question was discussed. Participants practised conducting interviews with each other; mostly with a governor from the same settlement areas or one close by.

Participants had little previous experience asking quantitative and Likert scale question. During practise some research assistants had difficulty particular questions. They were also not confident about asking people to talk about showering and bathing habits of family members. Thus, the researcher helped explain the different attitudinal scales.

The workshop environment allowed participants to share their administration and surveying skills and to teach each other. Information sheets, questionnaires, background information about the project and about water policy and prices in Ulaanbaatar, contact information, stationary, pens, the researcher's business card and phone charge cards were all provided to the research assistants.

Data was collected by support of research assistants, who were students, USUG's technicians and khoroo' s governors.

Training for the students was more dynamic; the students were interested in urban area water resource management, research and data collection methods and interview techniques. The attitudinal scale questions did not bother or confuse the students. Interestingly, for them, it seemed easier to conduct a survey.

The researcher introduced and explained the research methods and issues on the questionnaire to Ms Tuya, the head of the customer department of USUG. The USUG's technicians were also trained by me and Ms Tuya. The participants also met difficulty in indicating tabular questions and attitudinal scale.

In 2011, the researcher organised a half day workshop for khoroo governors, technicians of USUG and postgraduate students of Humanity University of Mongolia, to present the results of the data collected in 2010 and to retrain the research assistants for the next surveys.

In the 2011 study, subset research assistants from the 2010 study were used in the survey. Since the researcher only planned to collect data from apartment residents, where the price of water had increased therefore only, 20 research assistants conducted the survey in 2011 and each research assistant gathered approximately 20 surveys from their khoroo's residents.

In 2011, the participants of the workshops were more actively involved as they had more background information about water management in Ulaanbaatar and were better able to discuss the implications of the results. They shared their water saving habits and criticised the lack of institutional responsibilities for water loses (inter-medium water piping systems). During the workshop a session was held to explain the practices of surveying and to ensure they remembered how to interpret questions on the survey.

Feedback about the 2010 survey was collected from all research assistants, in the form of presentations in the MOU, the HUM and the USUG.

The interviewer comments included:

1. Confusing wording for the contingent behaviour questions (their comments were used to help improve wording).

2. Likely high non-response rates for certain questions – e.g. the fact that most people would not know the price of water and at other utilities (The importance of ensuring that interviewers carefully recorded responses was, consequently, highlighted, differentiating between ‘no response’ and ‘do not know’).

3. Question order effect – respondents found difficulty in answering the contingent behaviour questions about pricing policies, which starts with decreasing pricing policies then jumps to increasing prices (generally people did not allow for increasing prices even though it was an anticipated question). The order of questions was subsequently altered to give a more ‘natural flow’.

5.2 SAMPLING METHOD

Mongolia and Ulaanbaatar accessible (central six districts) populations are presented in Chapter four. The researcher focused on collecting data from residential and non-residential users for providing information to answer the research questions. With the limited financial source and time frame, I had only one option to use probability sampling method, which utilises some form of random selection, in especially a multi stage sampling and collection used research assistants. Three different sampling strategies a) a cluster random sampling for a selection of khoroos (more information in Section 4.1.1) b) a stratified random sampling for a selection of non-residential users and c) a simple random sampling for selecting respondents were used for the sampling method of this study.

5.3 DATA COLLECTION

The research assistants conducted between 20 and 25 interviews each, depending on the living conditions in the sampling areas. The USUG technicians gathered two to five surveys from his/her business territory. The students conducted only two residential interviews each. In each year, data were collected over a two month period (see Table 11).

Table 11: Data collection for water use

Groups to be surveyed	No. of respondent interviewed	Collection method	Data collection completed	Data collection period
Apartment areas residents	401	Direct interview	10th June 2010	6 weeks
	294		20th June 2011	4 weeks
Ger areas dwellers	263	Direct interview	10th June 2010	6 weeks
Non-residential users	104	Direct interview	17th July 2010	8 weeks
	257		16th June 2011	4 weeks
Thermal power plants	3	Posting from MERA	2nd July 2010	2 weeks
	3		20th July 2011	2 weeks

5.3.1 SAMPLING AND DATA COLLECTION FRON NON-RESIDENTIAL USERS

5.3.1.1 SAMPLING STRATEGY FOR NON-RESIDENTIAL USERS

Researchers were keen to ensure that their sample included a) large water users such as 'tanneries' and 'beverage factories', and b) a broad range of different types of organisations from different parts of the city. The sample strategy was thus to stratify by district/location, by size (specifically number of employees and earnings) and by industrial sector. The final sampling of non-residential users' data collection was presented in Figure 28, which shows overall central six districts businesses were involved and sub-districts were not the same as administration unit.

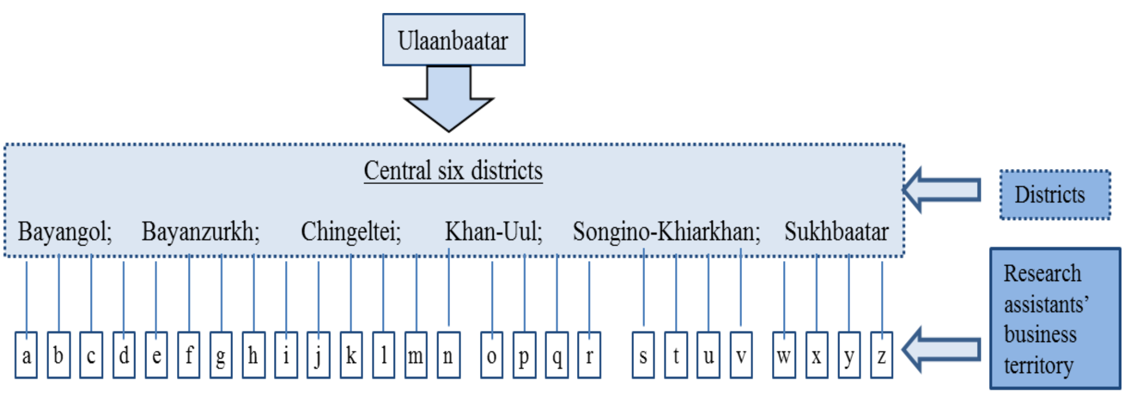


Figure 28 Sampling method for data collection from non-residential users

When starting the data collection process (Spring, 2010), researchers initially sought interviews with over 50 non-residential water users in each of the six central districts of Ulaanbaatar (randomly selected within each size/sector/location category). Trained research assistants (details in Section 5.2), from USUG charges his/her business territory – this is not same as administration areas, randomly selected respondents from his/her area and they gathered from all 375 non-residential users.

The questionnaire for non-residential users attempted to collect data that would enable me to use cost and production functions to estimate non-residential water demand; however, only 50% of observations from those respondents were valid. The researcher found out that the questions related to financial information, such as costs should be avoided when asking to non-residential users.

In 2011, the sampling strategy was stratified only by the districts and a simple random sampling, which aimed to collect 0.1% of the total permanently operate businesses, for non-residential users. During spring 2011, researchers thus worked through the USUG's department of consumer service, making contact with (and then interviewing) various non-residential consumers.

5.3.1.2 DATA COLLECTION FROM NON-RESIDENTIAL USERS

Collecting primary data from non-residential users was complicated in terms of finding an appropriate method of data collection. Four different methods (see Table 12) of data collection were employed to obtain data from participants.

The first method involved seeking the support of the Mongolian National Chamber of Commerce and Industry (MNCCI). The researcher met with the chairman (S. Demberel) and the general manager (B. Tsogtoo) to explain the study. We discussed different data collection methods and decided to post a letter (with a questionnaire) to 100 randomly selected members at their organisation.

The second method was to use the web and to send an email (with a link for the survey) to all members at MNCCI. A reminder email was sent 2 weeks later. The questionnaire was posted on the MNCCI website for six months. However, no responses were received from the members during that period. This could be because businesses are not yet used to communicating via email (despite the fact that email is a standard method for communicating in most organisations and between individuals in developed countries). Another reason could be that MNCCI sent a number of unsolicited commercial emails to the members, so they might not have had any interest in checking their email. Furthermore, the members may have faced a number of challenges, such as high internet access rates and a lack of computer and business communication skills.

The third method involved contacting the customer department of USUG. Under supervision of the head of the customer department, D. Tuya, 52 technicians conducted surveys within their business territory at a selected firm office. Subsequently, data were collected over 10 days in 2010; each officer was equipped with two questionnaires, and interviewers randomly selected respondents from any economic sector. In 2011, 26 technicians were selected from the 52 that had been used the previous year. Ten interviews were conducted by each assistant over a period of four weeks in the customer's office.

The fourth method focused on the largest self-suppliers of water in Ulaanbaatar – namely the thermal power plants, which operate under authority of MERA. Support was provided by the Mongolian Energy Regulatory Authority (MERA); its personnel helped me gather data from these suppliers during both 2010 and 2011.

Table 12 Data collectors from non-residential respondents

Interviewer / year	Frequency	Per cent
Researcher	5	1.4%
USUG's technicians-2010	99	27%
MERA-2010 and 2011	6	1.7%
USUG's technicians-2011	257	70%
Total	367	100%

In summary, the majority of the data from non-residential users were gathered by the research assistants (USUG's technicians). Only three thermal plants permanently operate in the study area and all plants were involved in this study and in both study years. I interviewed only 1.4 per cent of non-residential respondents in 2010.

5.3.2 SAMPLING AND DATA COLLECTION FROM RESIDENTIAL USERS

5.3.2.1 SAMPLING STRATEGY FOR RESIDENTIAL USERS

The sampling method of this study for collecting data from residential users is a multi-stage sampling strategy including a stratified sampling for selection khoroos and a simple random sampling, which aimed at involving between 0.1 and 0.2% of the Ulaanbaatar households, for residential respondents.

According to Nauges and Whittington's recommendation (2010) on gathering information from households of developing countries responses should be obtained from a broad cross-section of people. To minimise the logistical problem of collecting data in a large city, I therefore used clustered sampling – randomly selecting 26 khoroos out of 152 khoroos from the central six districts by involving both living condition areas i.e. apartment and Ger. Trained research assistants randomly selected participants from who came to the governor's office for collecting a statement from the khoroo governor office in 2010. In

2010, about 440 surveys were collected from Ger and apartment areas households. The number, which represents 0.16% of the Ulaanbaatar total households, of collected surveys was achieved to the aim.

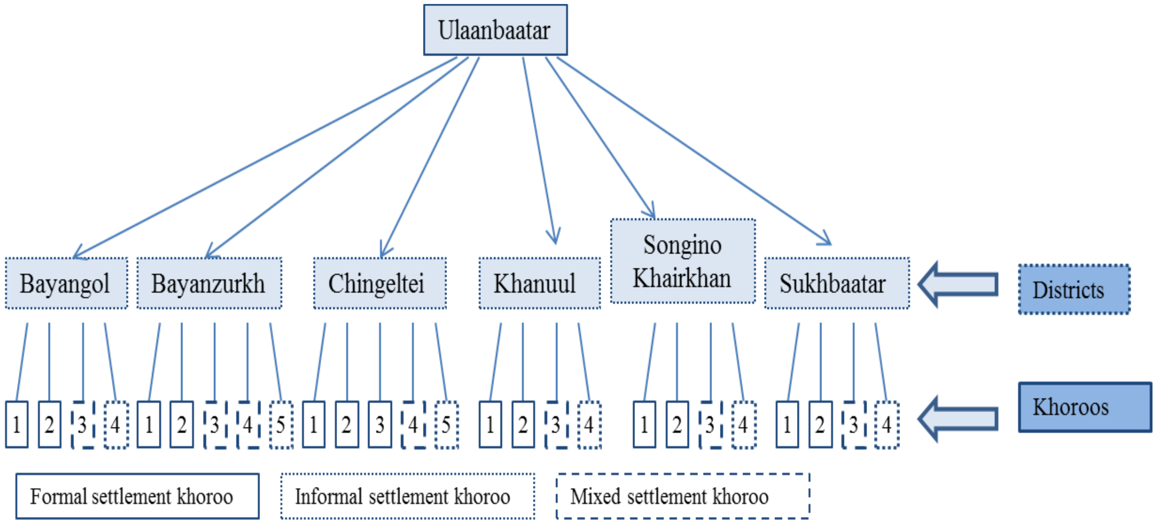


Figure 29 Sampling for residential user by settlement condition

The second year (2011) of data collection thus provided opportunities to: a) compare water usage at the price before (2010) and after (2011) price change, b) investigate effectiveness of the government media campaign on users' attitudes towards water policies and c) gather more data from non-residential users. Thus the researcher went back in 2011 and collected more data from apartment area households. In 2011, 224 apartment households were involved and represented about 0.2% of the total households of apartment areas.

In both 2010 and 2011, residential surveys were more successful with the administrative support from the Mayor's office of the capital city and the district governor offices. The clustered random selection was made with the support of the deputy Mayor of Ulaanbaatar city. For the residential respondents, the clusters were clearer and targeted collecting the smallest administration level.

5.3.2.2 DATA COLLECTION FROM RESIDENTIAL RESPONDENTS

The research assistants 'khoroo governors' conducted interviews with their khoroo's residents at their offices. Residents, who visited the governor's office and who were willing to participate in the survey were interviewed face to face, by the research assistant in her/his office for about 20 to 30 minutes. In total, the 26 khoroos governors collected 958 surveys (664 surveys in 2010; 294 surveys in 2011).

In addition, each research assistant interviewed 20 people at the governor's office for Ger areas and interviewed approximately 25 people at the governor's office in the selected apartment areas. Collection periods were selected to include workdays and some weekends, excluding public holidays. 294 questionnaires (168 surveys from metered households; 126 surveys from non-metered households) were completed in this way in 2011. During the data collection process, I visited some at the khoroos offices and had regular contact with the research assistants.

5.4 RESPONDENTS OF THE STUDY

Overall data were collected from 1333 respondents, 28% of which were from non-residential users (see Figure 30).

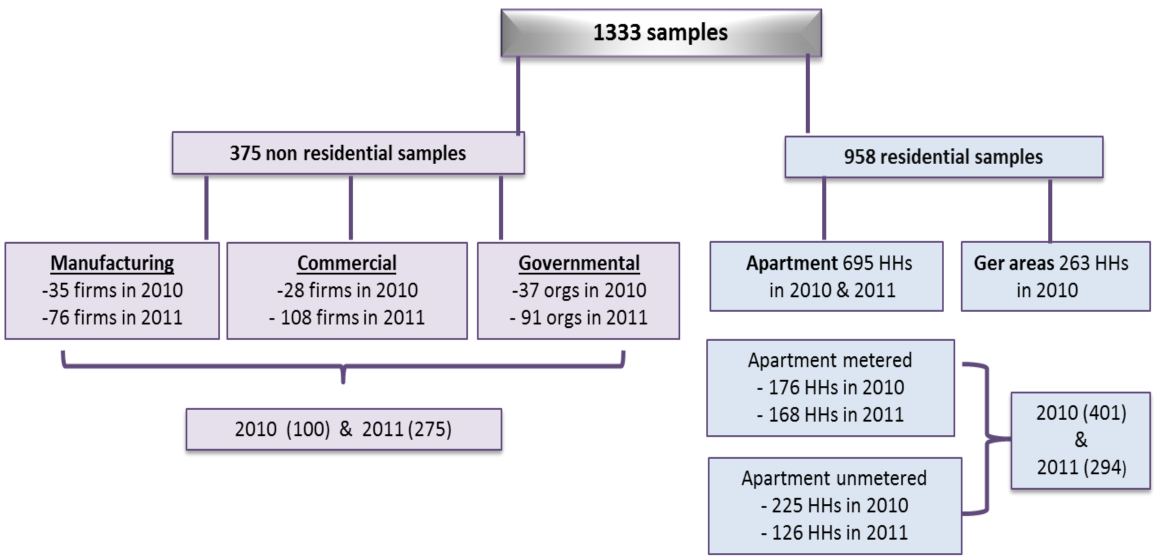


Figure 30 Participants by user groups and by the study years

About 57% of the overall respondents were collected in 2010 and involved from all user groups such as manufacturing, commercial, governmental, metered and non-metered apartment and Ger areas households.

5.4.1 CHARACTERISTICS OF NON-RESIDENTIAL RESPONDENTS

In total, researchers interviewed 375 non-residential users – approximately 1/3 of which (30%) were from the ‘manufacturing’ user group, 36% from ‘Commercial’ and 34% from ‘Government and other’. By design, the sample was thus not ‘representative’ of the overall population of non-residential users on a per-capita, instead, the sample included a relatively large number of observations from three user groups (see **Figure 31**). Overall, the sample included 0.11% of the total permanently operate businesses in the study area. The sample size achieved a significant level according to a commonly used equation table (KREJCIE AND MORGAN, 1970).

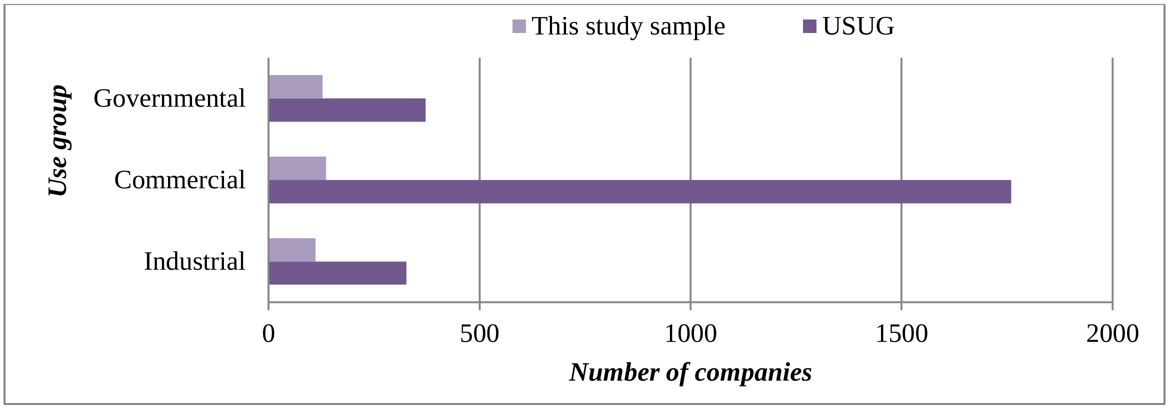


Figure 31 Number of businesses by water user group

Data was obtained from all economic sectors, defined by the Mongolian National Statistics Office, (Table 13). The numbers of samples from the economic sectors are uneven. The largest number (18.4%) of the respondents was from the 'Manufacturing' sector, 15.5% from the 'Hospitality industry' sector and the smallest number from the 'International organisation' and 'Agricultural' sectors.

Table 13: Numbers of participants by the economic sectors and the study year

Economic sector	2010	2011
Hospitality industry	17	40
Construction	10	12
Transport, Travel & Storage	1	8
Education	16	32
Health & Community Services	3	17
Manufacturing	16	50
International organization activities	0	1
Agriculture, hunting, fishery industry	0	1
Electricity, gas production and Water Suppliers	4	8
Financial service	1	3
Retail & Wholesale shops/stores	6	24
Government administration & Defence	3	22
Rental, property and business services	11	31
Personal & Other Services	4	18
Other	8	8
Total	100	275

Data were aggregated into three broad categories, which are used by both the Mongolian National Statistics Office and USUG. These were: manufacturing (111 respondents), commercial (136 respondents), and the government (128 respondents) – see Table 14. The manufacturing water user group consists of firms from the construction, transportation, manufacturing, agriculture and electricity sectors.

The commercial water user group consists of firms from the hospitality, retail, rentals and financial services sectors. The government user group consists of firms from government and administration, education, health, international organisations, personal services and firms from other sectors.

Table 14: Non-residential user groups

User groups	Economic sectors	Number of samples	Total N
Manufacturing	Electricity, gas production and Water Suppliers	12	111
	Transport, Travel & Storage	8	
	Construction	21	
	Manufacturing	69	
Commercial	Hospitality industry	58	136
	Retail & Wholesale shops/stores	43	
	Financial service	3	
	Rental, property and business services	32	
Government	Government administration & Defence	12	128
	Education	47	
	Health & welfare Services	21	
	Personal & Other Services	25	
	Own business	23	

A comparison of non-residential respondents between study years is presented in Figure 32, which shows that in 2010 the largest number of responses was collected from the ‘Government’ user group, but in 2011 from the ‘Commercial’ user group. Across both study years the numbers of observations from the three user groups is approximately equal.

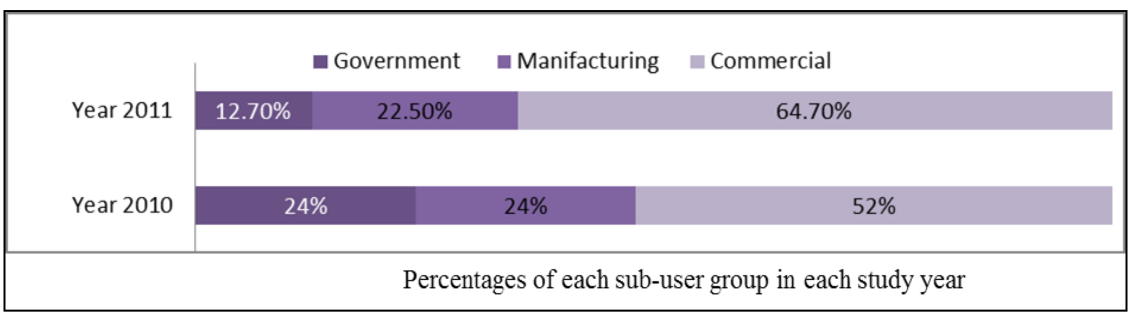


Figure 32: Non-residential user group by broad sector and year

5.4.1.1WATER SOURCES AND INFRASTRUCTURE

The majority of non-residential respondents (93.1%) were supplied water from the USUG (more details in Section 4.3.1). Some respondents were supplied water from different sources. For instance, there were 18 self–supplied firms, (three from the manufacturing user group, ten from the ‘Commercial’ user group and five from ‘Governmental’ user group), and 4 firms, which were supplied water through a combination of public and self-supplied sources: One firm sourced its water from a protected well and one firm from a water kiosk, which was connected to the city’s central water supply system.

Most the self-supplied firms' wells (64.5%) were built in the 2000s and the rest between 1960 and 1980. Respondents were asked to provide information about the capacity of those wells.

About 23% of the respondents (27 in 'Manufacturing' firms, 28 in 'Commercial' firms and 31 in 'Government' organisations) gave details about their own water infrastructure in terms of the length of their water pipes (outside of the buildings) and the year of construction. The mean length of these pipes was 119.19 meters, with a range of 0.1 to 38 kilometres. The length of the water pipes was 8 times loner in the 'Manufacturing' group than in the 'Government' group and 4 times longer in the 'Commercial' group than the 'Government' group. This shows that the 'Manufacturing' firms invested more money in expanding their infrastructure compared to other groups.

There were no participants with their own recycling system an expected result since recycling is not a common practice for Mongolian non-residential users. About 74% of respondents answered questions about the reuse of water. Over 7% of the firms said that they reuse water (seven from 'Manufacturing' group, eight from 'Commercial' group and six from 'Government' group). They indicated that the quality of their reused water met Mongolian Technical Water Standards.

5.4.1.2INCOME OF NON-RESIDENTIAL RESPONDENTS

About 97% of the non-residential respondents answered question about their monthly income. The average monthly income was 1555.2 million ₮ with a median value of 15 million ₮. Approximately 31% had a monthly income between 1 and 4 million ₮. The majority of respondents (61.5%) had a monthly income of less than 20 million ₮, and most respondents were involved in medium sized businesses. Tests indicated that there was a significant difference in the monthly income between the National Statistica Office of Mongolia (NSOM) in 2010 and 2011 samples. According to the study years, the average income (Figure 33) was 1633.5 million ₮ in 2010 and 1464.5 million ₮ in 2011. Fewer small income firms were more involved in 2011 than in 2010. Small-income firms were more involved in 2010 and in 2011.

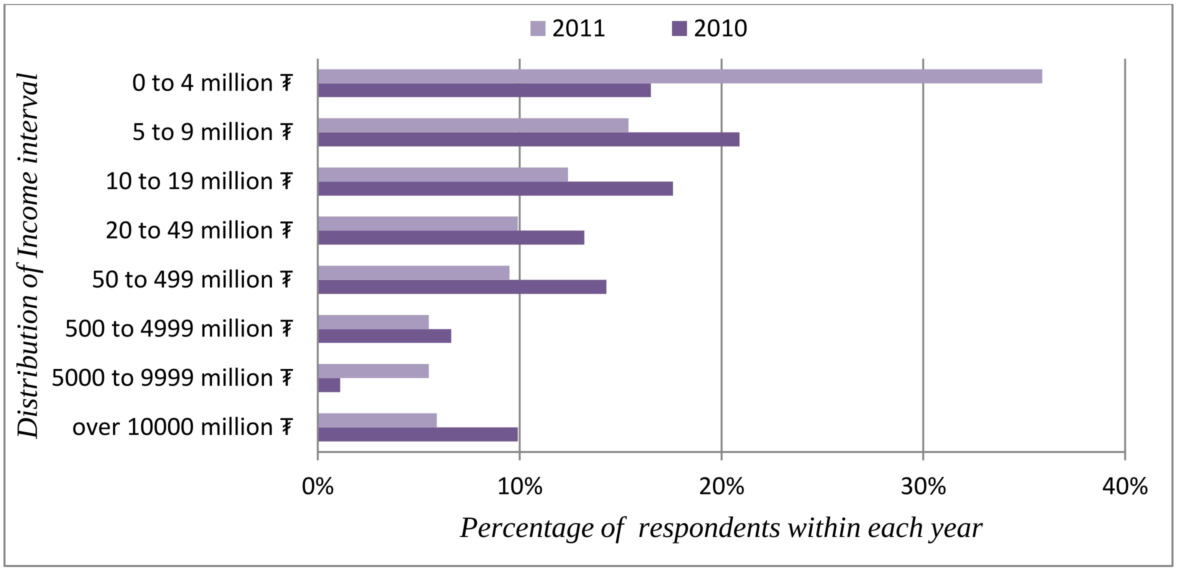


Figure 33: Distribution of businesses by income and year

In terms of the user groups (Figure 34), the monthly income of the respondents was 1553.19 million ₮ for the 'Manufacturing' group, 2013.20 million ₮ for the 'Commercial' group and 1069.98 million ₮ for the 'Government' group.

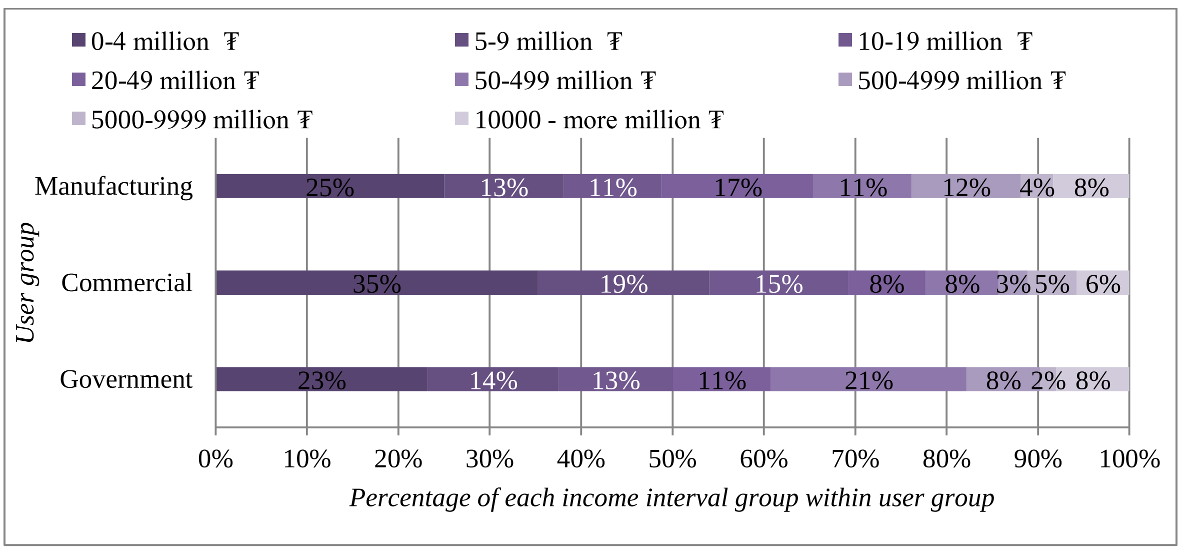


Figure 34: Distribution of businesses across income categories in sub-user group

5.4.1.3 NUMBER OF EMPLOYEES

About 96% of the non-residential respondents indicated their average employment size categorised within the nine different employee ranges. The average number of employees was 131, with a median value of 45 people for each firm. The average number of employees (Figure 35) was 104 in 2010 and 138 in 2011.

Evidently, fewer larger firms were involved in 2011 than in 2010, but the average number of employees for firms in this study was higher than in the business census (NSOM, 2011a).

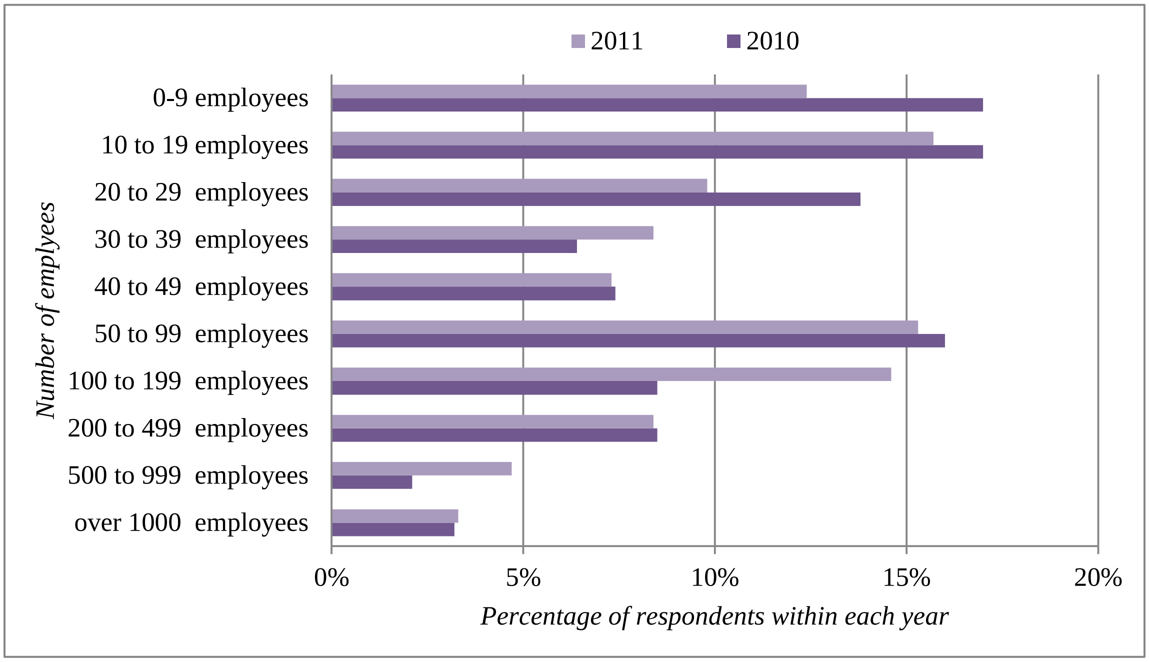


Figure 35: A comparison of employment size between 2010 and 2011

There were 157.8 employees with a median value 75 in the 'Manufacturing' group and 89.9 with a median value of 178.8 employees in the 'Government' group. As reason for the higher median value for Government group might be related to the involvement of schools and hospitals in this group, which have larger numbers of employees, and administration organisations with small number of employees.

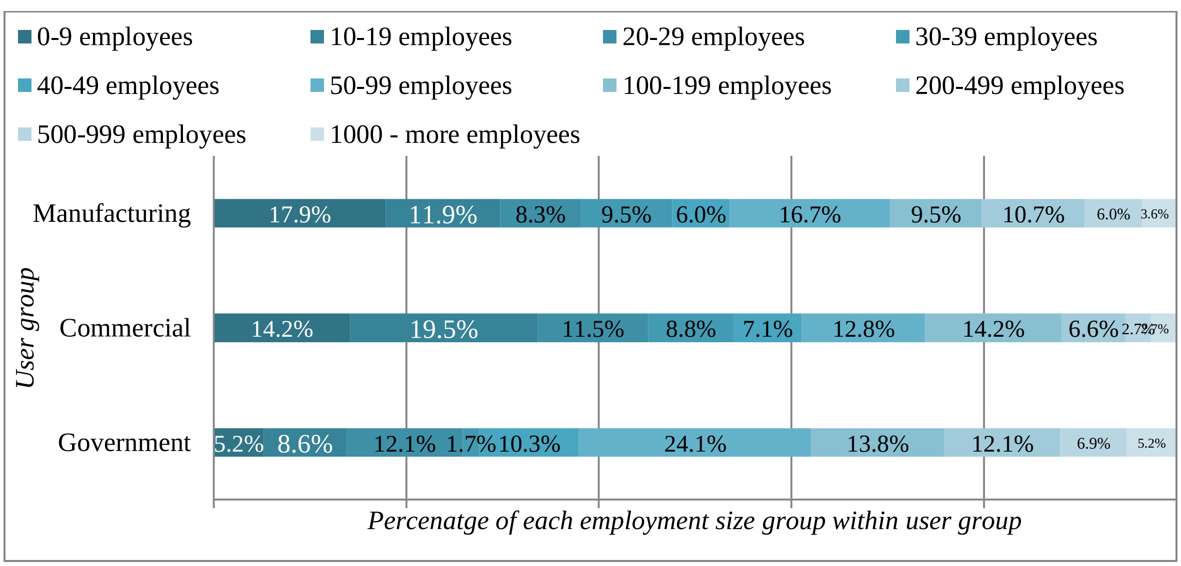


Figure 36: Distribution of businesses across number of employees' categories in user groups

5.4.2 CHARACTERISTICS OF RESIDENTIAL RESPONDENTS

Researchers interviewed 958, which is just over 0.3% of the total Ulaanbaatar households, residential users – approximately 27% of residential users were from Ger areas, about 36% of which from metered households of apartment areas and 37% of which from non-metered households of apartment areas. The sample size achieved a significant level according to a commonly used equation which determines sample size from a given population (Krejcie and Morgan, 1970).

The total number of residential respondents, across Ulaanbaatar's apartment and Ger areas' dwellers years in 2010 and in 2011, was: 958 households (4116 people), of which apartment dwellers were 41.86% and 30.86% in 2010 and 2011 respectively, and 27.45% from Ger' areas in 2010. Across all respondents mean household size was 4.27 and 3.94 people for apartment households in 2010 and 2011, and 4.77 for the Ger areas' households in 2010, which is 10% higher than the mean of overall respondents.

The mean of number of children per household was 1.61 (under the aged 15); on average 1.491 per household were older than 60 years of age. Table 15 shows that apartment areas had a higher number of households containing children and Ger areas had larger households.

Table 15: Age structure of residential respondents (2010-2011)

Number of people	Apartment -2010			Apartment -2011			Ger area -2010		
	<15	15~59	>60	<15	15~59	>60	<15	15~59	>60
1	121	29	90	81	39	68	79	21	43
2	80	120	54	56	97	55	55	75	23
3	13	106	2	7	71	2	16	53	5
4	3	72	1	2	47	1	8	55	1
5	1	39	1	1	14	126	1	29	1
6		13		1	6			17	
7 & 8 &9		2						8	

Figure 37 shows the highest education level achieved by in each household: overall 64% of respondents had someone in the household who had attended university; this was just 41% for Ger areas, while no-educated households are three times higher than apartment in 2010.

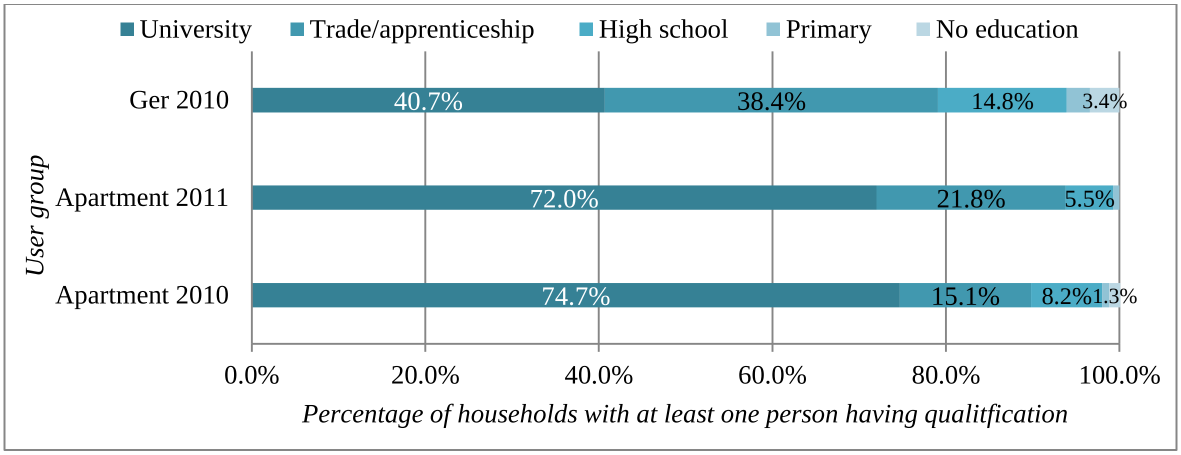


Figure 37: Percentages of highest achieved education level of sub-user group

The mean number of persons employed in each household was 1.75 with a median of 2. The mean number of the unemployed persons was 1.47 with a median of one, and a mean of number of students was 1.7 with the median of one person (see Figure 38).

Figure 38: Employment status by year (user group)

Around 14% and 13% of this study's household respondents were employed in the "education" and the "government" sectors; 6.4% were self-employed in private business, and 1.1% of the respondents worked in the "Real estate, renting and other business activities" and "agricultural" sectors.

The average monthly income for residential water users was 466.4 thousand ₮[10]; 491.37 ₮ for apartment dwellers in 2010, 350.77 ₮ for the Ger and 536.35 ₮ for apartment dwellers in 2011. The majority (51.4%) of households had a monthly income between 200 and 600 thousand ₮ (Figure 39). Tests indicated that there was a significant difference in the monthly income between the Ulaanbaatar city

[10] ₮ – Tugrug, which is the Mongolian currency and AUS $1 equated to 1250 Tug, in June 2011.

reports (UBSO, 2011c) carried out in 2010 and 2011, and the current study[11]. The tests indicated that respondents to the current study, especially those from the Ger areas in 2010 and apartment residents in 2010 earned a lower income than the averages indicated in the report.

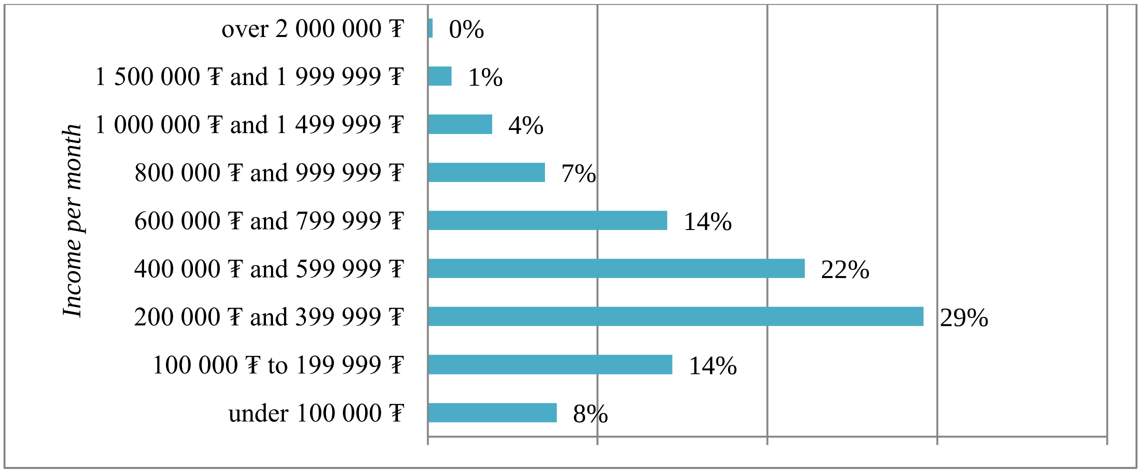


Figure 39: Percentage of the household income.

The monthly income of the residential respondents was 431 thousand ₮ for the 'Ger-2010' user group, 502.5 thousand ₮ for the 'Apartment-2010' user group and 693.8 thousand ₮ for the 'Apartment-2011' user group (see Figure 40).

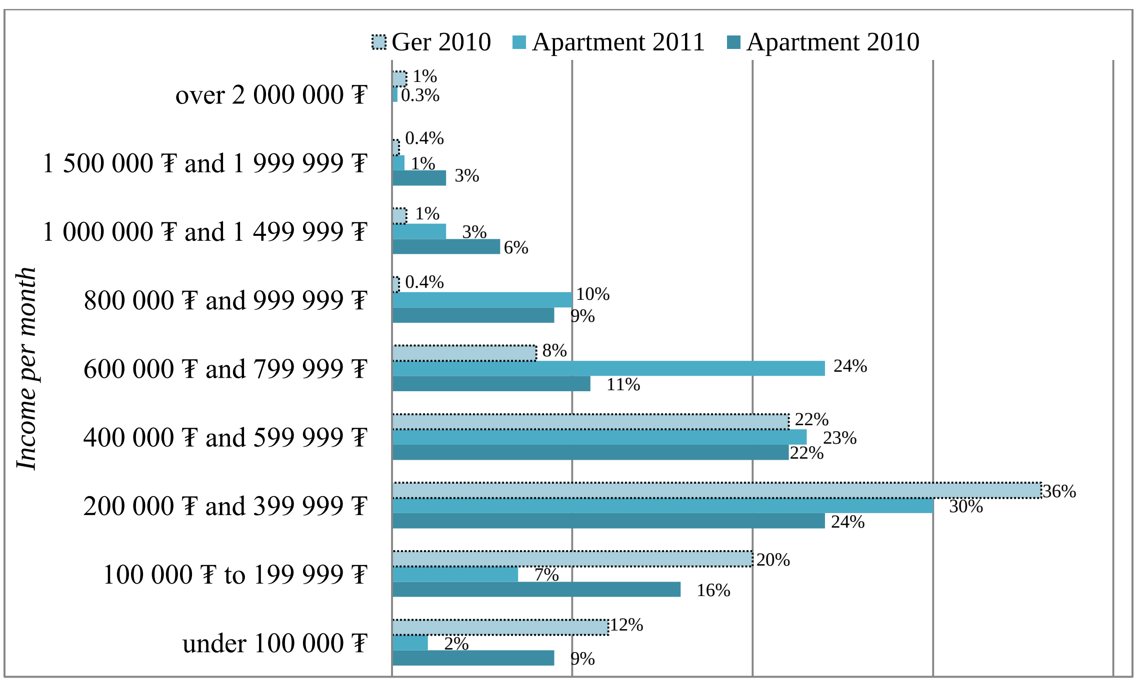


Figure 40: Household income

[11] Apartment areas' households in 2010: t-statistics = 0.411, p-value = 0.681; Ger areas' households: t-statistics=-6.676, p-value=0.000; Apartment areas' households in 2011: t statistics=-4.084 p value=0.000

Most respondents (84.4%) lived in their own house or Ger[12] but 90.6% of the apartment respondents lived in their own house. Approximately 16.7% of the Ger respondents rented rather than owned, which was 5.6% higher than the census (NSOM, 2011b).

Most apartment area respondents lived in an apartment (95.9%[13]); relatively few lived in a modern house (0.9%), a townhouse (0.6%), a dormitory (1.2%) or donga (1.3%). Approximately 45.2% and 54.4% of the Ger areas' respondents lived in Ger and in unofficial detached houses.

The age of houses varied: 51.6 % of apartment respondents lived in buildings that were between 20 and 39 years old, and the mean age of houses/flats was 27.36 (16.56) years old. In the Ger areas, 47.9% of respondents lived detached houses less than 10 years old. Most Ger area respondents (83.1%) had been settled for less than 20 years.

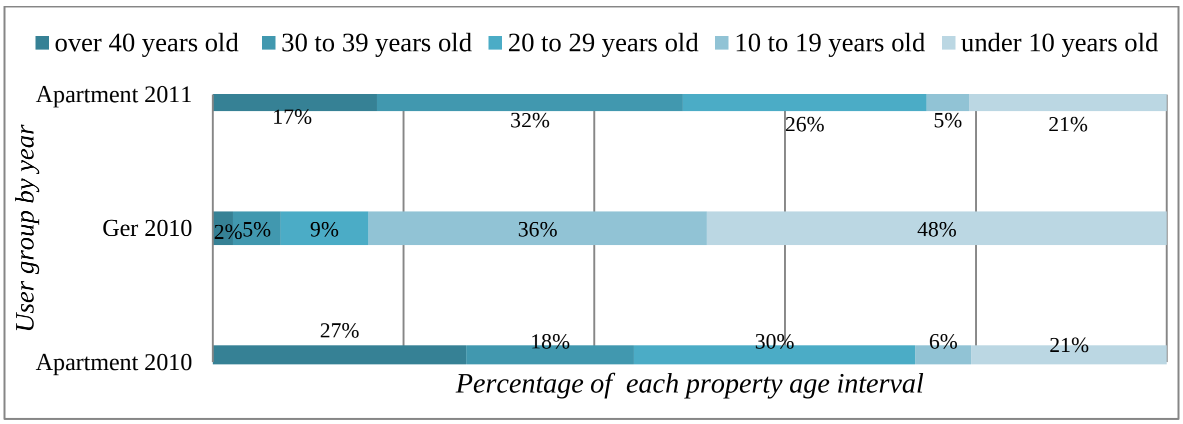


Figure 41: Range of property ages by type

The "average" house size of apartment respondents was 40.34[14](24.98) m^2 (64.23 (29.73) m^2 for new houses (under 10 years old)) slightly smaller than in the Ger, where the mean was 47.89 (23.51) m^2.

About 99% of the apartment respondents lived in apartments that were connected to the USUG's water systems; 99.7% and 97.5% of the respondents' houses respectively were connected to housing utilities systems including hot water system.

Only 0.3% and 0.7% of the apartment households had no bath or shower at home. Fewer than 8% of the households had only one tap at home, and only 2% of the households had 2 toilets in the house. This

[12]Ger-Area is informal settlement of the city. However, the difference between them is as follows: 1) Ger-Areas are consisted of the row of the streets with the fences surrounding up to 700 m2 of plots by wood for each households; 2) Households live in houses or Gers (traditional house of Mongolians suited to the nomadic life style) and 3) Lack of basic infrastructure etc…

[13]From the census, 94.57% of the dwellers of the apartment areas lived in apartments.

[14] Slightly over 70% of the apartment areas household were less than 50m² by the census 2010.

indicates that most respondents lived in water using appliance-equipped houses, with 2 taps, a bath, a showerhead and one toilet.

Overall, 59.1% of apartment residents reported that they had water meters but only 56.6% of those households had sub-meters (i.e. for individual apartments instead of for entire building) metering at home. The rest of these households had universal water metering, meaning they still pay for water at a flat rate tariff. Almost 63.7% of sub -metered households had 2 sub-meters installed; one was for the cold water pipe and the other for the hot water.

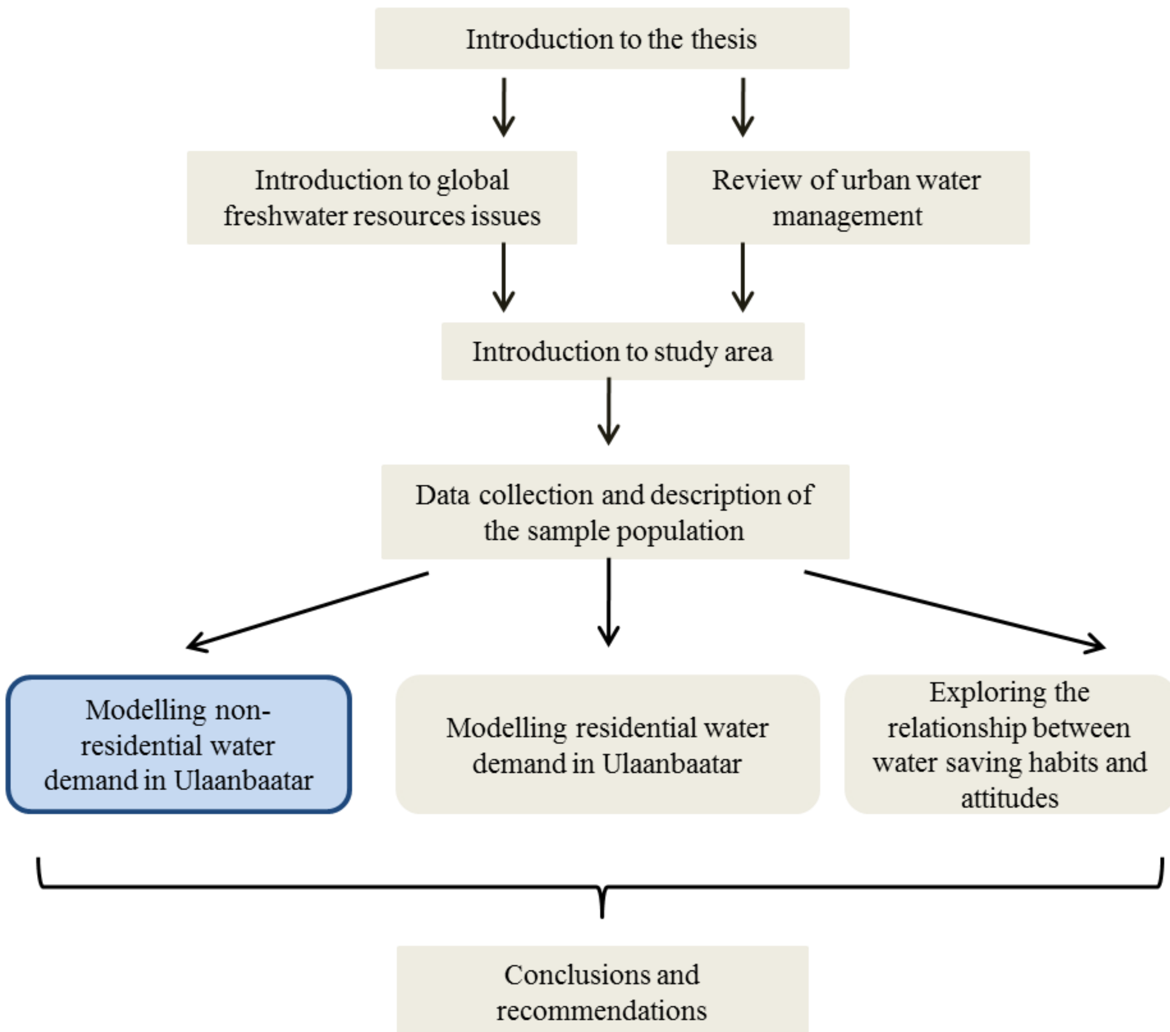
In the Ger, 92.9% respondents purchased their water from piped water kiosks. Very few respondents were supplied with water from a non-piped water kiosk, and only 0.4% of Ger areas' respondents were self-supplied. From the population and housing census of 2010, the Ger areas' households took water from different sources: 57.4% from piped kiosks, 27.4% from un-piped kiosks, 7.8% from own wells and the rest of from protected and unprotected rivers and springs (UBSO, 2011b).

5.5 CONCLUSION

- This study investigates the potential effectiveness of urban water demand side management policies in Ulaanbaatar. The study area does not have enough historical or cross-sectional water use data, so, one cannot use "standard" techniques to estimate demand. Therefore, a questionnaire was developed, that would collect current water use/price data and also hypothetical water use/price data that could be utilised in a contingent behaviour study.
- A multi stage sampling method including cluster sampling, stratified sampling and simpler sampling strategies was used.
- The residential survey was conducted using a clustered random strategy for selecting khoroos, which were selected by geographical and administration divisions, of central six districts and then the participants were selected randomly. The clustered sampling was suited for residential users.
- The non-residential users were also distributed within those districts, most successfully through USUG's technicians' business territory division and then the participants were selected randomly.
- Research assistants were trained at one day and a half day workshop. As I have worked in the Mayor's Office of Ulaanbaatar prior to the start of this study, I easily got administrative and academic support from my old job and the university. I had daily contact with all my assistants and also undertook some interviews myself. This helped me to improve the questionnaires particularly in making word corrections.

- The administrative support was the most important tool for data collection in Mongolia, as the people trust the government and found they had an opportunity to share their opinions. Therefore, the sampling errors and non-responses error were less than expected (Dillman et al., 2009).
- Overall survey data were collected from 958 residential users (households) and 375 non-residential users (firms/organisations) in 2010 and 2011, comprising 263 Ger; 695 apartment households including 344 metered households and 351 non-metered households.
- The non-residential user sample is in the 1.2% of the total Ulaanbaatar permanently operating businesses. The residential user sample is 0.3% of the total Ulaanbaatar households. The sample sizes of both groups achieved a significant level (Krejcie and Morgan, 1970).
- In 2011, the number of residential respondents, who had sub-water meters at home, were only slightly higher than in 2010, and in terms of income non-water metered households are a little poorer than metered households. Overall samples were distributed across different living areas, household sizes, and income and property types.
- As for the non-residential respondents, all economic sectors were represented in the sample. These users were aggregated into three groups specifically manufacturing; commercial; and government user groups. Relatively fewer high income or small firms were involved this study.
- The non-residential sample was not (proportionally) representative of the true “population” of businesses in Ulaanbaatar (which is dominated by many small retail firms; as compared to the sample which includes large and small firms from many different sectors). This was done deliberately, to ensure I could learn more about the water use of different types of businesses.

Thesis layout



CHAPTER 6 MODELING NON RESIDENTIAL DEMAND FOR WATER IN ULAANBAATAR

This chapter is based on an article that empirically demonstrates how the contingent behaviour method (CBM) – commonly used to estimate the non-market values of individuals – can be adapted to business settings. It uses data that was collected from more than 375 non-residential water users in Ulaanbaatar, Mongolia, and estimates the price elasticity of water demand for three different user groups (manufacturing, commercial and governmental users). Water demand is shown to be relatively price inelastic with values ranging between -0.251 and -0.05. This inelasticity implies that prices would have to increase substantially to generate any significant reduction in water use (e.g. my population-weighted estimates indicate that even a doubling of water prices would only generate a 3.6 % reduction in water use), but that significant revenues could potentially be raised. The results also indicate that attempts to influence water saving habits (e.g. introducing water saving technologies or encouraging water conserving activities) may be better able to reduce water demand than increases in price.

6.1INTRODUCTION

Globally, water consumption is increasing faster than population growth. In the last century, population increased fourfold but water use increased by a factor of seven (UNDP, 2004). Industrialisation in developing and transitional economies, particularly in Asia, has been linked to substantial increases in water use (WWAP, 2006); an example of this can been seen in Mongolia. The capital city of Mongolia, Ulaanbaatar, is likely to face a water scarcity problem in the next few years. Short term problems are largely due to increasing water demand, caused by population growth, urbanization and economic development (WRG, 2009). In the longer term, Ulaanbaatar is also likely to see a decrease in its water supply as global warming melts the glaciers, which provide most of the city's water (Batima et al., 2008).

In developing and transit economies, supply side policies have historically dominated urban water policy because they attempt to achieve Millennium Development Goals (MDGs). However, in Mongolia current available hydrologic sources constrain supply. In 2000, the availability of freshwater in Mongolia, was measured by Falkenmarken's indicator as being between 1700m^3 and 1000m^3 per capita, per year, which represented a water stressed country (Smakhtin et al., 2000), and the UNEP (2002) observed that Mongolia had 'moderate to high water stress' (where stress is defined as the consumption of more than 10% of renewable freshwater resources). Moreover, in 2010, the sub-national map of the water stress index was assessed according to country (WASH, 2010), and showed that Mongolia, particularly Ulaanbaatar, belongs in the extreme to high risk range. According to several forecasts, including the Urban Development Master Plan of Ulaanbaatar (UDMP) to 2025, Ulaanbaatar Water and Sewerage Master Plan (UBWSMP) to 2020, and the study of Nemer et al. (2008), Ulaanbaatar will face what is formally defined as water scarcity by 2015 if the population and water usage continue to grow at the levels observed in 2005. Other evidence shows that Ulaanbaatar's seasonal water shortages are growing ever more common, and in the next 10 years, the city will be facing a critical shortfall in water availability (Emerton et al., 2009). Evidently, Mongolia cannot continue to pursue only supply-side policies.

In industrialized countries, urban water policy leans more towards demand side management – the primary aim being to promote the efficient use of scarce water sources (Kolokytha et al., 2002, Dziegielewski, 2003, Bera and McAleer, 1989). Demand side management strategies and policies can be powerful tools for balancing demand and supply (Griffin, 2006a). They can also be environmentally friendly (Kolokytha et al., 2002) and could, potentially, be applied to developing countries. For at least some of these reasons, international development organizations often encourage developing countries to introduce demand side management approaches, with social and economic considerations. But it still not clear in the Ulaanbaatar case, how users will respond to policy changes and if demand side policies are an efficient conservation tool in this context. This issue thus defines the main aim of this chapter – to explore the potential efficacy of water demand management policies in Ulaanbaatar, focusing, in particular, on non-residential water pricing.

It seeks to answer two main questions:

1) How sensitive is non-residential water demand to changes in the price of water? That is, by how much would non-residential water demand fall if water prices were to rise?
2) How much revenue could be collected through increased water prices?

Finding answers to these questions is a non-trivial exercise, primarily because of significant issues associated with data – there is simply not enough variation in, and information about, water prices and water consumption to estimate demand using 'standard' economic approaches. This chapter thus provides an empirical demonstration of a way in which to adapt the contingent behaviour method (CBM) – commonly used to estimate the non-market values of individuals – to business settings. As such, its contribution is both empirical and methodological.

This chapter does not contain an overview of the case-study area (provided in chapter 3). Section 6.2 discusses the methodological background for the non-residential water demand estimation and furthermore considers empirical issues that must be considered when modelling non-residential water demand, including a discussion of the particular research methodology used here, and the system for collecting data. Section 6.3 presents the results, while section 6.4 offers some concluding remarks.

6.2 METHODOLOGICAL BACKGROUND

Studies estimating non-residential water demand (i.e. industrial, commercial and government) only started appearing in the published literature from the 1960s onwards. But studies of residential demand were prevalent earlier – at least partially explaining why today, there is less literature on industrial water demand, compared to that which is available on residential and agricultural demand; there is even less published work on industrial water demand in developing economies.

The theory of production or cost (used by most neoclassic economists) provides the functional framework for thinking about non-residential water demand (Chambers, 1988, Renzetti, 2002a, Worthington, 2010, Reynaud, 2003). There are several different production, cost and profit functions that generate explicit analytical formulas for water demand estimations, which are derived from an economic optimization process (Baumann et al., 1998). But this chapter is essentially empirical and my intention is not to replicate such derivations; rather I wish to use this theoretical background to highlight the fact that non-residential water demand is a function of numerous variables including the price of water, the price of other factor inputs, technology, output prices and output levels.

Table 16 presents a list of non-residential water demand studies. Some have approached the issue from a production-function approach; some from a cost-function approach, but most have attempted to estimate the (derived) demand for water directly. In this study, I also approach the problem directly – essentially using conditional demand functions, which are derived using a consumption behaviour approach; i.e. by treating non-residential users of water as if they are 'consumers' and then seeking to measure the sensitivity of their water demand to various factors (Baumann et al., 1998, Griffin, 2006b).

Table 16: Non-residential and/or industrial water demand estimation studies

Type of functions	Type of technology	Sources
Production	Cobb-Douglas	(Wang and Lall, 2002)
	2 type production Cobb-Douglas and translog or input distance	(Reynaud, 2003); (Kumar, 2004); (Ku and Yoo, 2012)
Cost	Cobb- Douglas	(De Rooy, 1974)
	Linear	(Liaw et al., 2006)
	Non linear (translog)	(Grebenstein and Field, 1979); (Babin et al., 1982); (Renzetti and Dupont, 2003); (Feres and Reynaud, 2005); (Renzetti, 1988, Renzetti, 1992, Dupont and Renzetti, 2001)
Demand	Cobb-Douglas	(Ziegler and Bell, 1984); (Arbues et al., 2010); (Dharmaratna and Parasnis, 2010)
	Conditional factor	(Mercer and Morgan, 1974); (Joseph, 1982); (Onjala, 2001)
	Linear	(Elliott, 1973); (Kim and McCuen, 1979); (Lynne, 1989);(Williams and Suh, 1986); (Schneider and Whitlatch, 1991); (Malla and Gopalkrishnan, 1999); (Hussain. I. et al., 2002); (Gunatilake et al., 2001); (Moeltner and Stoddard, 2004)
	Stone-Geary	(Gaudin et al., 2001)

This approach was taken for pragmatic reasons: the study area does not have enough historical or enough cross sectional data to estimate water demand for non-residential users using secondary data, so all data had to be collected. A questionnaire pre-test revealed that users were not happy to disclose commercial-in-confidence information about their production costs and technologies; but they were happy to provide information about water usage and other characteristics of their firm, hence the decision to use the direct approach.

An additional complication concerns the fact that there has been little to no change in the price of water of late: all non-residential users pay the same tariff and that tariff has only changed twice in the last decade. As such there is no 'real' data providing information about water use for a range of different prices, so I could not estimate demand using any of the 'traditional' economic approaches. I therefore chose to use the contingent behaviour method (CBM) to determine likely consumer reactions to changes in the price of water – in essence supplementing observable price/quantity data with 'hypothetical' price/quantity data.

6.2.1 THE CONTIGENT BEHAVIOUR METHOD

The CBM is a type of stated-preference non-market valuation tool (like the contingent valuation method) that is most commonly used to assess the welfare effects of quality or price changes at recreational sites – i.e. to estimate the non-market values of tourists / final consumers (Englin and Cameron, 1996, Cameron et al., 1999, Kerr et al., 2003, Aberini and Khan, 2006, Prayag et al., 2009, Grijalva et al., 2002, Alberini and Zanatta, 2007, Jeon and Herriges, 2010). But it has also been used to estimate water demand for households of Hadejia-Jamare, Northern Nigeria (Acharya and Barbier, 2002) and Buan Ma Thuot, Vietnam (Cheesman and Bennett, 2008). To the best of my knowledge, however, this is the first study to use the CBM to estimate non residential water demand.

Like all stated-preference methods, the CBM is subject to criticism because it relies on hypothetical data to generate estimates – and applied researchers have found that actual responses to 'real' situations, frequently differ from stated responses to the hypothetical (Shogren and Taylor, 2008, Fredrik, 2010, Carson and Hanemann, 2005, Hanemann, 1994). But the CBM is considered by some to be superior to the contingent valuation (CV) method because people are more likely to be able to accurately predict their behaviour in response to a particular scenario than to be able to predict how much they would be willing to pay for a change in the quantity or quality of a variable (Morton et al., 1995, Cameron et al., 1996, Grijalva et al., 2002, Carson and Hanemann, 2005, Carson 2011). Moreover, hypothetical questions that are designed to reveal quantity responses tend to be subject to less strategic response bias than questions about money (Cheesman and Bennett, 2008, Acharya and Barbier, 2002, Eiswerth et al., 2008). So although not problem free, the CBM does offer itself as an 'acceptable' tool – particularly when the other option is to walk away saying '*there is not enough real data'* and thus forcing people to use estimates from other studies/regions, that may, or may not, be relevant.

Like most stated behaviour methods, survey design is critical. In this study, I asked respondents to indicate likely water usage under different hypothetical prices. I chose to do this (rather than to ask about the amount respondents would be willing to pay for changes in quantity – as would be done in a CV study) because this approach naturally mimics situations likely to confront organisations. To be more specific, it is relatively easy to imagine a situation in which the government raises the price of water, and businesses have to decide how to respond. It is harder to imagine a situation where individuals offer the government more money to change the amount of water supplied.

In the first instance, I asked respondents to tell us how much water their business/organisation used during the previous year (hereafter referred to as Q_1). Respondents were then asked to indicate how much their water use would be likely to change, if the price of water were to rise by (a) 10%; (b) 50%; and (c) 100% (i.e. if it were to double) – see Table 17.

Table 17: Sample Contingent behaviour question: Do you think your business would use more or less water if the price increased?

	We would probably use				
	LESS WATER				MORE WATER
	Less than half of what we use now	Probably use a little less	No change	Probably use a little more	More than twice as much as we use now
If water price increased by 10%	☐	☐	☐	☐	☐
If water price increased by 50%	☐	☐	☐	☐	☐
If water price doubled	☐	☐	☐	☐	☐

I then used responses to that question to estimate (hypothetical) water use (Q_i) at each (hypothetical) price. Specifically, if the respondent indicated that he/she would:

a) use less than half of what they used now, then hypothetical Q_i was calculated as 0.5 Q_1;
b) probably use a little less, then hypothetical Q_i was calculated as 0.75 Q_1;
c) no change, then hypothetical Q_i was calculated as Q_1;
d) probably use a little more, then hypothetical Q_i was calculated as 1.25 Q_1;
e) more than twice as much as we use now, then hypothetical Q_i was calculated as $2Q_1$.

The calculations associated with (a), (c) and (e) are relatively uncontroversial, but the phrases 'probably use a little less' and 'probably use a little more' could clearly be interpreted in a multitude of ways (e.g. a little less could mean that demand would fall to just 90% of current consumption rather than to 75%). So I conducted a sensitivity analysis – comparing estimates generated from these models, with estimates that were generated from models that used $Q_i = Q_1$ for the 'little less' scenario and $Q_i = Q_1$ for the 'little more' scenario. Key results (namely that water demand is inelastic) were not substantially different (although, as expected *a priori* this other specification generates slightly more inelastic estimates). I also compared estimates generated from these models, with estimates that were generated from models that used the alternative 'extreme' interpretation: $Q_i = 0.5Q_1$ for the 'little less' scenario and $Q_i = 2Q_1$ for the 'little more' scenario. Here too, my final conclusion (that non-residential water demand is inelastic) was not substantially different. As such, I have not presented those other results here, but they are available in Appendix C.

Using the assumptions outlined in the dot points above, mean annual consumptions were:

- at the current price level - 4068.74 Kilolitre (Kl);
- for prices that were 10% higher than the current price (1.1P) - 3979.17Kl;
- for prices that were 50% higher than the current price (1.5P) - 3869.04Kl; and
- for prices that were twice the current price (2P) - 3804.31Kl.

I conducted a series of non-parametric tests to see if the distribution of responses to the hypothetical questions were different at hypothetical price levels. The Kruskal-Wallis test for rejected the hypothesis that consumption is the same at all price levels ($\chi 2=22.664$; $p=0.0001$) and the Welch statistic also confirmed that there were statistically not significant differences between the stated and hypothetical water consumptions at the price levels (P &1.1P => t=1.61, p value= 0.246; 1.1P & 1.5P => t=1.25, p value=0.212; and 1.5P & 2P => t=0.705, p value=0.481).

6.2.2 CONFIGURING A CONTINGENT BEHAVIOUR DATA SET

To estimate demand using a CB model, one must create a panel data set by combining actual (current) price and quantity data with the ‘hypothetical’ data. In this case, this led to the creation of a dataset which included 4 panels: that relating to the current price, and those relating to prices that were 1.1, 1.5 and 2 times higher than the current. Dummy variables were constructed to differentiate between panels - Figure 42 (where Q_1 represents current water use, $Q_{2,\,3\,\&\,4}$ represent hypothetical water uses (at higher prices), X represents independent 'non-priced' variables thought to influence demand (see below), and where dummy variables were used to indicate P_2, P_3 and P_4).

Figure 42: CB questions creating panel data

This unbalanced panel dataset included 1,233 observations – indicating that only 87% of the 375 respondents provided enough data for us to be able to estimate their hypothetical consumption at different prices. There were all cases with valid data for identifying an outlier (z-score).

6.2.3 OTHER VARIABLES INCLUDED IN THE ANALYSIS

There were selected with reference to prior studies (see Table 18, which presents a summary of variables commonly used in studies of non residential water demand). Other questions asked in the survey (and used within each 'panel' of the data set) related to business characteristics (X in Figure 42).

Table 18 Summary of variables commonly used when estimating non-residential water demand

Type	Name	Measurement	Source
Dependent	Water quantity	Annual intake water	(Ziegler and Bell, 1984)
		Annual water consumption	(Lynne, 1989); (Williams and Suh, 1986); (Schneider and Whitlatch, 1991);(Malla and Gopalkrishnan, 1999); (Onjala, 2001); (Gopalakrishnan and Cox, 2003)
		Monthly water consumption	(Hussain, I 2002); (Dharmaratna 2010)
		Daily water consumption	(Joseph 1982); (Arbues, F 2010)
		Daily water consumption pre 1000$ value added	(Elliott, 1973)
Independent	Price for water	Average price	(Ziegler J 1984); (Malla P.B 1999); (Hussain, I et al 2002); (Gopalakishnan and Cox 2003); (Dharmaratna and Parasnis, 2010)
		Marginal price	(Elliot, D 1973); (Lynne, G 1979); (Joseph, E S 1982); (Williams, M 1999); (Schneider, M 1991); (Onjala, 2001)
		Shin and shadow price	(Arbues, F 2010)
	Output	Value added	(Williams and Sue 1999); (Arbues, F 2010)
		Value added per production	(Onjala, 2001)
	Labor	Number of employees	(Malla and Gopalakishnan 1999); (Hussain, I 2002); (Arbues, F 2010); (Babin, F 1982); (Hanemann, 1993); (Feres and Reynaud, 2005)
		Wage rate	(Elliot, R D 1973); (Onjala, J 2001)
	Capital	Technology level	(Ziegler and Bell 1984);
		Age of capital	(Ziegler and Bell 1984); (Moeltner and Stoddard 2004)
		Size of area for business	(Kim and McCuen 1979); (Gopalakrishnan and Cox, 2003); (Arbues F 2010)
		Surface area	(Arbues, F 2010);
	Other	Temperature	(Williams and Sue, 1999); (Hussain, I et al 2002); (Moeltner and Stoddand, 2004); (Dharmaratna and Parasnis, 2010)
		Rainfall	(Williams and Sue 1999); (Hussain, I et al 2002); (Gopalakrishnan and Cox 2003); (Dharmaratna and and Parasnis,2010)
		Number of connection	(Hussain, I et al 2002); (Dharmaratna and Parasnis, 2010)

Literature on water saving/conservation habit studies is mostly based on residential water consumption and this research highlights the importance of water use and socio demographic factors and also of water saving habits. My intuition leaded me to consider that the water saving habits of non-residential users is also likely to be important. So, I also sought to consider water using equipment/technology and water saving habits.

More specifically, respondents were asked a series of questions designed to measure water saving habits in terms of the frequency of each habit/technique employed. These techniques included: using water efficient equipment for all production processes (equipment), auditing water loss for water and sewerage systems (auditing sewerage systems), carrying out maintenance on water and sewerage systems and relevant equipment (maintenance), regularly auditing water loss/leakage at taps and toilets of office building (auditing building), fixing any leaking water using equipment and pipes (fixing), recycling effluent water, treating effluent as per Mongolian National Standard (recycling and treating effluent), using any technology for reducing waste water (reducing waste water) and using any technology for reducing water excluding production process (technology). The respondents indicated the frequency of their use at these water saving techniques by indicating where their business fit on a 5 point likert scale.

It is not strictly statistically correct to convert Likert scale data into numbers and to then calculate means, but doing so facilitates an easy visual comparison of responses. This was done by assigning each 'category' a number (as set out Table 19) and then calculating mean responses.

Table 19 Values assigned to categorical responses measuring water saving habits

Category	Value assigned
'more frequently'	5
'frequently'	4
'Occasionally'	3
'Rarely'	2
'Never'	1

The mean of each saving habit (by user group) is presented in Figure 43– indicating that Commercial and Governmental organizations generally appear to use water saving habits more frequently than do Manufacturing firms. Moreover, some water saving habits (particularly 'Fixing any leaking equipment and pipes', 'Reusing and recycling effluent water, treating the effluent as per Mongolian National Standard' and 'Using any technology to reduce waste water') are used much more frequently than others (such as 'Control water loss from main pipe system', 'Carrying out maintenance on water and sewerage systems and relevant equipment' and 'Regularly controlling leakage from taps and toilets in offices'.

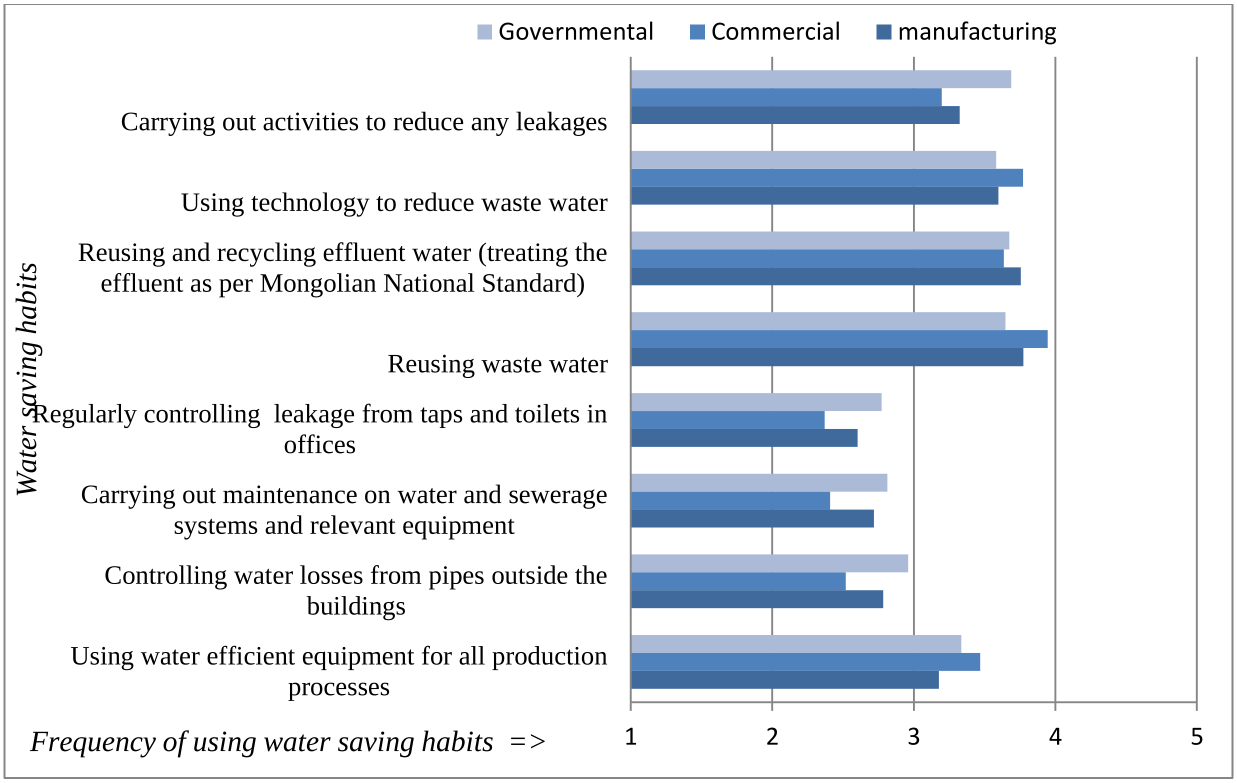


Figure 43 Water saving habits rate by each user group

I used this data to generate a single variable capturing all water saving habits (Wshr) – calculated as the mean of all individual habits. The consistency of the habit composition was determined by Cronbach's alpha. The alpha of overall respondents (0.714) confirmed that the water saving habit composition is acceptable. The overall mean was 3.23; it was 3.22 for the manufacturing user group, 3.16 for the commercial user group, and 3.31 for the governmental user group.

Having designed my own water saving habit variable, the full set of variables chosen for inclusion in my model were as follows:

The dependent variable 'quantity' was measured as the kilolitres of water used per annum by each firm. As discussed above, some of data referred to current, actual use, and some referred to 'hypothetical' quantities (that would obtain under different price levels), e.g.:

- Q_j^1 = Kl of water used per annum by the firm *j* in 2011 at the current price level
- Q_j^2 = Kl of water firm *j* says it would use if the price rose to 1.1 times its current level.
- Q_j^3 = Kl of water firm *j* says it would use if the price rose to 1.5 times its current level.
- Q_j^4 = Kl of water firm *j* says it would use if the priced doubled

The independent variables were:

- Y_j (output) – average monthly income/budget of organization j during 2011, calculated as
    - the average monthly income for manufacturing and commercial firms;
    - the average monthly budget for governmental organizations (Schneider and Whitlatch, 1991)
- Ej (labour) - the number of full time employees, (part time employment is very uncommon in the study area) within organization j at the time of the interview
- $Wshr_j$ - a variable designed to capture information about the use of water-saving habits (discussed above).
- P_{knj} - a dummy variable indicating respondent knowledge of price - set equal to one, if their response to a question about what price they were paying for water was correct, zero otherwise. This was included because knowledge of price has been shown to have a significant impact on water use behaviour (Carter and Milon, 2005, Cheesman and Bennett, 2008).
- B_{refj} - a dummy variable indicating whether the respondent felt there was a need for billing reform (1 if yes; 0 otherwise). This was included because Carter and Milon (2005) found that price policies are more effective if combined with billing reform (e.g. bills showing information about amount consumed water and price). In the study area, a water bill for non-residential users is sent out on a monthly basis. However, the water bill does not provide detailed information about consumption and, therefore, respondents were asked whether they required more information on their bills or not.
- $D_{1to\ 3}$ - price change dummy variables (all set equal to zero if data refers to actual price and quantity; D_1=1 if price and quantity data refer to the first hypothetical scenario (P_1=1.1P_0); D_2=1 if price and quantity data refer to the second hypothetical scenario (P_2=1.5P_0); D_3=1 if price and quantity data refer to the third hypothetical scenario (P_3=2P_0). The following equation presents descriptive statistics of variables of demand model used in the analysis (at the current price).

As such, the demand function was assumed to be:

$$Q_{JI} = B_1 + {}_{B2}Y_{JI} + B_3E_{JI} + B_4W_{shrji} + B_5\,P_{KNI} + B_6B_{REFI} + B_7D1_I + B_9D2_I + B_{10}D3_I + U_I + E_I$$

Equation 1

Table 20 provides a summary at these key variables.

Table 20 Descriptive statistics each sub group (mean with standard deviation in brackets)

Variable	Manufacturing	Commercial	Governmental
Monthly income (₮) (log)	3.581(0.138)	3.561 (0.131)	2.775(0.131)
Number of employees (log)	4.116(0.069)	3.904(0.067)	3.474(0.065)
Water saving habits (log)	1.111(0.018)	1.110(0.013)	1.151 (0.016)
Knowledge at water price (Yes=1, No=0)	0.840(0.018)	0.870 (0.015)	0.822(0.017)
Desire for billing reform (Yes=1, No=0)	0.230(0.021)	0.336(0.021)	0.178(0.018)

It was hypothesized that the quantity of water used by non-residential users was a positive function of the income (budget) and the number of employees, and a negative function of water saving habit rates, knowledge at water price, desire for a billing reform, and increases in price changes.

6.2.4 MODELLING APPROACH

In the economics literature, several statistical techniques are commonly used to estimate non residential water demand (Table 20). Basic problems facing all include the need to decide whether data should be expressed in logarithmic or original forms, and whether a single demand equation can be estimated for all or whether different models should be estimated for different types of users. But there are additional issues that need to be considered in this case. This is because the 'created' data set contains price panels with invariant explanatory variables (e.g. income and employment is the same for each respondent), so the error term is likely to be correlated across observations for each non-residential user. Moreover, the number of observations for each respondent varies (since not all respondents answered all questions). In this instance, several different models were thus estimated using both the logarithmic and natural forms; and by combining all users together (the pooled model) and by separating the data set into different user groups.

In the first instance, demand was estimated using both a random effects (RE) model and a fixed effects (FE) model. Both the RE and the FE models were estimated using firstly logarithmic and then natural data. The Hausmann test (Hill et al., 2011) indicated that the RE model was preferred to the FE model (irrespective of whether data were in logarithmic or natural form).

Both the non-nested Bera McAleer test (Bera and McAleer, 1989, Kobayashi and McAleer, 1999) and the PE test (Marno, 2000) were then used to determine the preferred functional form. The PE test (Marno, 2000) indicated that the log-linear model was preferable in all cases.

Having established that (a) the RE model was appropriate and that (b) the log-linear model was preferable, I also estimated demand (using the RE model) for all firms together, and for each separate group (manufacturing, commercial and government organizations). The LRT test indicated that demand for the three different types of organizations should be modelled separately.

6.3 RESULTS

The estimated models are significant at the 1% level and have chi squares between 29.56 and 192 (Table 20). Each coefficient, except that associated with income and water saving habits in the manufacturing model, and knowledge of price for all models, has the expected sign and most of the variables are significant. The goodness of fit of the equations, proxies by the Wald statistic, is exceptionally good.

6.3.1 MODEL COEFFICIENTS

As expected, the model indicates that higher prices are associated with lower water consumption, as evidenced by the negative coefficients on the dummy variables (each associated with an increasing price). As also expected, firms with a large number of employees tend to use less water than those with few employees.

Income is a significant parameter in all models, but the income elasticity of demand for the 'manufacturing' user group was -0.055, which has the opposite sign of other user groups. This indicates that an increase in income is associated with less water consumption. Possible reasons for this apparently anomalous result relate to the sample: it contained several very large firms that could be using water-saving technologies &/or may not be producing goods that require significant amounts of water for their production process.

Water saving habits were strongly associated with water use for all groups – although in different ways. Commercial and Governmental organisations, which frequently employed water saving habits, used less water (on average) than those that did not. But for manufacturing firms, the relationship went the other way. This might be explained by the fact that the manufacturing group contains some very large firms that may use only one or two water saving devices frequently – but these devices might be much more effective at conserving water than a multitude of other devices.

Table 21 Random effects model for non residential demand for water by users group

Dependent variable: log of annual water consumption in cubic meters

Coefficients provided in table, p-values reported in brackets

	Manufacturing	Commercial	Governmental
Income (₮) (log)	-0.081 (0.012)	0.102 (0.000)	0.044 (0.078)
Number of employees (log)	0.279 (0.000)	0.327 (0.000)	0.167 (0.002)
Water saving habits (log)	0.440 (0.037)	-0.953 (0.000)	-0.098 (0.648)
Respondent correctly stated the current water price water (Yes=1, No=0)	0.974 (0.000)	1.436 (0.000)	0.649 (0.003)
Respondent desires for billing reform (Yes=1, No=0)	-0.698 (-0.075)	-0.586 (0.000)	-0.051 (0.774)
Contingent behaviour dummy 1 - (Yes= 1 for P at 110 % current P; otherwise = 0)	-0.069 (0.736)	-0.104 (0.574)	-0.065 (0.728)
Contingent behaviour dummy 2 - (Yes= 1 for P at 150 % current P; otherwise = 0)	-0.203 (0.327)	-0.225 (0.192)	-0.236 (0.206)
Contingent behaviour dummy 3 - (Yes= 1 for P at 200 % current P; otherwise = 0)	-0.276 (0.185)	-0.292 (0.091)	-0.305 (0.101)
Constant	5.809 (0.000)	5.981 (0.000)	6.537 (0.000)
Wald $\chi^2(2)$ Prob> χ^2	86.14 (0.000)	192.79 (0.000)	29.56 (0.000)

6.3.2 ESTIMATES OF PRICE ELASTICITY

I used the coefficients from the models to generate estimates of water use at each price level (calculated by multiplying each coefficient by the mean of each corresponding variable). I then used a mid-point formula to calculate associated price elasticities for each price change for each type of businesses – see Table 21 which also presents estimates from other studies of non-residential water demand (although none have used the CBM).

Most evident from Table 22 is the fact that demand becomes more inelastic as price increases. In all cases, non-residential water demand is price inelastic – although manufacturers appear to have more inelastic demand than others. The most price sensitive non-residential user group is ‘Commercial and Service’ organizations.

Table 22: Non-residential price elasticities: my estimates compared with estimates from studies in other parts of the world

Studies	Price changes	Manufacturing	Commercial	Government
This study	P to 1.1P	-0.171	-0.251	-0.161
	1.1P to 1.5P	-0.091	-0.082	-0.115
	1.5P to 2P	-0.054	-0.050	-0.051
Other studies	(Ziegler and Bell, 1984)	-0.08		
	(Williams and Sue, 1986)		-0.36 to -0.14	
	(Schneider and Whitlatch,1990)	-0.44 to-0.11	-0.93 to -0.23	
	(Renzetti 1992)	-0.59 to -0.15		
	(Wang and Lall, 1999)	-1.0		
	(Onjala, 2001)	-0.37 to -0.21		
	(Reynaud and Dupont, 2003)		-0.3 to -0.1	
	(Hussain, I et al 2004)	-0.13 to -0.11	-0.17	
	(Moeltner and Stoddard, 2004)		-0.14 to -0.06	-0.02
	(Zhou and Tol, 2005)	-0.32		
	(Liaw, et al 2006)	-4.37 to -0.02		
	(Dharmaratna and Parasnis, 2010)	-0.75 to -0.03	-0.24 to -0.15	

For the ‘Manufacturing and industrial’ user group, the estimates ranged from between -0.171 and -0.054. These are similar to the results of Ziegler, Hussain and Dharmaratna in their studies in Sri Lanka (Dharmaratna and Parasnis, 2010, Hussain. I. et al., 2002, Ziegler and Bell, 1984). For the commercial sector, my results also corroborate the findings of others (Lynne et al., 1979, Williams and Suh, 1986, Dharmaratna and Parasnis, 2010, Moeltner and Stoddard, 2004). I could find only one other study that reported elasticities for Government organizations (Moeltner, 2004); my estimates are more elastic than theirs – perhaps because at least some of the organizations within the group were private organizations (as noted in Section 6.2). Interestingly, at any given price level, the elasticity estimates associated with the government sector are surprisingly similar to those associated with the manufacturing sector – despite the fact that these organizations are likely operating with different objective functions. Further research could be usefully undertaken to explore the possible reasons for this.

6.3.3 USING PRICE ELASTICITIES TO MAKE PREDICTIONS ABOUT THE IMPACT OF PRICE CHANGES

Having ascertained the ‘plausibility’ of my elasticity estimates, I then proceeded to use my coefficients to generate estimates of the approximate change in total non-residential water demand, and in water-revenues, following a 10%, 50% and 100% increase in price. This was done by firstly calculating projected water demand, for each type of organization, as shown in Table 23.

Table 23: Projected water use of the 'average' organization under each price scenario

Price changes	Manufacturing	Commercial	Government
Current P	8228.20	2619.83	6540.31
1.1P	8075.16	2556.95	6401.00
1.5P	7991.98	2535.73	6333.79
2P	7948.03	2523.56	6292.35

These estimates were then multiplied by the estimated number of firms in each group (327, 1760 & 372 – as reported in the USUG report 2010), to generate estimates of aggregate non-residential water use (and water price revenues) under each price scenario (Table 24). Aggregate estimates of water use were then multiplied by price to generate estimates of water revenue – see Table 25. Evidently, a 10% increase in price would approximately result in an annual conservation of approximately 200 Megalitres (Ml) of water and an increase in water use revenue of 410 million Tugrug (₮), which is equivalent to US$325.800 (using 16th June 2011 exchange rate at 1258.4 Tugrug per US$ (CBM, 2011)).

Table 24: Estimated aggregate water use in Gl under each price scenario

Price	Manufacturing	Commercial	Government	Total across all sectors in
Current P	2.69	4.60	2.43	9.72
1.1P	2.64	4.50	2.39	9.53
1.5P	2.62	4.46	2.37	9.45
2P	2.61	4.44	2.35	9.40

Table 25: Estimated respectively revenue in billion ₮ under each price scenario

Price	Manufacturing	Commercial	Government	Total across all sectors
Current P	1.48	2.53	1.34	5.35
1.1P	1.60	2.72	1.44	5.76
1.5P	2.16	3.68	1.95	7.79
2P	2.87	4.88	2.59	10.34

6.4 CONCLUSION

Ulaanbaatar city has experienced seasonal water scarcity over the last few years, and limit to hydrological sources means it needs to urgently adopt demand side policies, particularly water pricing, as per the recommendation of the World Bank.

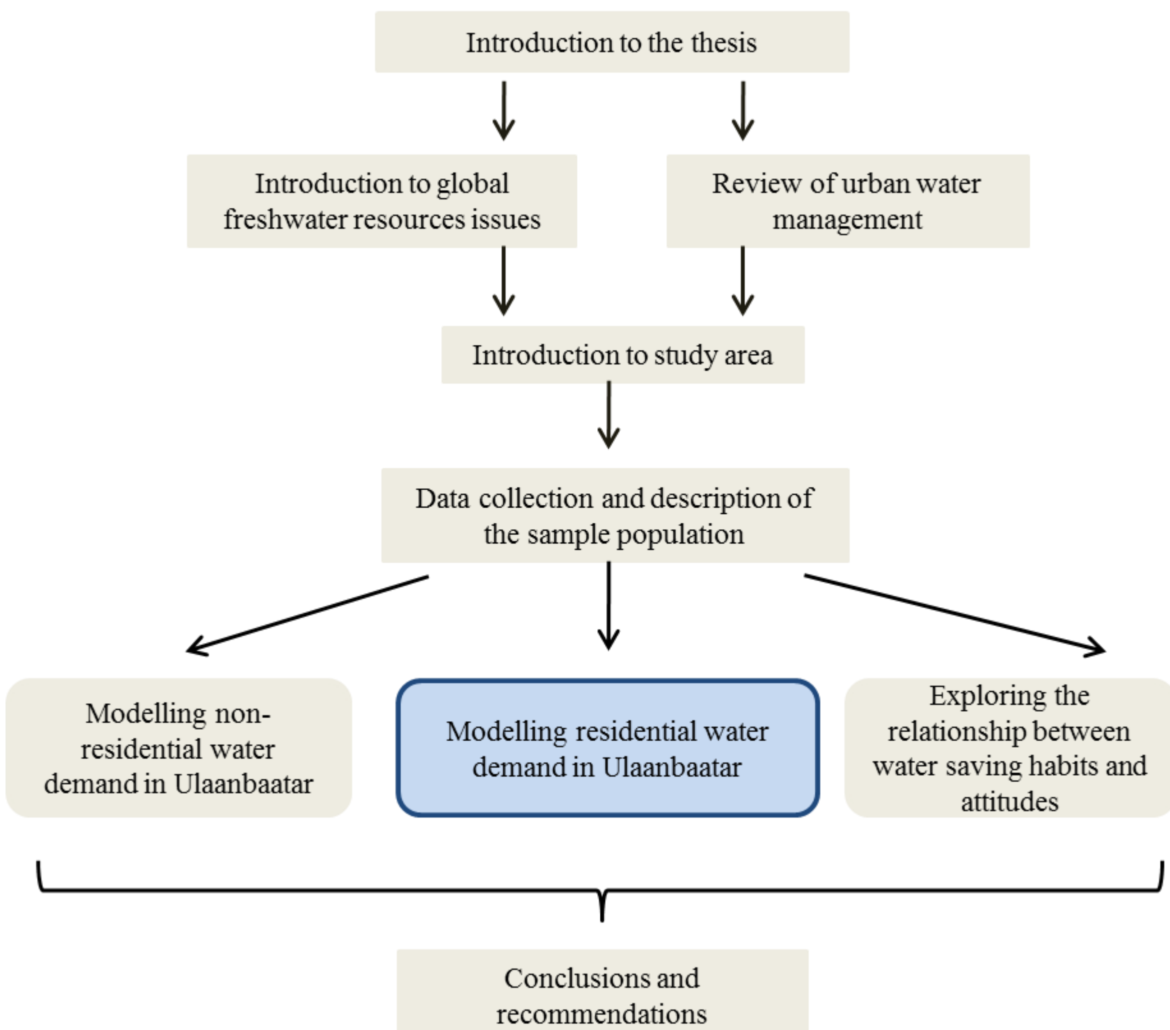
This study thus set out to explore the potential efficacy of water demand management policies in Ulaanbaatar, focusing, in particular, on non-residential water pricing. Using data from several hundred non-residential water users within a contingent behaviour model that was adapted for use in business settings, it sought answers to the following questions:

1) How sensitive is non-residential water demand to changes in the price of water? That is, by how much would non-residential water demand fall if water prices were to rise?
2) How much revenue could be collected through increased water prices?

- The results indicate that non-residential water demand is very price inelastic – perhaps partially due to the fact that current water prices are very low. Indeed if one were to double water prices, the total cost of water for non-residential water users would still likely be less than 35 % of the total amount spent by such users on their telephone bill (based on data from the 2010 business census of Ulaanbaatar - (UBSO, 2011a)
- My results indicate that a modest, 10% increase in price for non-residential users could help to conserve about 200Ml water per annum and bring about a 410 million ₮ revenue increase for the government, USUG.
- Although doubling the price is unlikely to be politically acceptable, Emerton et al (2009) found that non-residential users were likely to be willing to pay up to 150% of current prices and such a radical move could potentially reduce non-residential water consumption by just over 340Ml whilst increasing water revenues (collected from these groups) by about 4.96 billion ₮ (about 93% of current revenues). Most water would be conserved from commercial users and slightly more revenue would be gained from that group also.
- Not only has this study provided valuable empirical insights, but it has also contributed to existing literature by establishing that it is, indeed, possible to use the CBM to generate 'plausible' estimates of the price elasticity of non-residential water demand.
- To the best of my knowledge, this is the first study to use the CBM on non-residential water users in a developing country and the first time anyone has trailed the use of a water-saving habits indicator in such models.
- It must, however, be stressed that these estimates are, just that, estimates, and like all other estimates, subject to uncertainties associated with the quality of data, the accuracy of modelling, and so on. In particular, the hypothetical nature of the data used in the CBM must be considered: stated responses may not translate into actual outcomes. Nevertheless, my estimates appear plausible when compared to other estimates from other parts of the world using observed data. This indicates that the CBM is capable of generating robust estimates of price elasticities – a particularly good piece of news for those working in developing countries where absence of data is the norm, rather than the exception. Evidently, the contingent behaviour technique has much to

offer, beyond its more “traditional” uses (e.g. estimating consumer surplus in non-market valuation studies).

Thesis layout



CHAPTER 7 MODELLING RESIDENTIAL WATER DEMAND IN ULAANBAATAR

This chapter is based on my planned article that empirically demonstrates the potential efficacy of using increased water prices as a means of reducing urban water demand in a developing country. Data was collected from a survey of nearly 960 residential water users from formal and informal settlement areas in Ulaanbaatar, Mongolia. The data collected in 2010 and also 2011 following an observed increase in water price. Water consumption in metered and non-metered homes was estimated using both the direct indication and conditional demand approaches and a CBM was then used to estimate the price elasticity of water demand for different types of users (formal settlement - apartment areas and informal settlement - Ger areas). The results from the CBM indicate that consumption is relatively sensitive to small price changes among the households and that informal settlement households are likely to react to price changes much more than formal settlement households. I also found that price elasticity estimates from the hypothetical scenarios were better (i.e. had a narrower range of estimates that were closer to the observed responses) when respondents had experienced actual recent price increases.

7.1 INTRODUCTION

As discussed earlier, in developed economies, urban water policies often focus on demand side management – the primary aim being to promote the efficient use of scarce water sources (Kolokytha et al., 2002). Demand side management strategies and policies can be powerful tools for balancing demand and supply (Griffin, 2006a). They can also be environmentally friendly (Kolokytha et al., 2002) and could, potentially, be applied in developing countries (which, historically, have often focused on supply-side policies instead). For at least some of these reasons, international development organisations often encourage developing countries to introduce demand side management approaches, with social and economic considerations. However, it still not clear, in the case of Ulaanbaatar, how residential users will respond to these types of policy changes and if it is an efficient conservation tool in this context. This issue thus defines the main aim of this chapter – namely to explore the potential efficacy of water demand management policies in Ulaanbaatar, focusing, in particular, on residential water pricing.

Relatively little is known of the price sensitivity of residential water demand in Ulaanbaatar, which is the most important information for policy makers who wish to ascertain the potential impact on water use and water revenue of price increases. The problem is that data sets lack sufficient detail and variation to allow one to estimate price elasticity using conventional methods. Thus, I used the contingent behaviour method (CBM), which relies on hypothetical price and quantity data to supplement observed data in order to estimate water demand.

CBM has been used to estimate residential water demand in Hadejia-Jamare, Northern Nigeria (Acharya and Barbier, 2002), and Buan Ma Thuot, Vietnam (Cheesman and Bennett, 2008). But there have been very few tests of CBM validity (Grijalva et al 2002; Jeon and Herriges 2010). This is because few researchers have had the opportunity to compare hypothetical responses with actual behaviour. This study takes advantage of a unique opportunity that arose because firstly I collected data for a CBM study in Ulaanbaatar 2010; and then secondly a real price change occurred shortly after this data were collected. I thus returned to the city in 2011, collecting more data after this price change. As such, I was able to analyse the data in a manner that allowed me to investigate the following research questions:

1) How sensitive is the residential water demand to changes in the price of water?
2) How do the estimates of price elasticity that have been generated from hypothetical scenarios compare to estimates generated from observed data?
3) Are estimates of price elasticity that have been generated from hypothetical scenarios ‘better’ when study participants have had recent experience with ‘real’ price increases?
4) How much would residential water demand be likely to fall if water prices were to rise?

5) How much revenue could be collected from the residential users through increased water prices?

7.2 LITERATURE REVIEW

7.2.1 RESIDENTIAL WATER DEMAND AND ESTIMATION METHODS

Studies estimating residential demand for water only started appearing in the published literature from Howe's (1960) study onwards. But there are now a large number of articles on the topics of household/residential water demand and associated modelling issues (Arbues et al., 2003, Espey et al., 1997, Dalhuisen et al., 2001, Nauges and Whittington, 2009, Terrebonne, 2005, Taylor, 1975), which presents a summary of residential water demand estimation methods and variables in developing and developed countries). Some studies use data from a sample of individual households, some use data relating to entire residential buildings, other studies use very aggregated data - for example looking at the whole of utility consumption of a town or a city (Mayer et al., 1999, McIntosh and Yniguez, 1997). Irrespective of unit of analyses (households, city, etc), most studies include measure of water price, income, population (or number of family members), education, housing, religion, distance of water availability, temperature and/or location specification. Studies have been undertaken in developing countries and variables that have been used when estimating water demand in those countries are presented in Table 26. But even today, there is less literature on residential water demand in developing countries than in industrial economies; there is even less published work on residential water demand in transit economies.

One of the first investigations of residential water demand in developing countries was that of Katzman (1977), who estimated income and price elasticities for domestic water in Malaysia. Since then studies have been done on water demand for residents who have private and public connections or wells (piped and non-piped) in Uganda (Whittington et al., 1990), the western part of Saudi Arabia (Omar S. Abu Rizaiza, 1991), Jakarta (Crane, 1994), Salatiga, Indonesia (Rietveld et al., 2000b), 17 cities in Central America and Venezuela (Strand and Walker, 2005), Madagascar, three cities in El Salvador and Honduras (Nauges and Strand, 2007), Buon Ma Thuot, Vietnam (Cheesman and Bennett, 2008), Sri Lanka (Nauges and Berg, 2009; Dharmaratna and Parasnis, 2010), Tunisia (Sebri, 2012) and northern Pakistan (Khan, 2012). Nauges and Whittington (2010) reviewed residential water demand estimations in developing countries and their finding was that the price elasticity of residential water demand is generally in the range of -0.3 to -0.6: similar to estimates from developed countries.

Table 26 Residential water demand estimation variables in developing countries

Variables		Measurement	Source
Depen -dent	Water consumption	Annual usage per hh	Abu Rizaza (1991);
		Monthly water consumption	Rietveld (2000); Strand. (2007);
Independent	Price	Average price (AP)	Whittington (1990); Abu Rizaza (1991); Strand (2005); Cheesman (2008); Khan (2012)
		Marginal price (MP)	Crane (1994); Basani (2004); Strand (2005); Rauf (2008); Sebri (2012);
		Ratio AP/MP	Rauf (2008); Cheesman (2008);
		Knowledge for price	Cheesman (2008);
		Connection fee	Basani (2004);
	Household size	Number of women	Whittington (1990);
		Number of adults and children	Strand (2005); Nam (2005); Sebri (2012);
		Household size	Abu Rizaza (1991); Crane (1994); David (1998); Rietveld (2000); Basani (2004); Nam (2005); Nauges, (2007); Rauf (2008); Cheesman (2008);
	Income	Annual labour income	Hindman (2002);
		Monthly income	Crane (1194); Rietveld (2000); Whittington (2002); Strand (2005); Nam (2005); Larson (2006); Nauges (2007; 2009); Cheesman (2008); Sebri (2012);
		Household expenditure	Basani (2004);
	Education level	Mean of 2 adults educated year	Whittington (1990);
		Education of household's head	Abu Rizaza (1991); Basani (2004); Nauges (2009);
		The highest education level of a male	Madanat (1993); Larson (2006);
		Education level of a respondent	David (1998); Whittington. (2002); Nam (2005);
	Labour	Collection time	Whittington (1990); Crane (1194); Hindman. (2002);
		Distance to water sources	Whittington (1990); Crane (1194); David (1998);
	Property characteristics	Storage tank	Whittington (1990); Cheesman (2008);
		Value of house	Strand (2005); Rauf,(2008)
		Size of the property and lot	Nauges (2007); Rauf (2008)
		Access to electricity and other sources	Nauges (2007; 2009); Basani (2004);
		Years in house	Crane (1194);
		Property ownership	David (1998);
	Other	Quality and taste	Whittington. (1990); David (1998); Whittington (2002); Nam (2005); Nauges (2007); Cheesman (2008); Sebri (2012);
		Ethnicity	Basani (2004; 2008);
		Temperature	Abu Rizaza (1991); Rauf (2008)
		Technology adoption	Renwick (1998) (California, US);

7.2.2 LITERATURE REVIEW OF STUDY AREA

Details of the study area are presented in Chapter four, however, the following additional information is relevant to this chapter.

In 2009, 53.1GL of water were recorded as being supplied to users in Ulaanbaatar, by USUG/OSNAAUG. During 2010, the average monthly water consumption for apartment households was estimated from an internal report by the OSNAAG as being approximately 13.2 m^3 for households with their own individual meters, approximately 40.8m^3 for non-metered households and approximately 27.7 m^3 for apartment (combined metered and non-metered) households of the USUG (MNAO, 2011). In contrast, a Ger area household with 4 people used an estimated 0.9 to 1.2 m^3 per month: 40% for food, 30% for cleaning, 20% for washing hands, face and hair, and 10% for washing dishes (UNDP et al., 2004).

Water usage by Ger area residents is about one-twelfth of the basic water requirement (BWR), as stated by the World Health Organization (2000, 2008). According to Gleick (1996), this minimum of 50 litres per day is required for meeting the four basic human needs: drinking, human hygiene, sanitation and preparing food. For the Ger area dwellers, being able to have showers depends on the limited numbers of public showers, or having access to an apartment in the city. The shower-water use of Ger dwellers has not yet been estimated, so may explain some of the “gap’.

Discrepancies between the availability of water in Ger areas, which have little formal infrastructure and where water is generally purchased from public kiosks, and formal living areas, which have piped water, also raises equity questions. The city is attempting to achieve target 10 of the MDG; this requires more investment in water infrastructure, particularly in the Ger areas, which also means that more money is needed to fund that investment. Hence my desire to look at the potential of increasing price to both reduce quantity of water used and to raise much needed revenue.

7.3 METHODOLOGICAL BACKGROUND

The general research methodology and data collection procedures were discussed in Chapters five and six. Additional information about the CBM data and its implementation requirements are detailed in Section 6.3.1. The discussion in this chapter thus focuses only on new issues and those specific to my investigation of residential water use.

7.3.1 ESTIMATING CURRENT WATER USE

I firstly needed to find out how much water each household was using. This study used two different approaches to do so: a conditional approach (Dziegielewski et al., 2000) for estimates of water use in apartment areas (the formal settlements), and a direct indication approach (Grima, 1972) for Ger area households in informal settlements.

The conditional demand approach (most often used to estimate electricity consumption) was needed because, as discussed above, not all households have individual water meters at home and are thus unable to provide estimates of water use. Stoeckl et al, (2013) used a combination of the conditional approach and the direct indication approach (Grima, 1972; Stoeckl et al., 2013)) to estimate household water use in northern Australia, and this method was adapted for use here. To be more specific, basic information about the presence and frequency of use of various water-using household fixtures was collected from the household. This information was then combined with external information about approximate water consumption per load, or use (see Table 27) of the water using fixture to calculate total water use for each household.

Table 27 Water use of a variety of different household appliances and fixtures

Fixture	Litres of water usageper load	Frequency
Dual toilet	5	140 flushes per person per month on average
Non dual toilet	11	140 flushes per person per month on average
Leaking toilet	44	Per day
Water saver showerhead	7.5	Per minute for showering
Inefficient shower head	12.5	Per minute for showering
Bath	96	Per bath (if water is full 120L and shallow 60L in a bath)
Running tap	5	Per running tap per minute
Leaking tap	800	Per leaking tap per month
Hand washing dishes	40	Per load
Front load washing machine	100	Per load (if it is a frond loader 100)
Twin tube washing machine	40	Per load
Drinking	3.5	Per person per day
Cooking and kitchen	25	Per person per day
Hand and face washing	11.5	Per person per day
Car wash	200	Each bucket
Carpet wash	100	Per wash
Garden	10``	Each bucket

Source: (MCC, 2008)

Monthly water consumption (Q_{ahhi}) per apartment household was then estimated. In this case, I used the following equation:

$Q_{ahhi}= W_{wmi} + W_{shi}+ W_{bi}+ W_{toi}+ W_{lei}+ W_{cdpi}$ Equation 2

Where: W_{wmi} – water used by washing machine (litres per household per month-LHM)
W_{shi} – water used in showers (LHM)
W_{bi} – water used in bathing (LHM)
W_{toi} – water used in toilets (LHM)
W_{cdpi} – water used in cooking, drinking, personal hygiene (LHM)

The monthly water consumption for washing machine was calculated as:

$W_{wmi}= W_{wmi}*F_{wmi}* 4weeks$ Equation 3

Where: F_{wm} – frequency of the washing machine used per week
W_{wm} – volume of water used by washing machine (see Table 27)
i – i^{th} respondent

The monthly water consumption from a household's shower was calculated as:

$W_{shi}=\Sigma(F_{shi} * L_{shi})* W_{pm} * 4weeks$ Equation 4

Where: F_{shi} – average number of showers that the householder has each week
L_{shi} - average length of shower in a week
W_{pmj} – water consumption of shower per minute (depends on type of showerhead; see Table 27)

The monthly water consumption associated with the use of baths was calculated as:

$W_{bi}=F_{bi} * N_{hhsi} * W_{pb} * 4weeks$ Equation 5

Where: F_{bwi} – average number of baths per week per person
N_{hhsi} – household size
W_{pmj} – water consumption per bath (see Table 27)

The monthly water consumption for the toilet was estimated using technique adapted from Mayer et al., (1999), which assumes that people of different ages use the toilet at different and that allows for different types of toilets (e.g. dual flush) (Mayer et al., 1999). In the apartment areas, 38.2% of households in 2010 and 41.8% in 2011 reported that they had a dual flush (low flow) toilet in my samples. Following White et al (2007) I assumed that a single flush toilet uses 11 litres of water in a non-dual/inefficient toilet and 5 litres of water with a dual/efficient toilet. Average toilet flushing frequency was adapted from Gato's (2006) study, that is 5.05 times per person, per day, for all age groups except the group 'older', which uses 10% more than others (Gato, 2006).

$$W_{toi}=(F_{tki} * N_{kyo} * W_{tj} * 28\ days) +(1.1*F_{tki} * N_{kel} * W_{tj} * 28\ days) \qquad \text{Equation 6}$$

Where: F_{tki}- frequency of flushes per day

N_{kyo}- number of household' members, who are younger than 60 years old

N_{kel}- number of household' members, who are older than 60 years old

W_{tj}- water used per flush (differentiated by type of toilet; see Table 27)

The amount of water "wasted" in leaking taps and toilets was calculated as:

$$W_{lei}=(W_{taplei} * G_j) +(W_{tapruni} * G_j) +(W_{toileaj} * G_j * 28\ days) \qquad \text{Equation 7}$$

Where: W_{taplei}- water wasted by dripping taps (LHM – see Table 27)

$W_{tapruni}$- water wasted by a running tap (LHM – see Table 27)

W_{toilei}- water wasted by a leaking toilet (LHM – see Table 27)

G- the number of leaking and running taps and toilets

Miscellaneous water use (W_{cdpi}) per day for cooking, drinking, personal and home hygienic purposes was estimated by multiplying the tap's utilisation[15], household size and water consumption per running tap per minute[16].

$$W_{cdpi}= 8.1 minutes\ per\ person\ (Mayer\ et\ al.,\ 1999) * 5 litres\ per\ minute\ (MCC,\ 2008) * N_{hhsi}$$

Equation 8

For the entire data set, the average monthly water use per household was approximately 16.8 m^3water in 2010 and approximately 14.1 m^3 in 2011. Monthly water consumption in Ger areas' household was 6.5 m^3 per household (see Figure 44).

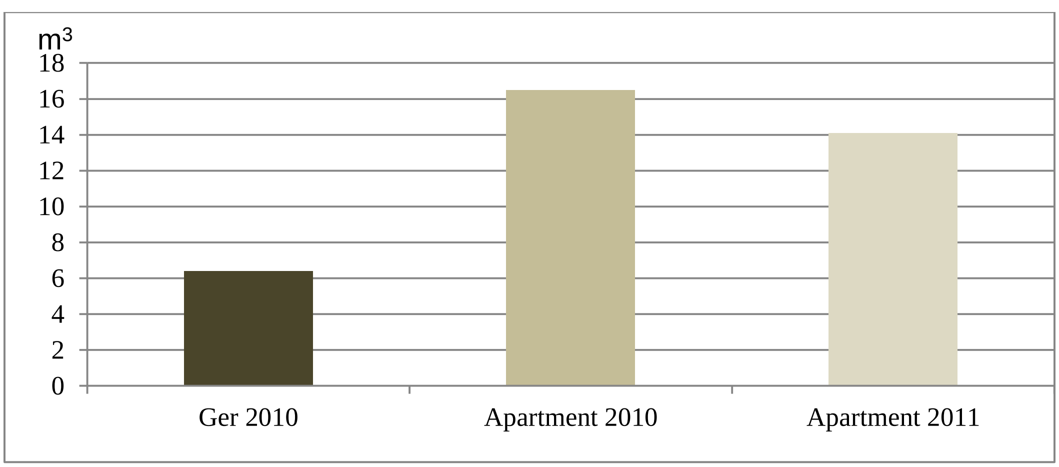


Figure 44 Average household's water consumption per month by user groups in m^3

15 Faucet utilisation per capita per day is 8.1 minutes.(Mayer, Deoreo, Opitz, Kiefer, Davis & Dziegielewski 1999. *Residential end uses of water)*.

16 Water for a tap per running per minute is 5 litres. (Mcc 2008. Household water use calculator).

Figure 45 shows monthly water consumption[17] at different fixtures for the average apartment household. Most water use relates to miscellaneous composition (W_{cdpi}) that attributed to cooking, drinking and personal hygiene.

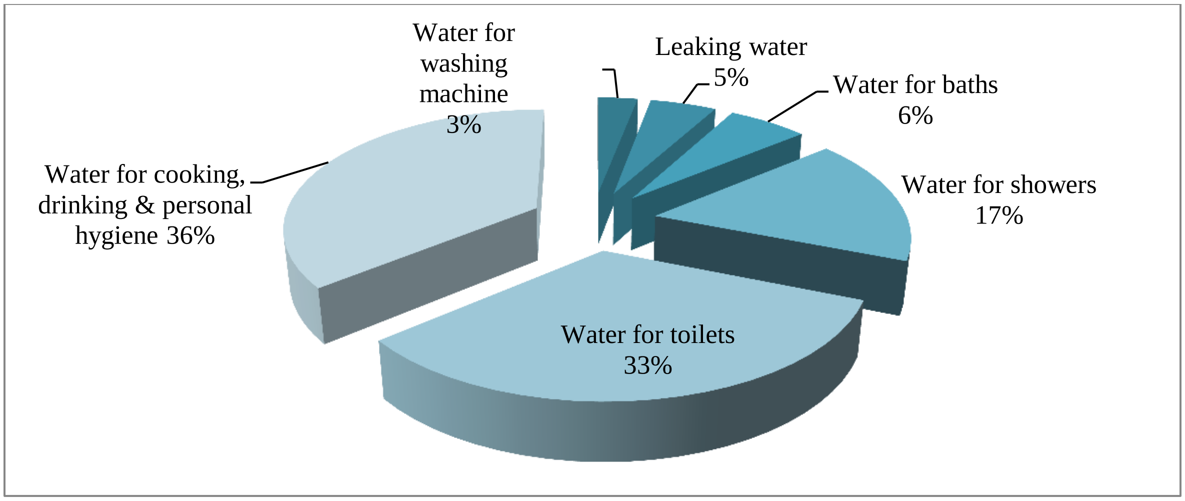


Figure 45 A component of an apartment household's water consumption

A comparison of the micro-component of monthly water use is presented in Figure 45, which shows there is only a small difference in apartment user groups water use between 2010 and 2011. After the price increases, people fixed their leaking taps and toilets, thus the leakage percentage decreased by 5%.

Table 28 Monthly water use of an average household in each user group

Component of household's consumption	Ger 2010	Apartment 2010	Apartment 2011
Water for cooking, drinking & personal hygiene	1200	5959	5506
Water for toilet		5544	5118
Water for showers	5016	2131	1820
Water for baths		1048	1010
Leaking water		1128	321
Water for washing machine	86	335	342

The Ger area household water use per household per month was estimated at 6.5 m^3 of water and about 80% of this was attributable to the use of water for showers (either public showers or in a house of somebody else in the apartment areas). The total water use estimates are 5 times more than estimates from other studies (MOUB and Ltd, 2006, UNICEF and UNDP, 2008, MOUB, 2009, USUG, 2011). The

[17]The micro-component is calculated for all samples from apartment areas. The seasonality of the water consumption is also taken into account. However household usage and its components do not indicate any differences in the warm and cold seasons, possibly due to the fact that the calculation is based on indoor usage.

difference is likely to arise because previous studies have not accounted for showers – instead only looking at the water purchased for home consumption at water kiosks.

Mean monthly water consumption in apartments was estimated at 16.8 m^3 in 2010 and 14.1 m^3 in 2011, compared to OSNAAG' s (2011) estimate of 13.4 m^3 for metered households and 32.1 m^3 for non-metered households (OSNAAUG, 2011) and 27.7 m^3 for apartment (combined metered and non-metered) households for the USUG's consumer in 2010. Table 29 shows estimates of water use from a range of other aggregated estimations.

Table 29 Monthly water consumption of an average household in each user group (m^3)

	OSNAAG	USUG	This study
Apartment		27.7	15.6
metered household	13.4		15.7
non-metered household	32.1		15.4
Ger		1.06	1.09
Indoor and shower			6.5

7.3.2 ESTIMATING HYPOTHETICAL WATER CONSUMPTION AT HYPOTHETICALLY HIGHER PRICES (MOVING INTO THE CB MODEL)

The procedure for converting hypothetical responses into estimates of water use that was described in section 6.3.1 is also used in this chapter.

For an average metered apartment household, consumption patterns were thus estimated as:

- the current price level – 15.7m^3;
- for 110 % of the current price (1.1P) – 14.4 m^3;
- for 150% of the current price (1.5P) – 12.8 m^3; and
- for twice the current price (2P) – 12.3 m^3.

For an average non-metered apartment household, consumption patterns were estimated as:

- the current price level – 15.4m^3
- for 110 % of the current price (1.1P) – 13.4 m^3;
- for 150% of the current price (1.5P) – 12.2 m^3; and
- for twice the current price (2P) – 12.2 m^3

These estimates are shown in Figure 46.

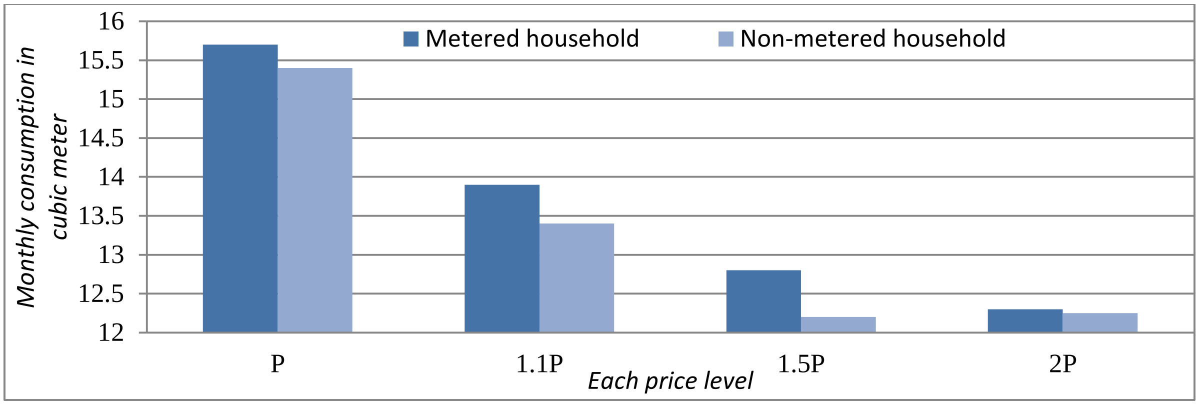


Figure 46 Projected monthly water use of the ‘average’ apartment household under each price scenario (using data from both the 2010 and the 2011samples)

For those living in Ger areas indoor consumption (excluded water for showers) patterns were estimated as:

- the current price level (P) – 1.29 m^3;
- for 110% of the current price (1.1P) – 0.99 m^3;
- for 150% of the current price (1.5P) – 0.93 m^3; and
- for twice the current price (2P) 0.84 m^3.

I conducted a non-parametric test to see if the distribution of responses to the hypothetical questions were different at hypothetical price levels for each sub-user group. The Kruskal-Wallis tests rejected the hypothesis that consumption was the same at all price levels χ^2=109.27 with p value= 0.0001 for Ger areas samples, χ^2=63.35 with p value= 0.0001 for metered apartment households and χ^2=60.77 with p value= 0.0001 for non-metered apartment samples.

As explained in Section 6.3.1 and Section 6.3.2, to estimate demand using a CBM model, one must create a panel data set by pooling actual (current) consumption at the current price level and quantity data with the ‘hypothetical’ data[18]. In this case, my dataset included 4 panels: that relating to the current consumption ‘Q’, and those relating to prices that were 1.1, 1.5 and 2 times higher than the current (aas explained in the previous text). Figure 47 presents a panel, where Q represents current (Q_1) and hypothetical (Q_{2to4}) consumptions, and X represents independent 'non-priced' variables thought to influence demand.

[18] According to the review of urban water demand estimation, panel based regression methods produce accurate forecasts of per capita residential water demand and represent an improvement over traditional methods House-Peter & Heejin 2011. Urban water demand modelling: Review of concepts, methods, and organizing principles. *Water resource research,* 47**,** 15.

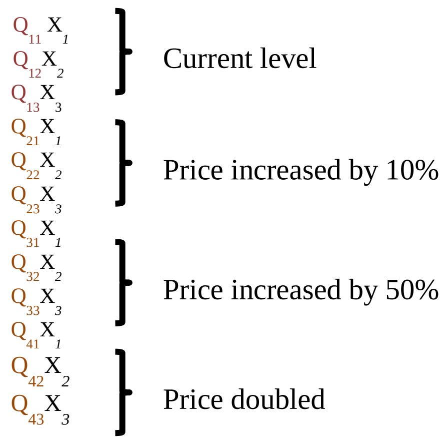


Figure 47 Panel dataset creating structure using CBM data

This unbalanced (it is unbalanced because 8% of 958 the residential respondents did not provide enough data for me to be able to estimate their hypothetical consumption at different prices) panel dataset included 2,548 observations.

7.3.3 VARIABLES INCLUDED IN THE ANALYSIS

Other variables used in the model were selected with reference to prior studies (see Table 26), this presents a summary of variables commonly used in studies of household water demand in developing countries.

In addition to these variables, I also considered water saving habit (details in Section 6.3.3). This is because previous studies have found that socio demographic factors relate to water saving habits. For example, lower water use households have been found to have greater awareness of water conservation issues, and are often more involved in decisions about water use (Gregory and Di Leo, 2003), lower income households are more likely to commit to water saving habits (Aisa and Larramona, 2012) and those with both a higher education and higher income may be less likely to have water saving habits (Mondejar-Jimenez et al., 2011).

Similar to the non-residential study, respondents were thus asked a series of questions designed to measure water saving habits in terms of the frequency of each habit/technique employed, which might result in lowered water use. These techniques include the households' water conservation *curtailment* behaviour, which refers to everyday water saving actions: 'using stored water in a sink for dishes washes', 'not rinsing dishes after washing', 'turning tap off while soaping hands', 'taking shorter showers', 'turning tap off while brushing teeth', 'turning shower off while soaping up' and 'reducing water level of washing machine'. Other habits relate to the households' water conservation *control efficiency* behaviours, which include: ‘encouraging children to turn taps off’, ‘checking taps to ensure turned off and they are not leaking’, and ‘fixing leaking taps’. Only three of these water saving habits ‘encouraging children to turn taps off’, ‘using stored water in a sink for dish washes’, ‘not rinsing dishes after washing’ were relevant to, and thus asked of the Ger area respondents. In all cases, the respondents were asked to indicate the frequency of their water saving techniques by indicating where their household fit on a 5 point Likert scale: from very frequently (5) to never (1) (more details in Section 6.3.3).

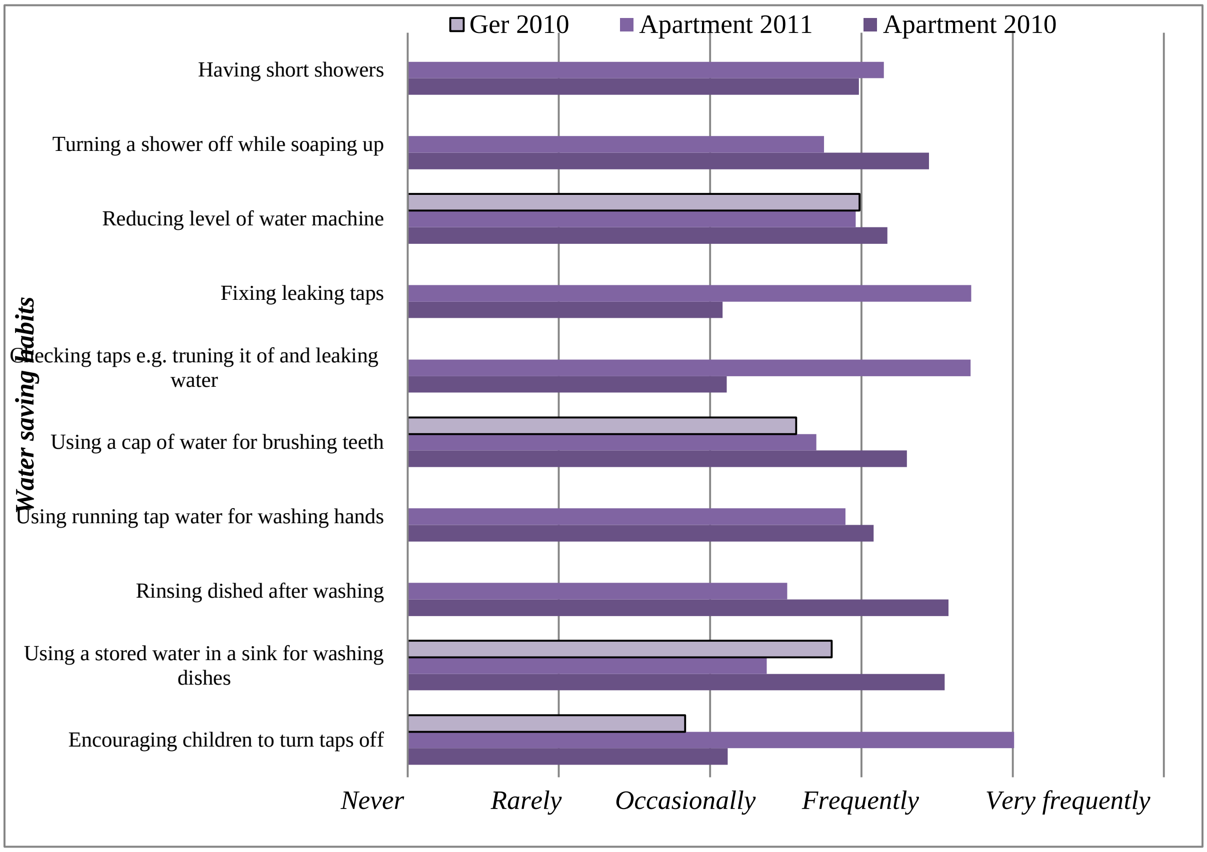


Figure 48 Water saving habits rate of residential sub users group

The impact of the 2010 water campaign and water price increases are quite apparent: apartment dwellers (with tapped water) are now much more apt to encourage children to turn off taps, and to check (and fix) leaking taps. They are also less likely to rinse dishes after washing. But the campaign does not appear to have affected all behaviours – e.g. there is little apparent difference between the length of showers between 2010 and 2011.

An overall index, termed the rate of water saving habits (*Wshr*) was calculated as the average of all habits. The consistency of the habit composition is determined by Cronbach alpha. The alpha of apartment (0.820) and Ger (0.209) respondents confirmed that the water saving habit composition is acceptable in its range for the apartment respondents of both user groups and unacceptable range for Ger respondents. I did not use the water saving habits rate variable for the Ger areas water demand model. Means of water saving habits are 2.795 for the apartment users 2010 and 3.058 for apartment users 2011.

- The independent variables used were:
  - Num_j - the household size *j*
  - Y_j - the monthly average income of the household *j* in ₮ [19]
  - E_{duj} - the highest education level of the household j
  - W_{shrj} - a variable designed to capture information about the use of water-saving technologies (discussed above and in Section 6.3.3 and Section 7.3.3).
  - P_{knj} - a dummy variable for knowledge of water price (1for know price of water; 0 otherwise) the same as non-residential water demand estimation variable –see details in Section 6.3.3
  - B_{refj} - a dummy variable for desire for a billing reform (1 if yes; 0 otherwise) the same as non-residential water demand estimation variable –see details in Section 6.3.3.

As such, my purposed demand functions were assumed to be:

$$Q_{ji} = \beta_1 + h_i + \beta_2 Num_{ji} + \beta_3 Y_{ji} + \beta_4 Edu_{ji} + \beta_5 W_{shrji} + \beta_6 P_{knji} + \beta_7 B_{refji} + \varepsilon_{ji}$$

Equation 9 Apartment household demand function

and

$$Q_{ji} = \beta_1 + h_i + \beta_2 Num_{ji} + \beta_3 Y_{ji} + \beta_4 Edu_{ji} + \beta_5 P_{knji} + \beta_6 B_{refji} + \varepsilon_{ji}$$

Equation 10 Ger household demand function

Table 30 summaries key variables used in these equations.

Table 30 Descriptive statistics for each sub user group (mean with standard deviation)

Variable	Ger 2010	Metered apartment sample	Non-metered apartment sample
Household's size	4.77 (0.061)	4.20 (0.046)	4.02 (0.048)
Income (₮)	431027.7 (10925)	627384.6 (11987)	548397.2 (10423)
Education level[20] (1 less to 3 higher level)	2.17 (0.026)	2.66 (0.012)	2.65 (0.018)
Water saving habit rate		3.17 (0.017)	2.82 (0.034)
Knowledge at water price (Yes=1; No=0)	0.83 (0.012)	0.09 (0.008)	0.05 (0.007)
Desire for a billing reform (Yes=1; No=0)	0.63 (0.015)	0.83 (0.010)	0.750.012)

[19] ₮ – Tugrug, which is the Mongolian currency and USA $1 equated to 1260.5 Tugrug, in June 2011.
[20] Education level measures men 1 = low education to 3= higher education level

7.4 RESULTS

Demand was estimated using a random effects (RE), a fixed effects (FE) and a random parameter (Seacrest and Herpel, 1997) model (RPM). The random effects and fixed effects models gave poor statistical results and the Hausman test rejected both models. The random parameter model was statistically strong. Results of RPMs for households' water demand for each user group are presented in Table 31.

The goodness of fit of the equations, measured by Wald chi (22.25 with p=0.0005 for Ger; 510.65 with p=0.00 for non-metered apartment users and 534.08 with p=0.00 for metered apartment user groups), is exceptionally good. The group specifications of the estimated models are significant at the 1% level and have a chi square statistics of between 100.11 for Ger and 111.83 for metered apartment.

Table 31 Results from the Random Parameter Models for Residential water demand for each user group

Variables	Ger area		Metered apartment		Non-metered apartment	
	Coefficient	Std error	Coefficient	Std error	Coefficient	Std error
Constant	1242.649**	114.995	1193.58*	858.44	3867.77**	942.13
Size of household	35.591**	9.648	3091.17*	141.22	3072.34*	170.38
Household income	0.00015*	0.000048	-0.000025	0.0003	0.00015*	0.0004
The highest education level	-95.579*	21.638	409.576	225.64	-117.41*	159.77
Water saving habits rate			-70.896	170.52	-601.76	637
Knowledge of water price	-35.124	45.204	-773.65	522.21	-1516.99	436.05
Desire for a billing reform	46.993	36.029	-508.201	362.95	599.4	495.59
Sample size	934		1300		1248	
Wald Chi2	22.25		534.08		510.65	
Prob> Chi2	0.0005		0		0	
Chi2	100.11		111.83		97.78	
Prob> Chi2	0		0		0	

*=significant at 5% level; **=significant at 10% level.

Education, household income and size of household are statistically significant determinants of water use for non-metered households of both settlement areas. In metered apartments, only household size is statistically significant. The signs of coefficients on the size of household, education, knowledge at water price, desire for a billing reform and water saving habits variables are as expected, but the coefficient on income for Ger area is not. The positive sign on the income coefficient for Ger areas water demand model may be because the richer Ger areas dwellers use more water for person hygiene.

Coefficients of residential water demand model at each price level in each water user group present following tables.

Table 32 Results from the Random Parameter Models for Ger areas residential water demand

Variables	Ger			
	P	1.1P	1.5P	2P
Constant	1242.649	1105.134	1050.852	945.627
Size of household	35.591	9.628	8.503	16.226
Household income	0.00015	0.000068	0.00008	0.00009
The highest education level	-95.579	-87.13	-90.598	-103.469
Knowledge of water price	-35.124	-38.13	-29.146	-27.511
Desire for a billing reform	46.993	50.373	44.423	54.443
Wald Chi2	22.25			
Prob> Chi2	0.0005			
Chi2	100.11			
Prob> Chi2	0			

Table 33 Results from the Random Parameter Models for metered residential water demand of apartment areas

Variables	apartment 2010 metered				apartment 2011 metered			
	P	1.1P	1.5P	2P	P	1.1P	1.5P	2P
Constant	-578.13	-1860.233	-1367.56	-2011.005	1193.58	2643.916	2983.855	3017.731
Size of household	3436.737	3206.422	3141.757	3069.792	3091.167	2696.798	2576.138	2561.24
Household income	-0.000067	-0.000687	-0.00115	-0.00033	-0.000025	-0.00053	-0.00081	-0.0009
The highest education level	412.479	277.48	85.348	311.629	409.576	384.459	286.82	170.555
Water saving habits rate	153.72	400.787	159.88	-89.323	-70.896	-214.053	-278.885	-268.345
Knowledge of water price	-519.038	-807.89	-768.907	-981.874	-773.65	-1742.029	-1523.043	-1400.879
Desire for a billing reform	1674.285	1738.39	1952.823	2086.453	-508.201	-662.895	-1147.549	-1331.505
Wald Chi2	535.15				324.35			
Prob> Chi2	0.000				0.000			
Chi2	51.23				84.94			
Prob> Chi2	0.000				0.001			

Table 34 Results from the Random Parameter Models for unmetered residential water demand of apartment areas

Variables	apartment 2010 unmetered				apartment 2011 unmetered			
	P	1.1P	1.5P	2P	P	1.1P	1.5P	2P
Constant	239.15	1490.24	1700.24	599.82	3867.77	3476.738	2763.068	2946.002
Size of household	3386.76	2633.77	2551.82	2826.808	3072.344	2920.946	2797.991	2648.668
Household income	-0.00089	-0.0014	-0.00165	0.000068	0.000156	-0.00056	-0.00073	-0.00037
The highest education level	805.05	1052.38	1010.112	862.806	-117.413	-178.686	-165.624	95.67
Water saving habits rate	98.58	86.76	-174.898	-314.79	-601.76	-416.096	-313.199	-587.718
Knowledge of water price	-900.87	-182.34	-100.115	-691.45	-1516.994	-847.807	196.457	-229.351
Desire for a billing reform	-269.16	-1071.24	-1117.167	-578.309	599.402	362.476	35.539	58.009
Wald Chi2	274.06				612.97			
Prob> Chi2	0.000				0.000			
Chi2	64.19				58.58			
Prob> Chi2	0.000				0.000			

7.4.1 PRICE ELASTICITY USING COEFFICIENTS FROM THE MODELS

The coefficients from the models were used to generate estimates of water use at each price level (calculated by multiplying each coefficient by the mean of each corresponding variable). I then used a mid-point formula to calculate associated price elasticities for each price change for each type of user group – see Table 35.

Table 35 Price elasticities of residential water demand using RPM for each user group

Price changes	2010			2011	
	Ger	Metered apartment	Non-metered apartment	Metered apartment	Non-metered apartment
P to 1.1P	-2.586	-1.506	-1.408	-0.927	-0.941
1.1P to 1.5P	-0.198	-0.23	-0.279	-0.313	-0.31
1.5P to 2P	-0.335	-0.132	0.103	-0.156	-0.099

Price elasticities using hypothetical data that residential water demand particularly in Ger areas are sensitive to small price changes. Because household water used for essential needs such as drinking, cooking and basic hygiene comprises only a minor part of typical daily use; the rest is used for 'lifestyle' or productive purposes. Thus, this finding may relate to poor respondents from Ger areas involved in this study.

7.4.2 PRICE ELASTICITY USING OBSERVED DATA

Next, I estimated price elasticity using observed data (see Section 7.3.1 – current water consumption of metered and non-metered apartment households calculated each year from my samples) from 2010 and 2011 with the real water price for metered apartment and non-metered apartment users. These are uniform tariff for metered apartment users increased by 35% (a cubic meter of water was 2.08₮ in 2010 and 2.81 ₮ in 2011) and flat tariff for non-metered apartment users increased by 22.5% (the tariff was 2375.1 ₮ per person per month in 2010 and 2910.54 ₮ per person per month in 2011). The price elasticities using observed data were -0.634 for metered apartment water demand and -0.547 for non-metered apartment water demand. Importantly, the estimates are in the range for the price elasticities generated by the RPM (between -0.927 and -0.313 for 2011 samples of metered households). Although the 'actual' elasticity estimates are not true estimates (the simple calculation does not hold other factors constant), it is interesting to note that the hypothetical scenarios presented in my questionnaires are statistically indistinguishable from the actual responses observed in the price change. Moreover, the price elasticity estimates appear to be similar to estimates from other developing countries, which typically range from -0.3 to -0.6 (Nauges and Whittington, 2010). For example, Nauges and Strans (2007) study of private and public wells and taps, trucks, and river water for residents in three cities of El Salvador (-0.7 to -0.4), Basani et al's (2008) study of seven provincial towns in Cambodia (-0.5 to -0.4), Cheesman and Bennett's (2008) study in Buon Ma Thuot city and Nauges and Berg's (2009) study of Sri Lanka (-0.37 to -0.15). The CBM may not be precise but it is, at least, capable of generating plausible price elasticity estimates for non-market goods and services.

Table 36 Price elasticities of apartment households' water demand for each user group and each estimation method

Estimation method	Metered	Non-metered
	P to 1.5P	P to 1.5P
RPM (CBM) 2011	-0.927 ~ -0.313	-0.941 ~ -0.31
Observed	P to 1.35P	P to 1.22P
	-0.634	-0.547

7.5 PROJECTIONS

Having ascertained the 'plausibility' of my elasticity estimates, I then proceeded to use my estimates to generate estimates of the approximate change in total residential water demand, and in water-revenues that would follow a 10%, 50% and 100% increase in price. These estimates were then multiplied by the estimated number of households in each group (206 000 for Ger; 51 600 for metered apartment and 61

800 for non-metered apartment households)[21] to generate estimates of the aggregate change in residential water use (and water price revenues) under each price scenario. This was done by firstly calculating projected monthly water demand for each type of household (shown in Figure 44), and then estimating monthly aggregate water use under each scenario (see Table 37).

Table 37 Estimated monthly aggregate water use in GL under each price scenario

Price changes	Ger	Apartment metered	Apartment non-metered	Total across all users group
Current P	0.261	0.809	1.439	2.509
1.1 P	0.204	0.741	1.266	2.211
1.5P	0.192	0.662	1.162	2.016
2P	0.174	0.635	1.179	1.988

These calculations indicate that a 10% increase in price would result in an annual conservation of approximately 3.6GL water, which is about 7% of USUG's extracted water (see Table 37, and a decrease of 7% of the current revenue from these users is shown in Table 38. If the price of water for residential users were to double, about 12% of the USUG's extracted water would be conserved and current revenue from residential users would increase by about 78%.

Table 38 Estimated water revenue in million ₮ under each price scenario

Price changes	Ger	Apartment metered	Apartment non-metered	Total across all users group
Current P	260.8	227.3	737.9	1226
1.1 P	224.1	229.1	811.7	1264.9
1.5P	287.5	279.2	1106.8	1673.5
2P	348.4	357.1	1475.8	2181.3

7.6 KEY FINDINGS

This study set out to explore the potential efficacy of water demand management policies in Ulaanbaatar, focusing, in particular, on residential water pricing. Using data from 964 households within a contingent behaviour model the study estimates average households water demand and price elasticity. Key findings are listed below:

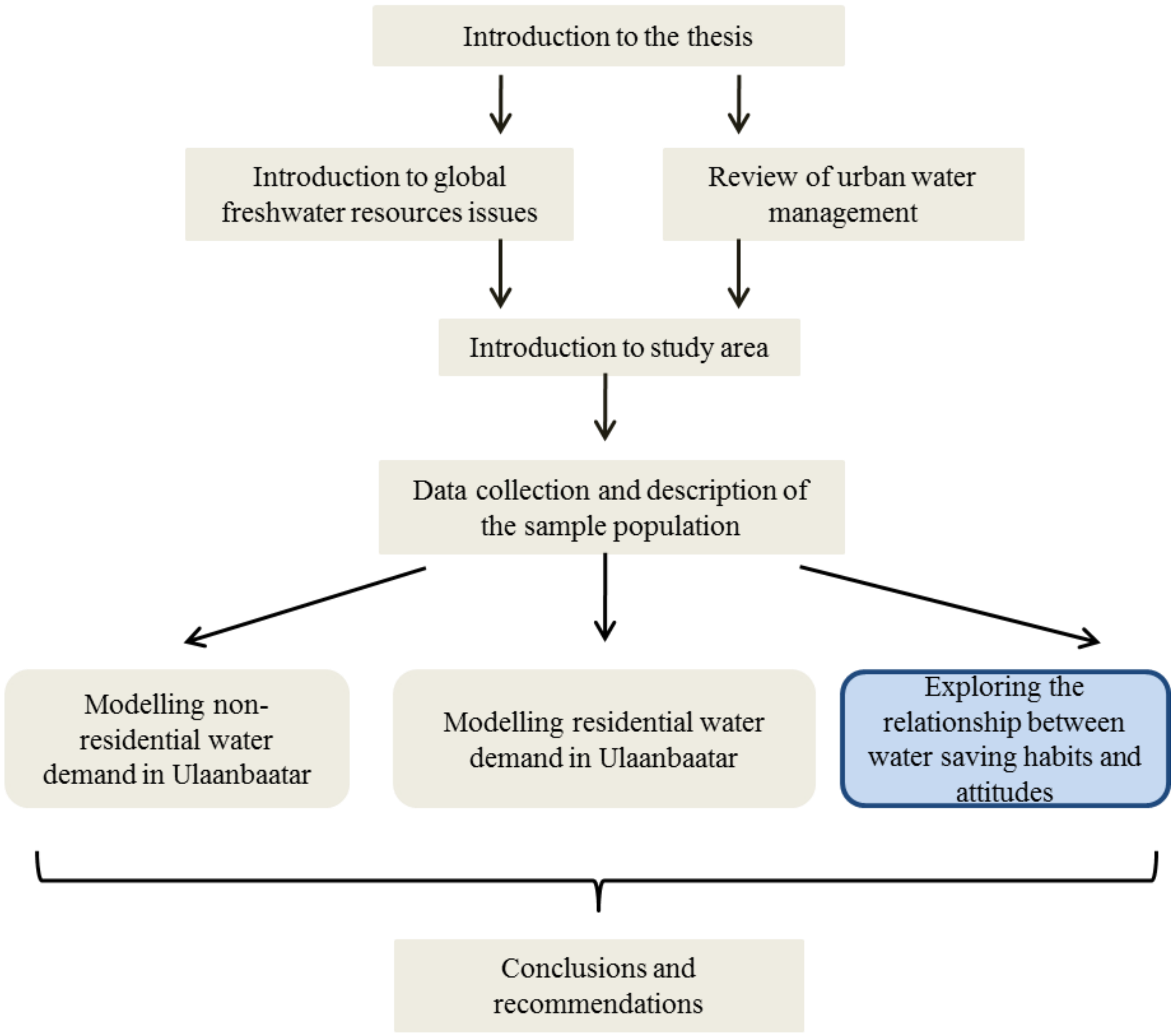
- The monthly water consumption of an average household in a metered apartment is approximately 14.1m^3, which consists of 36% for miscellaneous use (e.g. for cooking, drinking and personal hygiene), 33% for toilets and 23% for shower and bathing.
- An average non-metered household consumes approximately 13.3 m^3 of water per month.
- In the Ger areas the average household consumes approximated 6.4m^3 of water; almost 80% of which is attributable to the use of water in public showers.

[21] The numbers (in thousands) of households are employed from the real data of the USUG and OSNAAG operational reports in 2010.

- Analysis of data in CBM suggests that household water demand is relatively more sensitive to small price changes than to large changes. For example if the price of water rose by 10%, consumption would reduce by under 10%, especially in the Ger areas households (-2.586). In apartments water demand is approximately unit elastic (-0.927 for metered households and -0.941 for non-metered households). It seems that the responses of Ger areas' households water demand to increased price might not only be for potable water but may be largely associated with changes in the use of public showers.
- I compared my price elasticities from the CBM with estimates of price elasticity from observed data following the 2010 price rise. CBM is an adequate approach.
- My results indicate that a modest 10% increase in price would result in an annual conservation of approximately 3.6GL water, which is 12% of current residential consumption; it would also result in a 7 % reduction in revenue from residential users to the government.
- Although doubling the price is unlikely to be politically acceptable in this study area, such a radical move could potentially reduce residential water consumption by just over 6.25GL, which equals around 21% of current residential consumption, and at the same time increase water revenues (collected from residential users) by about 78 % of current revenue. Interestingly, by doubling water prices, the total cost of water for households would still be only 1.2% of non-food expenditure[22].
- Not only has this study provided valuable empirical insights, but it has also contributed to the existing literature by establishing that it is, indeed, possible to use the CBM to generate estimates of the price elasticity of residential water demand in Mongolia.

[22] This calculation is based on the 'monthly average income and expenditure of households of Ulaanbaatar' report. (http://ubstat.mn/StatTable.aspx?tableID=365)

Thesis layout



CHAPTER 8 EXPLORING THE RELATIONSHIP BETWEEN WATER SAVING HABITS AND ATTITUDES

8.1INTRODUCTION

Ulaanbaatar, the capital city of Mongolia, faces a growing problem of water scarcity. Resource scarcity is exacerbated by managerial capacity constraints and limited policy development for the allocation of an increasingly scarce resource. In this chapter, relationships between water saving habits and attitudes about various policies for promoting efficient water use and supply are investigated for different user groups. The attitudes of residential and non-residential users about different policy approaches, including demand-side (price), operational-technical, socio-political and supply-side policies are assessed for 2010 and in 2011. Key findings are: (i) a positive relationship between water saving habits and attitudes for both user groups; and (ii) that media campaigns were effective for convincing users about the benefits of price and operational-technical policies for residential users, and the benefits of socio-political policies for non-residential users. Assessments of the potential of urban water policies to influence water saving habits indicate that operational-technical policies by residential users, while supply-side policies were viewed most positively by non-residential users. Media campaigns seem to have had a big influence on attitudes and could thus play an important role in the development and implementation of water management policies in Ulaanbaatar.

8.2 BACKGROUND

Attitudes about water usage appear to be poor predictors of water consumption behaviour (Gregory and Di Leo, 2003) and, as outlined in Chapter 6 and 7, water saving habits are not significant predictors at residential water demand. An alternative option for influencing water demand might, therefore, be to influence water saving habits through different water management policies and/or media campaigns. A substantial literature has been generated on how the issue of water scarcity can be best tackled and how users might respond to different water management policies. Such policies are most often categorised as either supply-side – increasing the availability of water or the ability of governments to store water – or demand-side – moderating or reducing the demand for water. Successful policies, particularly on the demand-side, require changes in attitudes and behaviours amongst consumers. People may not be able to rapidly change their behaviour, however, as such a change depends on increasing the capacity of the institutional structure created to provide water services (Randolph and Troy, 2008). Lifestyle preferences and systems of provision also influence water conservation practices (Sharp, 2006). These factors therefore influence the preferences of consumers for different management strategies.

The relationship between the perceptions about the likely effectiveness of different water management policies and water saving behaviour is examined in this chapter. By understanding this relationship it is more likely that successful policies and strategies for water conservation will be implemented. It is also the case that different categories of users – residential and non-residential – might respond to different policy initiatives and, therefore, that a mixture of policies will be required to ensure that urban water management policies, in combination, are effective. The research reported here contributes to the understanding, by policy makers, of the relationships of different policies approaches to attitudes and behaviours and, consequently, the mix of policies that might best support more efficient management of water resources. Price policies, socio-political policies, operational-technical policies and supply-side policies were each considered for different user groups.

The principal questions explored in this chapter are:

- Which water management policies are perceived by users – both residential and non-residential – as likely to be the most/least effective in promoting the efficient use of water and improving the efficiency with which water is supplied?
- Which user group(s) had more positive attitudes towards various policy approaches?
- How did the media campaign affect users' attitudes towards urban water policies?
- Is there any relationship between water saving habits and attitudes towards urban water policies?

8.3 MANAGEMENT APPROACHES

In developing and transitional economies, supply-side policies have dominated urban water policy because of efforts to achieve the Millennium Development Goals (MDGs) and, perhaps, because increasing supply is conceptually simpler than other strategies. In Mongolia, however, current sources of supply are severely constrained. The availability of fresh water in 2000 – as measured by Falkenmarken's indicator – was in the range of 1,000–1,700m3 per capita per year, a level that denotes a water stressed country (Smakhtin et al., 2000). The United Nations Environment Programme (UNEP) observed that Mongolia had 'moderate to high water stress', where stress is defined as the consumption of more than 10% of renewable freshwater resources (UNEP, 2002). WASH (2010) mapped countries according to the water stress index and identified Mongolia, and particularly Ulaanbaatar, as being in the extreme to high risk range. According to forecasts reported in documents such as the Urban Development Master Plan of Ulaanbaatar (UDMP) to 2025, the Ulaanbaatar Water and Sewerage Master Plan (UBWSMP) to 2020, and the study by Nemer et al. (2008), Ulaanbaatar will face significant water scarcity by 2015 if the population and water usage continue to grow at the levels observed in 2005. Others have observed that Ulaanbaatar's seasonal water shortages are growing ever more common and that, in the next 10 years, the city will face a critical shortfall in water availability (Emerton et al., 2009). Clearly, Mongolia cannot continue to pursue only supply-side policies.

Notwithstanding this conclusion, Ulaanbaatar City is continuing to pursue a traditional supply-side policy, which requires costly investment; those responsible for water have given little thought to managing demand. The traditional supply-side policies of satisfying all demand for water by constructing new systems to meet peak demands is, however, no longer appropriate, and becoming still more inappropriate as the level of supply declines as a result of climate change.

Vairavamoorthy and Mansoor (in (Butler and Memon, 2006) defined demand management as *"the minimization of loss and/or waste, the preservation, care and protection of water resources and the efficient and effective use of water".* Urban water demand management strategies are likely to be more cost-effective and more environmentally friendly than supply-side strategies. Supply-side policies, such as infrastructure development, increase the use of water and may exacerbate market failure, although such policies are appropriate in areas that are not served, or are under-served, with potable water. They are, therefore, an important component of economic and social development. Demand management, conversely, is applied in order to mitigate actual or potential water shortages and/or to improve the efficiency of the use of water. Demand is based on the behaviour and habits of users, and can be influenced by signalling the scarcity of the resource and through the provision of incentives to change water using habits.

Verplanken and Holland (2002) defined habits as "*relatively stable behaviour patterns, which have been reinforced in the past and result from automatic processes, as opposite to controlled process consciously made decisions*". The frequency of past water conserving behaviour is a commonly used measure of habits, and may be an indicator of future intentions (Gregory and Di Leo, 2003). Understanding water usage and conservation habits can therefore support the design of demand-side management policies that seek to bring about changes in behaviour. Joseph and Welch (1982) demonstrated, in a Western U.S. case, that conservation measures such as process changes, recirculation, and the adoption of emerging technologies have significant impacts on water conservation in the industrial sector.

Human societies respond not only to actual changes that occur in the biophysical environment, but also to perceived and anticipated changes (McKenzie-Mohr, 2000). Consequently, the research approach included asking respondents to take account of specific conditions, including: 1) the importance of price policies 'when water is scarce'; and 2) importance of both non-price demand-side and supply-side polices 'when Ulaanbaatar city has more money to spend on encouraging efficient water use and improving water supply (e.g. through funding provided by donor organisations)' (see appendix A). Supply-side policies were considered because low income households in the Ger areas of Ulaanbaatar rarely have individual connections to piped water.

Policies that might be applied to promote efficient water use and improve the efficiency of supply in Ulaanbaatar were grouped into the following categories (following Sharma and Vairamoorthy, 2009):

- Price policies, including seasonal and zonal price strategies (Foster and Beattie, 1979)
- Social-political policies, including public information and education campaigns, and the auditing of water use strategies (Herrington, 2006)
- Operational-technical policies, including retrofitting and installing and/or fixing water using appliances and equipment
- Supply-side policies, including long and short term water resource solutions.

The four policies areas were adapted from management policies listed by the World Bank (Garc, 2010). A number of strategies were incorporated into the policies because, as explained by (Thurstone, 1928), attitudes about a policy cannot be described wholly by a single index. The policies and strategies are illustrated in Figure 49 and discussed further below.

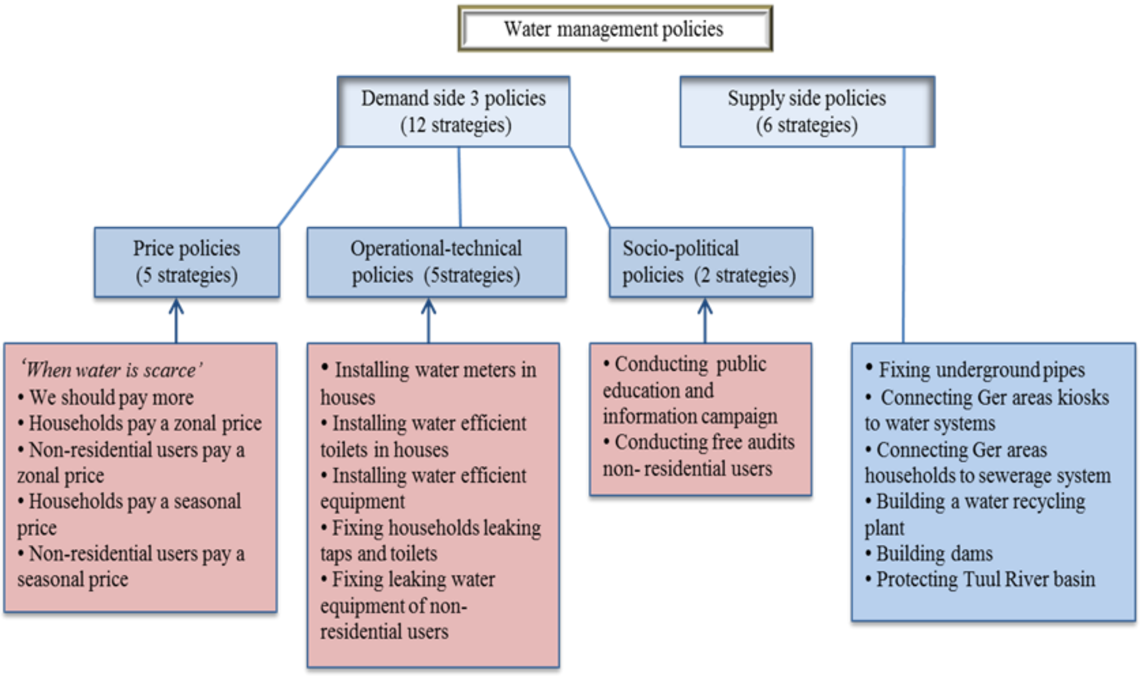


Figure 49: Urban water policies and strategies

Demand-side policies

I. Pricing

Price policies are focused on changes to prices and tariff structures that serve to signal the scarcity of water and the need to use it more efficiently. These include strategies such as block tariffs and the use of seasonal and zonal prices (Dalhuisen et al., 2001, Olmstead et al., 2007). These strategies are usually supported by other actions because increased prices, in isolation, are unlikely to be effective in managing domestic water demand in the short to medium term (Randolph and Troy, 2008). Price elasticity can vary significantly between seasons, between uses and across regions, while responses to price policies can be influenced by the implementation of other demand management strategies like public education, media campaigns and water use restrictions (Howe. Ch.W. and Lineweaver. P. F., 1967, Renwick and Green, 2000, Dziegielewski, 2003, Turner et al., 2006). Knowledge of price has also been shown to have a significant impact on water use behaviour (Carter and Milon, 2005, Cheesman and Bennett, 2008).

a. Seasonal pricing

Water prices can be adjusted on a seasonal basis, with higher prices typically applied during the months of peak demand, usually summer, and/or when water supply is at a critical level. Residential water use is normally highly sensitive to seasonal fluctuations (Worthington 2010). Renzetti and Chang (1991) found that peak load pricing induced a more substantial consumer response than prices based on annual water demand; price elasticities in summer exceeded those in winter by 30%. Conversely, Reynaud (2010), in a French study, found that peak prices resulted in no significant reduction in aggregate water consumption. Dziegielewski et al. (2000) also made the important observation that seasonality in terms of weather and supply availability may not coincide with the peak production or business period.

b. Zonal pricing

Zonal pricing for water is not commonly used to influence water saving behaviour. Pricing on the basis of zone may, however, be applicable in Ulaanbaatar and other cities typified by different levels of access to water supply services. UN Habitat (2003) found that households in informal settlements use less than half the amount of water used in more developed localities – such as apartment areas – owing to poorer availability and greater costs. Furthermore, the median water price in informal settlements was found to be almost five times the average urban price. Pricing on the basis of zones may, therefore, be relevant for encouraging improved equity of prices and access to water.

II. Non-price demand-side policies

Martinez – Espinera and Nauges (2004) found that when the price for water reached an insensitive threshold, non-price policies were more effective in reducing consumption than price policies. Non-price policies, which are often designed to increase efficient water use, may appear more politically or socially acceptable than price increasing policies. Although price policies can be more cost-effective than non-price demand management (Olmstead and Stavins, 2008), non-price policies may have more impact in the long run than price policies, while behaviour change may have only transient effects (Gilg and Barr, 2006).

Moreover, price policies (see Section 3.3.1) are likely to be more effective if supported by metering, billing reform, education and information campaigns, operational and technical and perhaps supply-side policies. Dzeigielewski et al (1999) found that implementing a mix of price and information policies would be effective because consumers become aware of the price increase while also gaining information on the best ways to reduce their water use or loss in response to price; the same results were found in Reynaud's (2012) study. These policies might also include socio-political strategies, such as public information and education campaigns (Michelsen et al., 1999), audits of usage (Butler and Memon, 2006), and operational-technical strategies such as retrofitting with water efficient devices. There are usually a number of cost-effective technological options available to commercial and residential users who wish to reduce water use.

a. Water metering

A water metering policy, which is the strategy most preferred by many residential users, is an effective tool for conserving water and for controlling losses of water supply. In the cities of developing countries, water losses, including real and apparent, reached levels of up to 40-60% of total water supply (Butler and Memon, 2006).

In Ulaanbaatar, an analysis of the 'public awareness raising campaign strategy' under the USIP II project, 2007, found that 13% of participants living in apartment areas had installed water meters at home and more than 6% were willing to install such metering (USIP II, 2007). Pricing – leading to long-term reductions in water use – and metering, which has a short-term impact, are the most easily implemented demand-side policy instruments. Sub-metering also encourages a reduction in water leakage by end users and in water distribution systems (Sharme and Vavo 2009).

b. Billing reform

Billing reform, usually involving more frequent bills, reminds consumers more often of the fact that water is not a free good. In the study area, however, water billing should become more of an information/communication tool: users stated that they wanted to have information about their water use, tariff, water saving activities and water resource availability on their bill. In the short term, households – particularly high consumption households –significantly reduce their consumption by the application of simple cognitive dissonance and feedback information (Aitken et al., 1994). Price information on water bills has a significant positive influence on residential water demand elasticity (Gaudin, 2006) and, in various cases, provides information about non-price policies to users (e.g. in a case study of Winconsin, US (Reynaud, 2012)). Carter and Milon (2005) found that price policies, supported by billing reform – particularly when information about consumption and price is provided – are an efficient tool for encouraging water conservation in urban areas.

In the study area water bills are sent to non-residential users on a monthly basis. However, the water bill does not include detailed information about consumption and, therefore, respondents were asked whether or not they would like more information on their bills.

c. Information and education campaign

Public information and education policies/programs encourage water users to adopt and maintain long-term water conservation measures and behaviours. All these individual decisions affect the sustainability of the urban/city water resources. Consequently, a public information and education program/strategy is crucial for the success of demand-side management, particularly in developing countries (Butler and Memon, 2006). Public information and education programs/strategies have influenced public water use. An example of a successful water conservation education program occurred in Utah, where approximately 27 % of indoor and 8% of outdoor water use was reduced by an education program (Hasenyager, 2009). Water use was reduced by 26% in a four year information and education program in California (Dziegielewski et al., 1993). Renwick and Green's (2003) study found that a public information campaign strategy reduced residential water consumption by 8% through influencing people's water use behaviours. Conversely, several studies show that information and education programs have a limited impact, especially in the short term (Camplell et al., 2004, Michelsen et al., 1999), indicating that outcomes vary from place to place.

Nonetheless, it is clear that information and education campaigns are critical components of successful demand-side management policies (Butler 2006). It is important that users know how to change their water consumption in the most efficient and effective manner when they are responding to the real water resource situation and to demand management policies. Public information and education campaigns increase users' awareness and change their water using habits. In a Melbourne case study (WAWRC and AWRC, 1987) it was found that consultation, advice and communication were often more effective than price policies in reducing industrial water consumption. Advisory and consultant services were found to have the potential to promote reduced water use and more water recycling or reuse amongst non-residential users.

d. Operational and technical policies

Michelsen et al. (2010) confirmed that operational-technical policies such as retrofitting and the requirement to install water saving appliances, reduced residential water use by up to 4%. Inham and Jeffrey (2006) demonstrated that replacing existing appliances with water efficient appliances resulted in savings in water use of 35-50%. In a Tampa, Florida study, water efficient toilets, washing machines, showerheads and taps were installed in 30 homes, resulting in a 49.7% reduction in per capita water use (Mayer et al 2004). The largest residential demand management study conducted in Australia on operational-technical changes found a reduction of 12% in water use (Turner et al., 2004).

The effectiveness of operational-technical approaches is likely to be influenced by property rights – home owners have direct control over their homes and are in a position to undertake refitting or to buy new appliances to assist in lowering overall potable water use. But tenants have little or no control over these aspects of their home and landlords may have little interest in, or incentive to equip rental properties with facilities that reduce water consumption.

e. Supply-side policies

Urban water resource management studies in developing countries are mainly based on supply-side policies (Vairamoorthy et al., 2008, UNICEF and UNDP, 2008). The efficiency with which water is supplied can be improved by strategies such as leak detection and repairs to municipal water infrastructure and/or by constructing a recycling plant or even dam. Strategies for managing infrastructure and for developing new infrastructure for water delivery and sewerage in Ger areas are also important in Ulaanbaatar. These long-term supply-side options were also assessed in this research.

8.4 ATTITUDES ABOUT URBAN WATER POLICIES

Survey participants were asked to indicate their water policy preferences in relation to price and non-price strategies on both the demand side and the supply side. These preferences were measured on a five-point Likert scale (see Table 1), which is deemed to be an appropriate method for measuring attitudes ((Gardner, 1975);(Gob et al., 2007). Responses to the Likert scale were assigned values as per below (Table 39).

Table 39: Values assigned to attitudes about water management strategies

Attitude	Value assigned
'much more dissatisfied' or 'very unimportant'	-2
'more dissatisfied' or 'unimportant'	-1
'not affected' or 'Moderately important'	0
'more satisfied' or 'important'	1
'much more satisfied' or 'very important'	2

Attitudes were measured as respondents' average preferences for: (i) combined all water management policies combined; and (ii) for specific ('separated') water management policies, including price policies, socio-political policies, operational-technical policies and supply-side policies:

- Att_j – attitudes towards of individual j towards all policies combined calculated as the average response to all 18 strategies (see Figure 49)
- PP_j – attitudes towards of individual j towards price policies combined calculated as the average response to those five price strategies (see Figure 49)
- SPP_j – attitudes towards of individual j towards socio-political policies combined calculated as the average response to those two strategies (see Figure 49)
- OTP_j– attitudes towards of individual j towards operational and technical policies combined calculated as the average response to those five strategies (see Figure 49)
- SSP_j – attitudes towards of individual j towards supply-side policies combined calculated as the average response to those six relevant strategies (see Figure 49)

Cronbach's alpha is commonly used to evaluate multiple attitudinal measures in terms of reliability, dimensionality and consistency for the creation of multi-item indices (Spector, 1992). A value of cronbach's alpha (α) $\geq$ 0.9 is excellent, 0.8 $\leq \alpha <$0.9 is good, 0.7 $\leq \alpha <$0.8 is acceptable, 0.6 $\leq \alpha <$0.7 questionable, 0.5 $\leq \alpha <$0.6 poor, and $\alpha <$0.5 means unacceptable internal consistency. In other words, the higher the α, the more appropriate it is to combine scores into a single measure.

Attitudinal dimensions were internally consistent for all policies in 2011, based on the standard alpha criterion of 0.7 (Table 40). In 2010, however, while the internal consistency of the policies for pricing, operational and technical policies was acceptable, the socio-political policies were poor and the supply-side policies unacceptable. This confirms a difference in respondents' attitudes towards supply-side policies.

The difference between the two study years might have been the result of the media campaign undertaken prior to data collection in 2011, when information was provided to citizens about the scarcity of water and the need for resource conservation. Specifically, the Mongolian Government announced that the year 2011 was the 'Water year'. The Mongolian parliament and government approved several water related laws and policies, and research and academic organisations organised conferences on water resource management, looking urban, agriculture, mining and hygiene issues. All arrangements and activities were promoted through TV, radio, daily news and online news media.

However, longitudinal data would be needed to accurately assess the degree to which the media (versus other factors, such as the mining boom) influenced attitudes. This study was not originally designed as a longitudinal study (since there had been no plans to change prices and/or run a media campaign) when it was set up. There are therefore two separate samples, rather than a longitudinal dataset. Consequently, it is not possible to accurately assess the significance of the media campaign on changes in attitudes between the two study years. Nonetheless, it is a very important topic for future research. The analysis below is focused only on how much attitudes changed between 2010 and 2011.

Table 40: Cronbach's alpha for each water policy and each study year

Type of urban water policy	2010	2011
Price policy	0.793	0.809
Socio-political policy	0.534	0.735
Operational-technical policy	0.787	0.904
Supply-side policy	0.374	0.855

From this point, the term 'preference/importance' is used to describe 'awareness and willingness to accept the urban water price', while 'scores' denotes a 'numerical level of preference'.

As explained above, all respondents were asked the same questions (see appendix A) to reveal their attitudes about urban water policies. The Mann-Whitney Test was used to identify whether the distribution of responses was the same in each year. The test results[23] meant that the null hypothesis was rejected at the 0.05 significance level, which confirms that attitudes towards policies were different in 2010 and in 2011. In 2010, survey respondents indicated negative attitudes towards the policies (mean values of -0.55 for the supply-side policy to -0.68 for the price policies (Figure 50)).

[23] Pricing policy z=-18.336 with p=0.000; Socio political policy z=-17.814 with p=0.000; operational and technical policy z=-18.818 with p=0.000 and supply-side policy z=-23.585 with p=0.000.

Friedman's test was used to assess if the distributions of responses to the four policies were the same. The results confirmed that there were statistically significant differences between attitudes towards the policies. In 2011, attitudes were generally positive, although there were significant different between attitudes towards price policies and operational-technical policies and supply-side policies (see Figure 50).

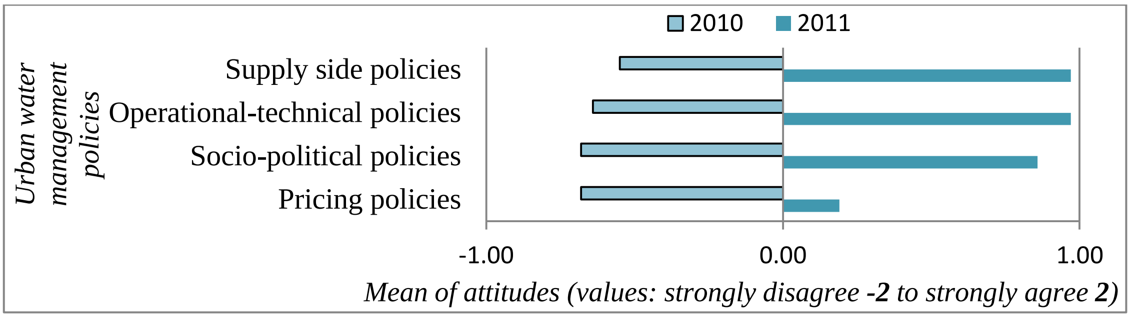


Figure 50: Attitudes towards water management policies, 2010 and 2011

Friedman's test was also used to assess whether the distribution of attitudes towards water policies was the same for different user groups in 2011. A significant difference in the attitudes of residential users was found, with χ^2=337.744 with p value 0.000; with mean ranks of 1.69 for the price policies, 2.69 for the socio-political policies, 2.83 for the operational-technical policies and 2.78 for the supply-side policies. For non-residential users, significant differences were also apparent with preferences highest for supply-side policies and lowest for price policies.

The Mann-Whitney test was also used to examine whether the distribution of each policy was the same across the user groups. There was only one significant difference (see Figure 51): supply-side policy mean ranks were 297.6 for non-residential users and 260.22 for residential users.

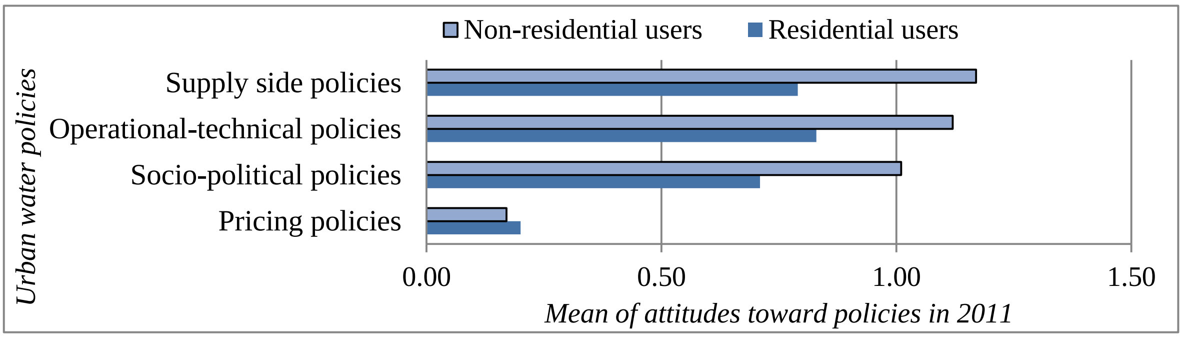


Figure 51: Attitudes toward urban water policies by user groups in 2011

Attitudes towards the operational-technical policies seemingly improved more between 2010 and 2011 than did attitudes to the other policies.

Table 41: Changes in attitudes towards policies between 2010 and 2011

Urban water management policies	Difference between mean attitudes in 2010 and 2011
Price policies	0.87
Socio-political policies	1.44
Operational-technical policies	1.61
Supply-side policies	1.52

I also looked at attitudes towards individual types of strategies within each broad policy group (see Table 41). The media campaign seemed to have had the biggest impact on attitudes towards the following statements: 'we pay more for water when water is scarce' (0.22), and 'fixing underground pipes (2.56) (Figure 52). 'Building a water recycling plant' was preferred less after the media campaign than before. Evidently, attitudes towards short term supply-side solutions (compared to longer term, more expensive solutions) improved more between 2010 and 2011, than did other attitudes.

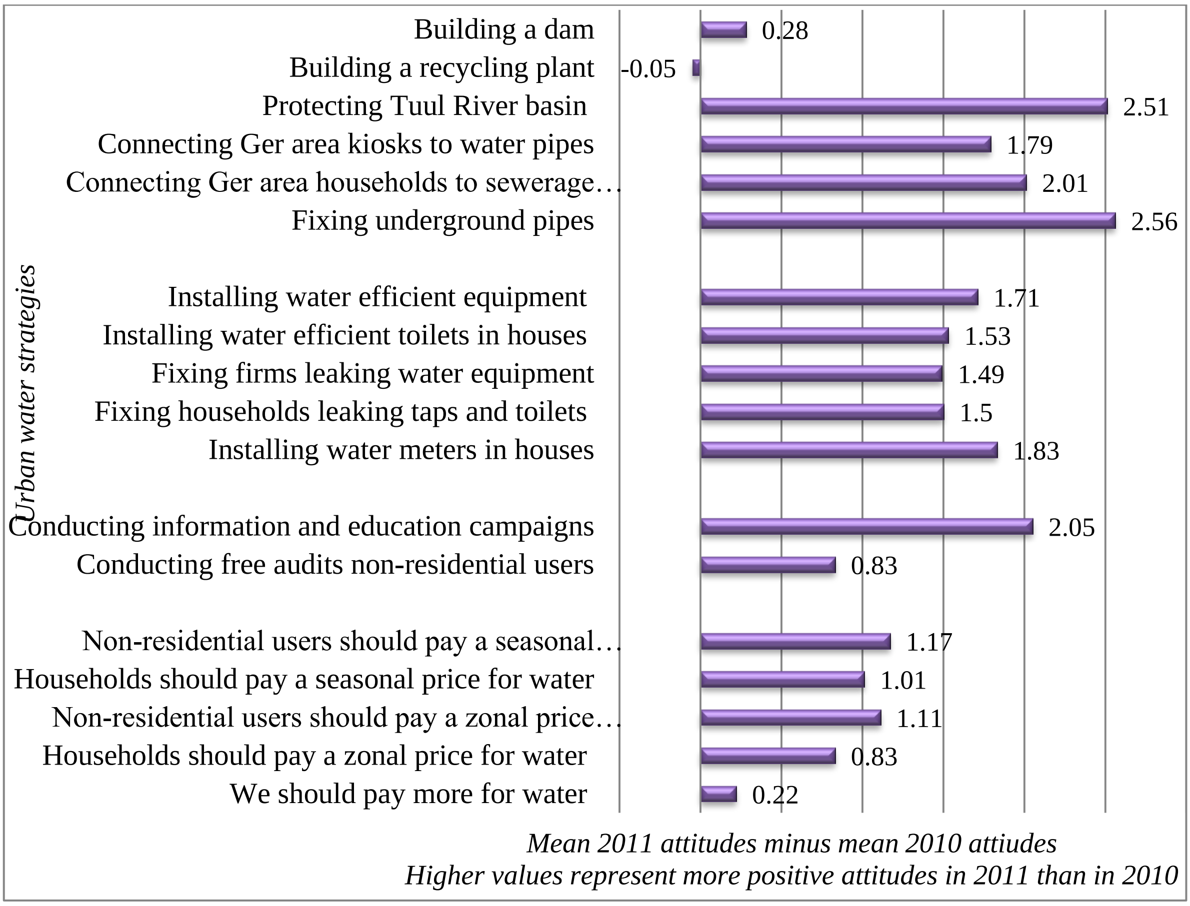


Figure 52: Changes in attitudes towards different strategies between 2010 and 2011

8.5 WATER SAVING HABITS MODELS

Non-residential and residential users' water saving habits (*Wsh*) were described and measured in chapters 6 and 7. In this chapter, I test the relationship between water saving habits and attitudes towards water management policies using a multinominal logistic regression model. Water saving habit rates were identified separately for non-residential and residential (apartment area households) user groups. Thus four different models were applied: residential and non-residential models by aggregated attitudes and separated attitudes.

a) Variables of water saving habits model for residential users:

The dependent variable for this model was:

- W_{shrj} – a variable designed to capture information about the water-saving habits of residential respondents (described in section 6.3.3).

The independent variables were:

- Num_j – the household size for household *j*
- Y_j – the monthly average income of household *j* in ₮ [24]
- E_{duj} – the highest education level in household j. The importance of communications to demand management and, in particular, the cumulative impact of messages and their interactions with people's existing understandings relate to this variable (Sharp, 2006)
- P_{knj} – a dummy variable indicating respondent knowledge of price (1 = price known by respondent; 0 otherwise) (see furthermore detail section 6.3.3)
- B_{refj} – a dummy variable indicating whether respondent felt there was a need for billing reform (1 if yes; 0 otherwise) (see furthermore detail section 6.3.3).

and either

- Att_j – the indicator of users' attitudes towards all urban water management strategies (described in section 8.4)

or

- PP_j – attitudes towards price policies (described in section 8.4)
- SPP_j – attitudes towards socio-political policies (described in section 8.4)
- OTP_j– attitudes towards operational and technical policies (described in section 8.4)
- SSP_j – attitudes towards supply-side policies (described in section 8.4)

b) Variables of water saving habits model for non-residential users:

For non-residential water users, the dependent variable for this model was:

- W_{shrj} – a variable designed to capture information about the water-saving habits of non-residential respondents (details in section 6.3.3). The habits included: using water efficient equipment for all production processes (equipment), auditing water loss for water and sewerage systems (auditing sewerage systems), carrying out maintenance on water and sewerage systems and relevant equipment (maintenance), regularly auditing water loss/leakage at taps and toilets of office buildings (auditing building), fixing any leaking

[24] ₮ – Tugrug, which is the Mongolian currency; USD1 equated to 1260.5 Tugrug in June 2011.

water using equipment and pipes (fixing), recycling effluent water, treating effluent as per the Mongolian National Standard (recycling and treating effluent), using any technology for reducing waste water (reducing waste water), and using any technology for reducing water use in production processes (technology). The respondents indicated the frequency of their use aof these water saving techniques by indicating where their business fits on a 5 point likert scale. This was done by assigning each 'category' a number (as set out in Table 18) and then calculating mean responses.

For residential water users, the dependent variable for this model was:

- W_{shrj} – a variable designed to capture information about the water-saving habits of residential respondents (details provided in section 7.3.3). These techniques include households' water conservation *curtailment* behaviour (which refers to everyday water saving actions: 'using stored water in a sink for dish washes', 'not rinsing dishes after washing', 'turning tap off while soaping hands', 'taking shorter showers', 'turning tap off while brushing teeth', 'turning shower off while soaping up', and 'reducing water level of washing machine'). Other habits relate to households' water conservation *control efficiency* behaviours, which include: 'encouraging children to turn taps off', 'checking taps to ensure turned off and they are not leaking', and 'fixing leaking taps'. Only four of these water saving habits ('encouraging children to turn taps off', 'using stored water in a sink for dish washes', 'not rinsing dishes after washing') were relevant to, and thus asked of the Ger area respondents.

The independent variables are:

- Y_j (output) – the monthly average income of organisation *j* during 2011
- *Ej* (labour) – the number of full time employees in organisation j during 2011
- Other variables – knowledge at water price, desire for billing reform, attitudes and policies; these are the same as for the water saving model for residential users above.

The water saving habits functions were thus assumed to be:

$$Wshr_j = \beta_1+\beta_2 Num_j + \beta_3 Y_j + \beta_4 Edu_j + \beta_5 P_{kni} + \beta_6 B_{refj} + \beta_7 Att_i + \varepsilon_{ji}$$

Equation 11: Residential water saving habits with aggregated attitudes function

$$Wshr_j = \beta_1+\beta_2 Num_j + \beta_3 Y_j + \beta_4 Edu_j + \beta_5 P_{kni} + \beta_6 B_{refj} + \beta_7 PP_j + \beta_8 SP_j + \beta_9 OTP_j + \beta_{10} SSP_j + \varepsilon_{ji}$$

Equation 12: Residential users' water saving habits with separated attitudes function

$$Wshr_j = \beta_1+\beta_2 Y_j + \beta_3 E_j + \beta_4 P_{kni} + \beta_5 B_{refj} + \beta_6 Att_i + \varepsilon_{ji}$$

Equation 13: Non-residential water saving habits with aggregated attitudes function

$$Wshr_j = \beta_1+ \beta_2 Y_j + \beta_3 E_j + \beta_4 P_{kni} + \beta_5 B_{refj} + \beta_6 PP_j + \beta_7 SP_j + \beta_8 OTP_j + \beta_9 SSP_j + \varepsilon_{ji}$$

Equation 14: Non-residential water saving habits with separated attitudes function

8.6 RESULTS OF THE WATER SAVING HABITS MODELS

In the first instance, models for water saving habits were tested for: (i) all residential users; (ii) residential users grouped by study year, (iii) residential users grouped by metered and non-metered households; (iv) all non-residential users; and (v) non-residential users grouped (manufacturing, commercial and governmental). The sample sizes for the grouped estimations were, however, insufficient to achieve an appropriate goodness of fit. The final models reported here, therefore, are for all non-residential users and for all apartment residential users in 2011 (after the increasing price policy and media campaign).

8.6.1 RESULTS OF RESIDENTIAL USERS' WATER SAVING HABITS MODELS

Both residential water saving models were tested using the last reference category; so groups of households who answered that they "more frequently" use water saving habits were compared to other who used water saving habits less frequently.

a) Results of residential water saving models with aggregate attitudes - 1

The final residential water saving habits model 1 specification was statistically significant (see Table 42), with $\chi 2$= 83.116; p= 0.001, -2 likelihood 1049.907 and Pseudo R^2 (Nagelkerke) = 0.258. The group of people who answered that they "more frequently" use water saving habits (rate group 5) were compared to other groups.

From the results, it is evident that attitudes towards aggregated policies are related positively to water saving habits. Occasionally, income had a positive association with water saving habits, but other variables were always statistically insignificant.

b) Results of residential water saving models with separated attitudes -2

The final residential water saving habits model 2 specification (see Table 42) was statistically significant ($\chi 2$= 107.106; p= 0.005, -2 likelihood 1030.862 and Pseudo R^2 (Nagelkerke) = 0.319).

From the results of the residential water saving habits multinomial logistic regression analysis in model 2, attitudes towards price policies, operational-technical policies and supply-side policies are significant factors for increasing residential users' water saving habits. There was no significant effect of household income, household size, or knowledge of water price and desire for billing reform.

Table 42 Outputs of residential users' water saving habits models

	Water saving habits rate 1		Water saving habits rate 1.5		Water saving habits rate 2		Water saving habits rate 2.5		Water saving habits rate 3		Water saving habits rate 3.5		Water saving habits rate 4		Water saving habits rate 4.5	
	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd
Constant	-17.358* (1.414)		-16.503* (2.327)		0.350 (1.526)		-0.486 (1.751)		0.480 (1.370)		-2.640 (2.423)		-15.4899 (1.278)		-17.769* (3.024)	
Household' size	0.059 (0.154)	1.061	-0.409 (0.343)	0.822	-0.108 (0.141)	0.897	-0.092 (0.166)	0.912	-0.143 (0.138)	0.866	-0.272 (0.197)	0.762	-0.208 (0.172)	0.812	-0.274 (0.255)	0.761
Income	0.000	1	0.000	1	0.000*	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000*	1
Education	0.104 (0.609)	1.110	-0.292 (0.815)	0.747	-.307 (0.393)	0.736	0.300 (0.581)	1.350	-0.429 (0.390)	0.651	1.247 (0.787)	3.480	-0.452 (0.467)	0.636	0.778 (1.037)	2.176
Knowledge at water price	16.18 (0.000)	1063	15.535 (0.000)	5579	1.844 (1.166)	6.321	-1.225 (0.804)	0.294	1.182 (0.923)	3.260	-0.313 (0.329)	0.731	16.243 (0.000)	1123	16.157 (0.000)	1039
Desire for billing reform	0.100 (0.060)	1.105	-0.206 (1.207)	0.814	0.024 (0.554)	1.024	-0.359 (0.731)	0.698	0.288 (0.534)	1.334	0.012 (0.721)	1.012	-0.103 (0.675)	0.902	-0.592 (1.160)	0.553
Attitudes towards aggregated policies	0.945* (0.292)	2.573	1.612* (0.759)	5.013	0.654* (0.232)	1.923	0.622* (0.317)	1.862	0.440* (0.225)	1.553	0.626** (0.326)	1.870	0.821* (0.305)	2.273	0.232 (0.404)	1.262
Number of HHs	39		6		63		23		62		20		29		9	
Chi Square	x2=83.116; p=0.001															
Pseudo R2	Nagelkerke=0.258															
Constant	-17.31* (1.431)		-16.899 (660.0)		0.647 (1.529)		-0.341 (1.798)		0.700 (1.395)		-2.671 (2.462)		-15.49* (1.308)		-19.634 (3.065)	
Household' size	0.063 (0.155)	1.065	-0.409 (0.351)	0.664	-0.107 (0.142)	0.891	-0.115 (0.170)	0.891	-0.135 (0.139)	1	-0.284 (0.197)	0.753	-0.220 (0.176)	0.803	-0.279 (0.265)	0.756
Income	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1
Education	0.097 (0.512)	1.102	-0.491 (0.842)	0.612	0.392 (0.405)	0.676	0.308 (0.603)	1.361	-0.523 (0408)	0.593	1.319 (0.808)	3.739	-0.446 (0.479)	0.640	0.625 (1.062)	1.867
Knowledge for price	16.184 (0.000)	1068	15.701 (0.000)	1.261	-1.855 (1.174)	6.391	-1.461* (0.085)	6.391	0.939 (0.928)	2.557	-0.547 (1.012)	0.579	16.204 (0.000)	1089	15.952 (0.000)	8466
Billing reform	0.174 (0.626)	1.191	-0.031 (1.230)	0.970	0.118 (0.570)	1.126	-0.532 (0.500)	0.588	0.490 (0.556)	0.377	0.055 (0.747)	1.057	0.036 (0.360)	1.036	-0.225 (1.183)	0.798
Attitudes towards price policies	0.149 (0.334)	1.161	0.320 (0.575)	1.377	0.252 (0.298)	1.286	0.046 (0.382)	1.047	0.377 (0.301)	1.459	0.653** (0.392)	1.920	0.026 (0.402)	1.026	0.232 (0.556)	1.261
Attitudes towards socio-political	-0.102 (0.366)	0.903	0.943 (0.966)	2.567	-0.002 (0.322)	0.998	-0.474 (0.407)	0.245	-0.365 (0.317)	0.694	-0.171 (0.449)	0.843	0.026 (0.402)	1.026	-0.467 (0.504)	0.627
Attitudes towards operational-technical policies	0.464 (0.433)	1.591	1.292 (1.229)	3.640	0.524 (0.387)	1.689	0.133 (0.477)	1.142	0.782** (0.374)	2.187	0.231 (0.518)	0.843	0.011 (0.440)	2.031	1.340* (3.940)	3.820
Attitudes towards supply-side policies	0.423 (0.460)	1.527	-0.779 (0.916)	0.395	-0.062 (0.396)	0.940	0.941** (0.543)	1.233	-0.129 (0.399)	0.879	0.300 (0.547)	1.260	0.709 (0.508)	1.961	-0.714 (0.754)	0.490
Chi Square	x2=107.132; p=0.005															
Pseudo R2	Nagelkerke=0.319															

Table 43 Outputs of non-residential users' water saving habits models

	Water saving habits rate 1.5		Water saving habits rate 2		Water saving habits rate 2.5		Water saving habits rate 3		Water saving habits rate 3.5		Water saving habits rate 4		Water saving habits rate 4.5		Water saving habits rate 5	
	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd	Coef B (S.E)	Odd
Constant	-2.338* (1.086)		-0.987 (0.634)		-0.259 (0.512)		-1.103 ** (0.651)		-0.381 (0.544)		0.099 (0.481)		-2.503* (1.090)		-1.119 (0.685)	
Income	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1
Employment size	0.000	1	-0.001 (0.001)	0.999	0.001 (0.001)	1.001	0.000	1	0.000	1	0.001 (0.001)	1.001	0.001 (0.001)	1.001	-0.001 (0.001)	0.999
Knowledge at water price	1.254 (1.131)	3.506	0.335 (0.681)	1.398	-1.194** (0.620)	0.303	-0.141 (0.714)	0.868	-0.047 (0.593)	0.955	-.306 (0.539)	0.737	1.693 (1.114)	5.438	2.202* (0.707)	9.4042
Desire for billing reform (need reform)	-0.974 (0.260)	0.378	0.712 (0.499)	2.034	0.108 (0.623)	1.114	0.293 (0.574)	1.340	-1.212* (0.594)	0.298	-0.509 (0.542)	0.601	-1.901* (0.839)	0.149	-1.155* (0.469)	0.315
Attitudes towards aggregated strategies	0.754* (0.382)	2.125	1.319* (0.297)	3.741	1.034 * (0.328)	2.812	1.565* (0.362)	4.785	1.825* (0.317)	6.202	0.859 * (0.262)	2.361	1.716* (0.374)	5.562	1.008* (0.226)	2.739
Number of firms	12		40		21		25		44		38		26		88	
Chi Square	x2=136.732; p<0.000															
Pseudo R2	Nagelkerke=0.329															
Constant	-2.322* (1.126)		-0.743 (0.660)		-0.271 (0.587)		-1.106 (0.711)		-0.284 (0.596)		0.264 (0.525)		-2.374* (1.122)		-0.931 (0.714)	
Income	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1
Employment size	0.000 (0.001)	1	-0.001 (0.001)	0.999	0.001 (0.001)	1.001	-0.001 (0.001)	0.999	0.000 (0.001)	1	0.000 (0.001)	1	0.001 (0.001)	1.001	- 0.001 (0.001)	0.999
Knowledge at water price	1.027 (1.144)	2.792	0.232 (0.694)	1.261	-1.188** (0.653)	0.305	-0.336 (0.733)	0.714	-0.109 (0.628)	0.896	-0.538 (0.566)	0.584	1.479 (1.130)	4.390	1.927* (0.725)	6.866
Desire for billing reform	-0.694 (0.894)	0.499	0.922** (0.542)	2.514	0.219 (0.696)	1.245	0.476 (0.614)	1.610	-1.021 (0.636)	0.360	-0.511 (0.599)	0.600	-1.734* (0.868)	0.177	-1.277 (0.546)	0.279
Attitudes towards price policies	-0.142 (0.473)	0.868	0.324 (0.319)	1.383	0.935* (0.368)	2.546	-0.337 (0.823)	0.714	0.085 (0.325)	1.089	-0.395 (0.315)	0.673	-0.296 (0.383)	0.744	-0.093 (0.274)	0.911
Attitudes towards socio-political policies	-0.007 (0.427)	0.993	0.070 (0.296)	1.072	-0.042 (0.334)	0.959	0.288 (0354)	1.334	0.209 (0.304)	1.232	-0.056 (0.287)	0.945	0.283 (0.371)	1.327	-0.264 (0.265)	0.768
Attitudes towards operational-technical policies	0.065 (0.456)	1.067	0.517 (0.343)	1.677	0.477 (0.401)	1.611	0.388 (0.402)	1.474	0.624** (0.344)	1.866	0.579** (0.330)	1.783	0.705** (0.417)	2.204	0.669 * (0.286)	1.952
Attitudes towards supply-side policies	0.880 (0.561)	2.412	0.459 (0.414)	1.583	0.207 (0.495)	1.233	0.963** (0.502)	2.619	0.772** (0.417)	2.164	0.470 (0.409)	1.600	0.673 (0.496)	1.961	0.660* (0.349)	1.934
Chi Square	x2=168.253; p<0.000															
Pseudo R2	Nagelkerke=0.400															

8.6.2 RESULTS OF NON-RESIDENTIAL WATER SAVING HABITS MODELS

Both models were tested using the first reference category, which involved 43 observations out of 337; as such, the group of firms who answered that they “never” use water saving habits was compared to other water saving habits rating groups. There is no significant effect of employment size and income as well.

a) Results of non-residential water saving model-3

The final non-residential water saving habits model 3 (with aggregated attitudes) specification of Table 43 was statistically significant ($\chi2= 136.732$; $p< 0.000$, -2 log likelihood and Pseudo R^2 (Nagelkerke) = 0.329). As for residential users, having a positive attitude towards urban water management policies is positively correlated with frequently use of water saving habits.

b) Results of non-residential water saving model -4

The final non- residential water saving habits model 4 (separated attitudes) specification of Table 44 was statistically significant ($\chi2= 168.253$; $p< 0.000$, -2 likelihood 1294.10 and Pseudo R^2 (Nagelkerke) = 0.4). Here too, it seems that having a positive attitude towards water polices is associated with more frequent use of water saving habits, but the main effect seems to be for technical and supply-side policies.

8.7 KEY FINDINGS

A number of conclusions arise from the analyses reported above, with these conclusions providing information that can be used by the authorities responsible for the management of Ulaanbaatar’s water resources. Importantly, users’ perceptions about the likely effectiveness of various water management policies were negative in 2010 but positive in 2011, although attitudes varied significantly across user groups.

- In 2010 respondents indicated that long-term solutions were better, particularly ‘building a recycling plant’ and ‘building a dam’ for promoting water end use and supply efficiency; there was an apparent belief that the government was responsible for bringing about an increase in the availability of water
- This indicates that public education campaigns are likely to be an effective strategy; the media campaign in Ulaanbaatar seems to have had a strong influence on attitudes about urban water management policies with perceptions about the likely effectiveness of policies and strategies significantly different before and after the media campaign. The extent to which the observed changes in attitudes are attributable to the media campaign and/or to other changes could not be tested here, however, yet is an important topic for future research.

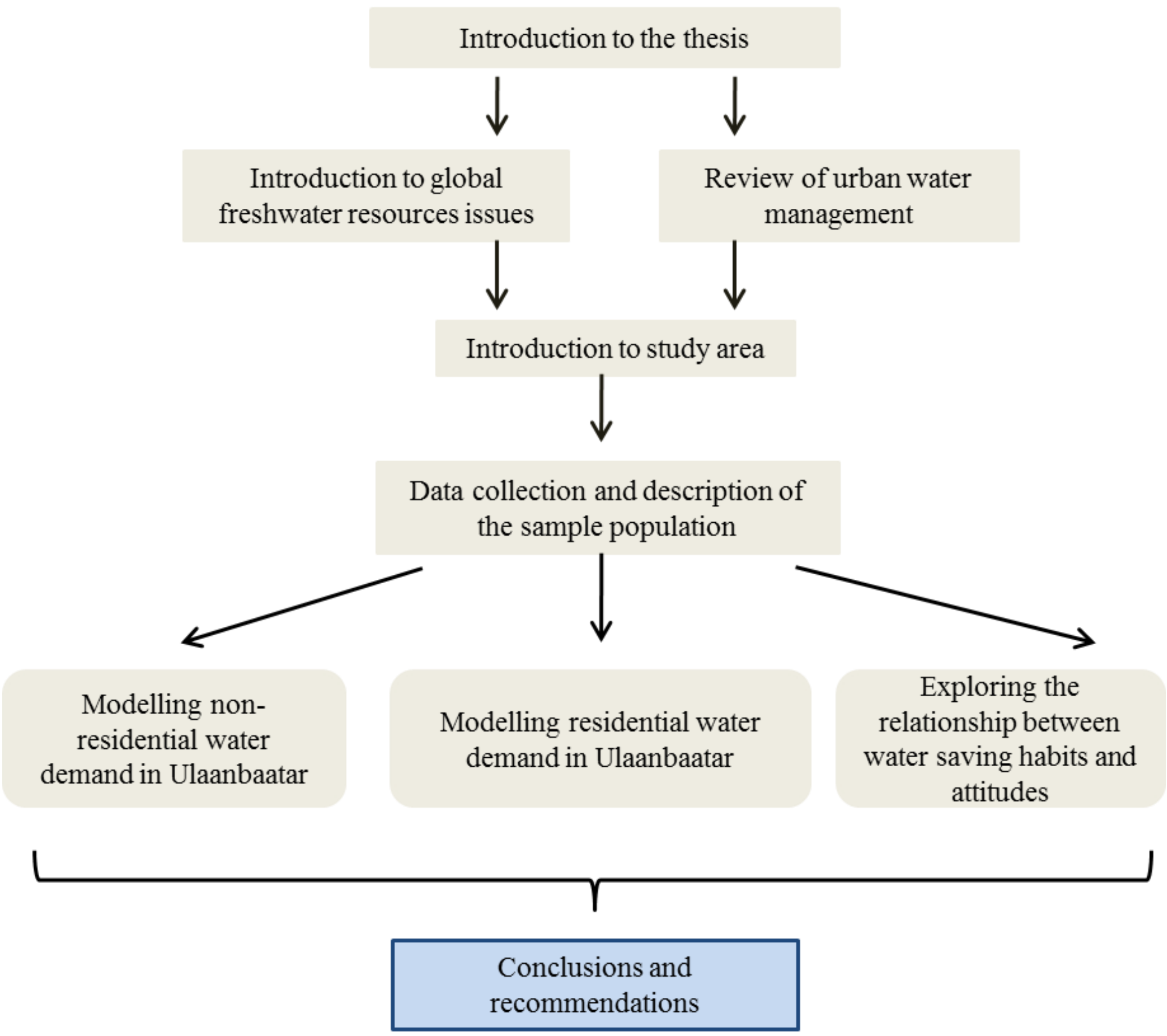
- Operational-technical policies and 'fixing underground pipes', 'protecting Tuul River basin' and 'public information and education' were the strategies for which attitudes changed most between 2010 and 2011.
- Between 2010 and 2011 consumer's perceptions about the likely effectiveness of various water management policies changed; they believed that operational-technical solutions, such as 'installing water meters at houses', 'installing water efficient equipment', 'fixing leaking taps and toilets', and 'fixing leaking water using equipment' were better solutions
- Between 2010 and 2011, non-residential particular in commercial users' perceptions about the effectiveness of 'operational-technical' policies were markedly increased.

The positive attitudes expressed in 2011 were very different from those expressed in 2010. The key findings listed below are, therefore, based on the 2011 sample and results as these provide information that is most useful for management. The key findings include:

- The policy that was viewed most favourably was the operational-technical policy, based on a strategy of installing 'water meters in homes'
- According to residential users, the most influential strategy was 'installing water efficient equipment to non-residential users'; price policies were viewed least favourably. Residential users also indicated a preference for seasonal price strategies, again applied to non-residential users
- Non-residential users expressed a preference for supply-side policies, particularly the strategy of 'protecting Tuul River basin'; like residential users, price policies were the least favoured
- All respondents preferred the adoption of technical changes for improving the efficiency of water end use, rather than changing their water using behaviour
- Perceptions about aggregated policies were more positive in both user groups in 2011, indicating that policy development is likely to increase the water saving habits of all consumer groups
- Attitudes about individual ('separated') were also more positive in 2011, particularly price policies, operational-technical policies and supply-side policies, each of which is likely to positively influence the water saving habits of both user groups
- Education, income and desire for billing reform were not significant variables in relation to the water saving habits of residential users; attitudes about policies were found to be more important than information about water prices in terms of water saving habits
- For non-residential users, knowledge at water price and desire for billing reform were significantly correlated to their water saving habits; income and employment are also unlikely to

relate to their water saving habits. The results confirm that firm size is not relevant in framing water conservation policies to induce non-residential water saving habits.

Thesis layout



CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

9.1 INTRODUCTION

As noted in the introductory chapter, the goal of the research reported on in this thesis was to:

> *Investigate possible and appropriate solutions for alleviating problems of water scarcity in Ulaanbaatar, Mongolia through water demand management policies*

The objectives were to:

- Investigate the potential impact of price increases on different user groups' demand for water
- Understand perceptions of users' about the likely effectiveness of urban water management policiesthat seek to promote the efficient supply and use of water
- Examine the relationship between water saving habits, water demand, and attitudes towards different water management policies.

. The research is unique because (to the best of my knowledge) this is one of the first studies to:

a) Comprehensively investigate urban water demand for a wide variety of residential (in both the formal and informal settlements dwellers) and non-residential (in different economic sectors) users in a developing country. Importantly, this study used the same methods/techniques to estimate the price elasticity of water demand, and to investigate attitudes towards water policy for each user group, thus making it possible to compare estimates and insights.

b) Adapt the contingent behaviour model (CBM most often applied to consumers) to estimate non-residential / business water demand.

c) Compare estimates of the price elasticity of water demand that that have been generated from a CBM both before and 'after' an actual price rise – thus checking the robustness of CBM estimates and also looking at the way in which the range of estimates changes (in this case narrows) when consumers have had recent experience with the 'hypothetical' scenario being investigated.

d) Investigate the relationship between water demand and water saving habits for non-residential consumers (with a complementary investigation of the same relationship for residential consumers).

e) Estimate the relationship between water saving habits and attitudes towards urban water management policies for both residential and non-residential users.

f) Compare perceptions of both user groups about the likely effectiveness of different urban water management policies.

The research reported in the preceding chapters was based on a case-study of Ulaanbaatar, Mongolia. Previous research efforts in water demand modelling in developing countries have been limited by data availability, which was the situation faced in Ulaanbaatar. To address this limitation, use was made of CBM data; i.e., survey respondents were asked to state how they would change their water consumption under hypothetical prices. Hypothetical responses were combined with actual data to construct a data set containing a range of price and quantity observations from which price elasticities could be estimated. A search of the literature indicated that CBM data had not previously been used to estimate non-residential demand for water. Furthermore, it has not been previously possible to check the validity of CBM estimates against observed responses, something that was done in the research reported in this thesis. Consequently, both methodological and empirical contributions were made to the literature on urban water demand in developing and transitional economies.

The principal outcomes of the research, in relation to the three stated objectives shown in Section 1.3, are summarised in this chapter. It highlights how the research findings comprise a unique contribution to the existing literature on urban water resource management

9.2 KEY FINDINGS

Research Question 1: How sensitive is non-residential water demand to changes in price?

Activity 1: An investigation of the price sensitivity of *non-residential* user groups in the manufacturing, commercial and government sectors. This was done by

a. estimating water demand functions for different non-residential user groups; and then
b. using coefficients from those functions to calculate
    - the potential reduction in demand for water by non-residential users in aggregate and for each specific non-residential sector if water prices were to rise; and
    - the potential revenue outcomes from the non-residential users' response to pricing policies.

The most direct economic tool for inducing water conservation behaviour is price and a substantial number of researchers have analysed and reviewed the impact of price on residential and non-residential water consumption, mostly in industrialised economies. A common area of interest for policymakers and researchers is the estimation of water demand and its price sensitivity. Analyses of residential and non-residential water demand in developing countries first appeared in the work of White, Bradley and White (1972), Katzman (1977), and Wang and Lall (1999), yet such analyses are limited in developing countries, particularly in relation to non-residential demand.

One apparent reason for the lack of attention to developing countries is that such analyses are hindered by limited and appropriate data sets: it is almost impossible to base a comprehensive analysis of water demand on secondary data from water utilities, which often do not record billing for each end user. Previous studies have thus been based mostly on residential water demand, exploring, for example, hypothetical water service improvements using the contingent valuation method (CVM) (WB, 1993, Whittington and Boland, 2000, Whittington et al., 2002) and hypothetical price increases using CBM (Cheesman and Bennett, 2008). A search of the literature did not reveal any investigations into non-residential water demand based on stated preference techniques, revealed preference techniques, or experimental methods.

Previous non-residential water-demand studies have used different estimation methods such as a cost function approach, production function approach, productivity approach or demand function approach (a summary of which is provided in Section 6.3). Irrespective of approach, most of these studies have used a similar set of explanatory variables in their models. To produce a study with estimates that were comparable to these other studies it was thus deemed beneficial to follow suit. In the research reported here, several different variables were thus used in the estimation of non-residential water demand, as summarised in Section 7.3.3.

As expected, business income (or budget, in the case of government organisations) was found to have a significant influence on water demand. The income elasticity of demand for the 'manufacturing' user group was -0.055, which has the opposite sign of other user groups. This indicates that an increase in income is associated with less water consumption.

Water saving habits significantly affected water use for all groups, although in different ways. Commercial and government organisations, which frequently employed water saving habits, used, on average, less water than those that did not. Conversely, for manufacturing firms the relationship went the other way. This might be explained by the fact that the manufacturing group contains some very large firms that may use only one or two water saving devices frequently – but these devices might be much more effective at conserving water than a multitude of other habits. For commercial users the water saving habit and water demand are negatively related, which means that technological factors are generally expected to have a large impact on commercial water demand (Worthington, 2010).

For the 'manufacturing and industrial' user group, the estimates of price elasticity ranged from -0.203 to -0.057. These are similar to the results of Ziegler, Hussain and Dharmaratna in their studies in Sri Lanka (Dharmaratna and Parasnis, 2010, Hussain. I. et al., 2002, Ziegler and Bell, 1984). For the commercial sector the results also corroborate the findings of others (Lynne et al., 1979, Williams and Suh, 1986, Dharmaratna and Parasnis, 2010, Moeltner and Stoddard, 2004). Only one other study that reported elasticities for government organizations could be found (Moeltner and Stoddard, 2004), and the estimates in the research reported in this thesis are more elastic than theirs – perhaps because at least some of the organisations within the group were private organisations. Interestingly, at any given price level, the elasticity estimates associated with the government sector were surprisingly similar to those associated with the manufacturing sector – despite the fact that these organisations are likely operating with different objective functions. Further research could be usefully undertaken to explore the possible reasons for this.

Also evident was the fact that demand becomes more inelastic as price increases – in accordance with expectations. In all cases, demand was price inelastic – although manufacturers appeared to have more inelastic demand than others. The most price sensitive non-residential user group is 'commercial and service' organisations.

The price elasticity estimates were then used to make predictions about the potential impact – on water demand and on government revenues from water prices – about increases in price. This analysis indicated, that if the price of non-residential water were doubled in Ulaanbaatar water use would fall by approximately3.5%; and revenues would almost double. This result suggests that higher prices may have relatively little impact on non-residential water use, but could raise significant amounts of revenue – which could, potentially, be used to fix leakages and improve the overall efficiency of water use.

Research Question 2: How sensitive is residential water demand to changes in price?

Activity 2: An investigation of the price sensitivity of *residential* user groups in the manufacturing, commercial and government sectors. This was done by:

a. estimating water demand functions for different residential user groups; and then
b. using coefficients from those functions to calculate:
    - the potential reduction in demand for water by residential users in aggregate and for each specific non-residential sector if water prices were to rise; and
    - the potential revenue outcomes from the residential users' response to pricing policies.

Studies estimating residential water demand started appearing in the published literature from Howe's (1960) study onwards. Since then, there have been numerous investigations of household/residential water demand in developed and developing countries (Arbues et al., 2003, Espey et al., 1997, Dalhuisen et al., 2001, Nauges and Whittington, 2009, Terrebonne, 2005, Taylor, 1975). Many of these articles are listed in EconLit[25]. That said, most of these studies used either time series or cross sectional data (limiting the geographic areas of research to those were data are available). Few studies have been conducted in data poor environments; fewer still have used the CBM in these situations(Cheesman and Bennett, 2008, Grijalva et al., 2002).

In this study, the CBM was used to estimate the price elasticity of water demand for different residential groups: those living in formal 'apartment' settlements (differentiated according to whether

[25]EconLit-http://www.econlit.org

or not their homes had individual water meters or not) – and those living in informal 'Ger' settlement households (Section 4.1.1). There was no recorded data about individual water use; so current levels of water use were estimated from survey data (using the conditional approach), and hypothetical levels of water use (under different hypothetical prices) were estimated from information collected in contingent behaviour questions. As noted in Section 7.3.3, the models used these current and hypothetical measures of water consumption as the dependent variable in a random parameter panel-data model; independent variables were selected to 'match' those commonly used in residential water demand studies and included measures of income, household size, education, water saving habits, knowledge of water price and desire for billing reform. Most variables, apart from education, were similar to those used in the non-residential models of Section 6.3.3.

Education level, household income, household size and education level were statistically significant determinants of water use for apartment dwellers. The coefficients on household size, knowledge of water price, desire for billing reform and water saving habit variables had the expected sign for all residential groups. However, for households in the Ger areas – the coefficients on income and education were positive indicating those on higher incomes use more water. Residential water saving habits were found to be poor predictors of water use in this study, a result also reported by Aitken et al (1994).

Overall, the estimates of price elasticity ranged from between -0.927 and -0.156 for metered apartment residential users and between -0.941 and -0.099 for non-metered apartment residential users. Evidently, in Ulaanbaatar, residential water demand, particularly for Ger area users, is more sensitive to price than non-residential water demand. This overall range is broadly comparable to the price elasticity estimates generated by others in studies of residential water demand in developing countries (Nauges and Whittington, 2010). For example: Nauges and Strand (2007) found that the price elasticity of demand for private and public wells and taps, trucks, and river water for residents in three cities in El Salvador ranged from -0.7 to -0.4; (Basani et al., 2008) looked at seven provincial towns in Cambodia, concluding that the price elasticity of water demand was between -0.5 and -0.4; Cheesman and Bennett (2008) generated estimates between -0.53 and -0.06 in Buon Ma Thuot; and Nausges and Berg (2009) concluded that the price elasticity of water demand in Sri Lanka was between -0.37 and -0.15. Importantly, I was able to collect residential water use data before and after the 2011 water price increase. I then generated an alternate estimate of price elasticity – using average household water consumption in 2010 and 2011 and actual water prices. This estimate fell within the range of price elasticity estimates generated by the CBM models; more, *prime facie* evidence of the validity of the approach.

Water demand was price elastic for small price changes (< 10%) in Ger area households (-2.586). This is similar to the findings of Lyman (1992), David and Inocencio (1998) and Rietveld's (2000).

Lyman (1992) reported price elasiticities during peak demand periods of -1.38 in the USA; David and Inocencio (1998) found the demand elasticity for vended water in Manila of -2.1; and Rietveld (2000) reported Indonesian residential demand for piped water at -1.6.

For larger price increases, demand was inelastic – as per prior expectations. Moreover, water demand in 2011 (after the price increase) was more inelastic than in 2010. Moreover, the range of price elasticity estimates generated from the CB models was narrower in 2011 than in 2010. This suggests that recent experiences influence responses to contingent behaviour questions – in effect, reducing respondent uncertainty.

As in the non-residential study, estimates of price elasticity were used to make predictions about the likely change in water demand and water revenues following price increases. This analysis indicated that in the study area, doubling the price of residential water would likely reduce overall water use by about 4% (compared to current usage levels). Revenue would increase by about 95%. Here too, it seems that increased water prices would have relatively little effect on water demand, but could substantially increase government revenue.

Research Question 3: Is there any relation between water saving habits and attitudes towards urban water management policies?

Activity 3: An analysis of the relationships between water saving habits and attitudes about urban water management policies for non-residential and residential user groups. Here, I

a. assessed consumer's attitudes towards different policies to promote water end use efficiency and improved water supply efficiency;
b. looked at attitudes towards urban water management policies before and after a government media campaign (aimed at increasing awareness of water scarcity); and
c. explored the relationship between water saving habits and attitudes towards water management policies for *non-residential* and *residential* user groups

Previous studies found that perceived consumer effectiveness was negatively related to ecological interest and concern (Kinnear et al., 1974), while water saving habits led to water saving (Aisa and Larramona, 2012). Some studies have investigated the relationship between attitude towards water management policies and residential water saving habits, especially in residential water use (Martinez - Espineire and Garcia-Valinas, 2012, Fielding et al., 2012, Willis et al., 2011, Russell and Fielding, 2010, Inman and Jeffery, 2006, Syme et al., 2000). However, there have been no investigations into the relationship between attitudes and non-residential users' water saving habits; the present study undertook such an investigation.

The analysis of Chapter eight demonstrated that operational-technical policies, particularly the strategy 'Installing water meters at home', were viewed most favourably by all users. Price policies were viewed least favourably. But supply-side policies, particularly the strategy of "Protecting Tuul River basin" was the most favoured option for non-residential users.

Chapter eight also compared attitudes towards various water management policies before and after the 2010/11 media campaign. In this study it was found that both user groups' perceptions about aggregated policies were more positive in 2011 than prior to the media campaign policy, indicating that such a campaign is likely to enhance the water saving habits of all consumer groups. This is in accordance with Syme et al's (2000) study that evaluated water conservation campaign studies, concluding that they had a significant impact on water use. The media campaign appeared to have had the greatest influence on non-residential users' perceptions about the 'operational-technical' policies; while commercial users indicated more positive perceptions about 'operational-technical' and 'socio-political' policies following the media campaign.

The final analysis of Chapter eight highlighted the fact that non-residential and residential water users who had positive perceptions of the various water management policies were also likely to have more water saving habits than their more negative counterparts. Residential users viewed technical policies more favourably than policies aimed at altering behaviours. The results in this study are not the same as those reported in other studies on the relationship between water saving habits and socio-demographic factors for both user groups (Mondejar-Jimenez et al., 2011, Gilg and Barr, 2006). Income and employment are not significant variables in the non-residential water saving habits model. This confirms firm size is not significant to water conservation by non-residential users.

9.3 POLICY IMPLICATIONS

The research reported in this thesis involved close collaboration with the mayor's office of Ulaanbaatar and USUG to ensure the work was applicable and easily translated to ongoing urban water management. Urban water policies were discussed in Chapter three, and the current situation in the study area was reviewed in Chapter four. The research results will be used by the mayor's office and USUG to address the impending water scarcity in the city. Overall, 1,333 respondents were surveyed through support from the city and USUG (the sample was described in Chapter five).

The analyses presented in Chapters six, seven and eight was focused on the effectiveness of price policies on non-residential and residential water demand and perceptions about the likely effectiveness of urban water management policies, including demand and supply side policies. The research results will be presented to the mayor's office and will also feed directly into the ongoing development of urban water resource management policies, planning and practice in Ulaanbaatar.

Lessons are also provided for the management of water in the urban areas of developing and transitional economies more generally.

The results of economic models developed in the research impart several key policy messages for the management of the scarce water resources of Ulaanbaatar. These include the following:

- Government organisations, including schools and hospitals, used more water than industrial and commercial firms. This result could suggest that water audits and further installation of water efficient appliances and equipment in schools, hospitals policies and other government buildings would result in greater levels of water conservation.
- Water consumption of an average non-metered apartment household was less than an average metered household in this study and as reported by USUG and OSNAAG. There is a gap in non-metered household water consumption between the research calculations and the institutional reports. Although there are water leakages, it is unclear whether water is leaking at home or in the water infrastructure which is the responsibility of the body corporate (in basements of high rise apartment buildings). It is recommended that the city keeps implementing the water meters policy, although the policy could be updated to include a rebate strategy. Implementation of the policy would bring benefits such as reducing water use from non-metered households and leakages from pipe systems.
- Demand for water will be dramatically changed due to the implementation of the housing program II phase. This particular housing program, which is part of the urbanisation process, will apply more pressure on already limited water supplies. The housing program will have the effect of rapidly increasing residential consumption; Ger area dwellers currently consume 8.8 Litres per person per day, which will increase by up to 12 times. The demand for residential water strongly and significantly relates to household size, which is higher in Ger area households. Consequently, there is substantial pressure to understand the demand for water and to implement policies to manage the resource in a more sustainable fashion.
- The effectiveness of price policies is demonstrated by demand models for non-residential and residential water. Potential changes in revenue to the government are also estimated from the outputs of the models. It was found that a price increase of 10% would reduce consumption by residential users and would also – slightly – increase revenue from them. Conversely, social welfare and equity considerations for Ger area households need to be considered in relation to implementation of price policy. Non-residential users would reduce water demand less than residential users, but more revenue could be collected from this group, particularly commercial organisations. The policy would conserve around 9.5% of current total water consumption and would increase current revenue by 8.6%.

- The World Bank report confirms that Ulaanbaatar water users are willing to pay 50% more than the current price (Emerton et al., 2009). A 50% price increase would reduce the current water consumption by 15.6% and increase revenue by 16.6%.
- Although doubling the price is unlikely to be politically acceptable, such a move could potentially reduce annual water consumption by just over 1.7GL of water, with a reduction in demand of around 20% by non-residential users; it would result in an increase in revenues of approximately 19.8 billion ₮ (about 90% of current revenues). Most water would be conserved by commercial organisations for the non-residential users and non-metered households for the residential users; slightly more revenue would be gained from these groups also.
- Seasonal water pricing is a strongly accepted policy by users. In the extreme case, the seasonal price policy might result in government revenue being unstable; there might be a shortfall without the block rate, which aims to ensure economic efficiency, social equity, sustainability of water supply and services, and political acceptability.
- The price elasticity of non-metered households was estimated and it was found that the non-metered demand is more elastic than the metered; evidently if it were possible to charge non-metered households for their water use, then demand could decrease markedly. That may not be financially feasible in the short run (since installing meters is expensive). But this study also showed that attitudes towards water policy changed markedly between 2010 and 2011 – some no doubt due to increased prices (for the metered apartments), but most likely due to the media campaign (no other users had similar price increases). Price is clearly not the only way of influencing attitudes (and perhaps also behaviours).

Perceptions about the likely effectiveness of urban water management policies indicate that several policies and strategies can contribute to mitigating the impending water shortage in Ulaanbaatar. Important conclusions include:

- Price policies, operational-technical policies and supply side policies are likely to positively influence the water saving habits of both user groups.
- Operational changes, including pressure reduction management for water pumping increases water savings by a further 20–55% and leads to a reduction in maintenance and operating costs of 25–45% (Burn et al., 2002b). Reduced water losses in the system, including leakage detection and repair, would conservatively save 20.4% of water, which is the established leakage figure for Ulaanbaatar.
- Adoption of water efficient aerator taps, which consume 2.5l/min (White et al., 2003b) would conserve water in residential apartment areas, commercial and government premises.

Currently, 37.5% of apartment households' water consumption is miscellaneous water, which is mostly tap water at a rate of 5l/min (Rekacewicz, 2005).

- Implementing a shower flow restrictor policy resulted in a 26% saving of water for showers after five years (Arnell, 1999). The equivalent savings reported for low-flow showerheads was 9% (Mayer et al., 1999). Current showerheads in Ulaanbaatar use A label, which uses 12-15l/min; the adoption of a AAA rated showerhead, which consumes < 9l/min (Loucks, 2000), could save 40% of the water now used for showers.
- White et al (2005) summarised the results of demand management programs, noting: per toilet flush consumes 11/6l – most old apartments do not have dual flush toilet (those old toilets consume >11l/per flush); adopting AAA rated toilets, which consume 6/3l or 4/3l per flush (Loucks, 2000) would reduce toilet water usage by 63%. Retrofitting toilets resulted in a 19% reduction in residential water consumption months later, but resulted in a 47% reduction after five years (Arnell, 1999).

Overall, urban water management policies are likely to be effective for alleviating problems of water scarcity in Ulaanbaatar; price increasing policies will also support greater revenue collection. Non-price policies can also influence water conservation by both user groups.

The findings of this research are likely to be transferable to urban areas in many other developing and transitional economies. The results show that water demand is generally price inelastic, but price policies could be a tool for increasing revenue – as long as one is aware of the potentially significant equity consequences of such. Price policies are a commonly offered option for conserving water from all users, but it is clear that non-price policies can also influence consumers to change their water use behaviour.

9.4 FURTHER RESEARCH RECOMMENDATIONS

An integrated analysis of technical 'fixes' funded through price increases

Part of my interest in looking at both the potential reductions in water use and the potential increases in revenue might result from increased prices, was driven by the recognised financial needs of developing countries. An interesting extension of the work started here, would be to work with engineers and other technical experts to estimate the cost of infrastructure improvements (particularly those that would serve to conserve water, e.g. fixing leaking pipes), and to then use estimates from these models to determine the feasibility of raising some of that money with higher water prices.

Comparison of advertising and price elasticities of water demand

Several studies have found that education and information campaigns impact on demand for water, yet there has been no exploration into the impact of simultaneously increasing prices and undertaking media campaigns. It would be beneficial to analyse and compare the price elasticity of water demand with the media/advertising elasticity of water demand in the short and long term, and to make comparisons between developing and developed countries. The more challenging issue would be to estimate the impact of a media campaign on the price elasticity of non-metered and/or flat rate payers' water demand.

Contingent behaviour methods modification for water demand estimation

The research undertaken here has confirmed that CBM is an appropriate method for analysing urban water demand. However, in this study, CBM was based on a hypothetical scenario that used a relatively straightforward demand estimation for water, and which assumed that water was priced at a flat (single) volumetric price. Increasing block tariffs (IBTs) have become more popular as the tariff structure of choice in developing countries following the recommendations of international development organisations (Whittington, 2006), and price structure significantly affects price elasticity (Espey et al., 1997, Nieswiadomy and Molina, 1989a). A further research option is, therefore, to modify the CBM so that it is able to look at the potential effects of other price strategies such as a discontinuous tariff structures (e.g. block rates and a combined rate with fixed access charge and block rates). Furthermore, researchers could compare the potential 'effectiveness' of those strategies determining if the predictions of others (e.g. Dalhuisen et al (2003), Reynuad et al (2005) and Olmstead et al (2007)) are true in other contexts..

Encouragement of urban water management strategies to change water saving habits

This thesis investigated water management policies that influence water saving habits, but data limitations did not allow for an exploration of the variation between water saving habits and behavioural or technical changes through policies. Further research might demonstrate more detailed information about which of the micro-components of residential and non-residential water use can be more effectively reduced by various policies, and which components of water use have more potential to decrease via changes in water saving habits.

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APPENDIX A: QUESTIONNAIRES

APPENDIX A-1: QUESTIONNAIRE FOR RESIDENTIAL USERS FOR GER AREAS

Water scarcity is one of Ulaanbaatar's most pressing issues. Ulaanbaatar city's main water users are residential and industrial customers. There is a significant water usage difference between Ger[26] areas and apartment areas water users. This study's purpose is to minimise residential water usages difference by implementing water demand management policies. This survey will support by investigations such as residential customers current water usage and practice, water usage behaviour change with the policies. The result of the survey will provide information that can be used to encourage behaviour change and develop water saving policies, and to find some solutions of potential of postponing water scarcity. If do you need more information about the study, can ask by an email to zulgerel.altai@jcu.edu.au

A. Characteristics of household ***(Please write the number)***

1. How many people live in your house (including yourself)? _______________

2. How many of those people are *(please write the number on appropriate box)*:

☐ 0-14 years old ☐ 15-59 years old ☐ 60 + years old

B. **Characteristics of properties**

3. Do you live your own house or rent?

☐ Own ☐ Rent ☐ other

4. Type of house?(*Please tick your house type)*

☐ House *(Please go to following section)* ☐ Ger ☐ Unofficial house

Which type of house, do you live in a house? (*Please circle the appropriate type)*

a. Modern house
b. Other ___________

5. How old is your house? _________ years (*Please write the number)*

6. What is the size of your house? __________ Square meters (*Please write the number)*

7. From which water resources is your family supplied the water? (*Please tick the appropriate box)*

☐ Water infrastructure ☐ Water kiosk is connected to water network
☐ Protected well ☐ Water kiosk is not connected to water network
☐ Spring ☐ Water by the water truck
☐ Bottled water ☐ other

8. Is your house connected to the following utilities infrastructure networks?

To the water infrastructure ☐ Yes ☐ No
To the hot water infrastructure ☐ Yes ☐ No
To the sewerage system ☐ Yes ☐ No

9. Does your house have any water metering?

☐ Yes ☐ No ☐ don't know

10. Does your house have any inside plumbing?

☐ Yes ☐ No

If yes how many taps, toilets and baths does your house have?(*Please write down the number in the appropriate box)*

☐ Bathrooms ☐ Taps ☐ Toilets

C. **Water usage:**

11. Where does your household get most of your water from? (*Please tick an appropriate box)*

☐ From water pipe ☐ From a river or stream
☐ From well (by track) ☐ From private underground bore or well
☐ From well (water pipe) ☐ Other____________

12. Approximately how many litres of water did you use in the last month? (*Please tick appropriate box)*

☐0-500 ☐501-1000 ☐1001-1500 ☐ more 1501 ☐ don't know

13. Approximately, how much water does your household use per month?

---

[26] Mongolian traditional house suit to live nomadic people

Approximately_____ cubic meters/litres per month in the cold season and
Approximately _____ cubic meters/litres in the warm season

14. Do you use water for any of the following? *(if yes please write down the monthly using number)*

a. for the garden ☐ Yes ☐ No If yes, how many time a week? ☐
b. for carpets☐ Yes ☐ No If yes, how many time a season?☐
c. for washing the car ☐ Yes ☐ No If yes, go to next question.

15. If your family has a car, how and where do you wash it?

☐ Carwash service ☐ At home ☐ other

How many times a week do you wash the car? *(Please write down the number)*

______________ times a week in winter
______________ times a week in summer

16. Does your family have a washing machine?

☐ Yes ☐ No

If yes, what type of washing machine do you have? (*Please tick appropriate box)*

☐ Twin Tub ☐ Front Loader ☐ other types

17. How many times per week do you use a washing machine? (*Please tick appropriate box)*

☐ Rarely ☐ Once a week☐ Twice a week ☐ 3 times a week
☐ 4 times a week ☐ 5 times a week☐ 7 times a week ☐ other a week

18. Where do you and your family members shower? (*Please tick appropriate box)*

a. At home ☐
b. Public shower ☐
c. In sauna ☐
d. In someone's apartment ☐
e. Other ☐

19. How many times per week, approximately, does each person shower? (*Please write the number of showers)*

	once	twice	triple	4 times	5 times	6 times	7times	more
In the warm season	☐	☐	☐	☐	☐	☐	☐	☐
In the cold season	☐	☐	☐	☐	☐	☐	☐	☐

On average, how long does each person spend in the shower? *(If different for individuals please write the number in appropriate boxes)*

☐ Less than 5 minutes ☐ 5 – 10 minutes ☐ 10-15 minutes
☐ 15 – 20 minutes ☐ 25 – 30 minutes ☐ More than 30 minutes

20. How does your family waste the sewerage water? (*Please write in the space)*

D. **Knowledge for price of water**

21. Do you know how much do you pay the cold water price per litre and the hot water price per person? *(Please tick the appropriate box)*

Water (per litre) ☐20 mungu ☐50mungu ☐1 tugrug ☐2 tugrug ☐ don't know
Hot water (p p) ☐1000tug ☐1500tug ☐2000tug ☐ 2500tug ☐ don't know

22. On average, how much does your family monthly pay following utilities costs?*(Please indicate in Tugrug)*

a. Cold water cost tug
b. For shower tug
c. Electricity tug
d. Heating tug

23. Do you need any information on your water bill?

☐ Yes ☐ No ☐ do not know

If Yes, please indicate what type of additional information about you would like to have included on your bill?

E. PRICING POLICY FOR WATER CONSERVATION

24. Please tell us whether you think your household would use more or less cold waterif the price of water, monthly income of your household, and increasing family members were to change? *(Please tick appropriate box* for each item*)*

	We would probably use				
	LESS WATER				**MORE WATER**
	Less than half of what we use now	Probably use a little less	No change	probably use a little more	more than twice as much as we use now
If water price increased twice the current price	☐	☐	☐	☐	☐
If water price increased by 50%	☐	☐	☐	☐	☐
If water price increased by 10%	☐	☐	☐	☐	☐
If water price decreased by 10%	☐	☐	☐	☐	☐
If water price decreased by 50%	☐	☐	☐	☐	☐
If water is free	☐	☐	☐	☐	☐
If your household's income increased by 100%	☐	☐	☐	☐	☐
If your household's income decreased by 50%	☐	☐	☐	☐	☐
If your household's member increased by one adult	☐	☐	☐	☐	☐

25. If the water price structure could be changed which structure would you prefer to pay? (*This question is only for apartment area's respondent. Please tick the your choice*)

☐ Uniform tariff ☐ IBT ☐ DBT ☐ Don't know

26. The following are some possible water pricing policy changes. Please indicate how you feel about each suggestion:

	We would agree				
	Strongly agree	agree	undecided	disagree	Strongly disagree
Business should pay more for water then private individual when water is scarce	☐	☐	☐	☐	☐
We should pay a zoning price rather than current price, when water is scarce	☐	☐	☐	☐	☐
Businesses should pay a zoning price rather than private individual, when water is scarce.	☐	☐	☐	☐	☐
Business should pay more according to seasonal effects when water is scarce.	☐	☐	☐	☐	☐
People should pay more according to seasonal effects when water is scarce.	☐	☐	☐	☐	☐
Other ______________________	☐	☐	☐	☐	☐

F. NON PRICING POLICY FOR WATER CONSERVATION

27. Do you and your family members have any of the following water saving habits:

	We do				
	Always	Usually	About half the time	seldom	never
encouraging children to turn taps off	☐	☐	☐	☐	☐
using stored water in a sink for dishes washes	☐	☐	☐	☐	☐
not rinsing dishes after washing	☐	☐	☐	☐	☐
reducing water level of washing machine	☐	☐	☐	☐	☐
Others_________________________	☐	☐	☐	☐	☐

28. Imagine the Ulaanbaatar government had more money to spend on water infrastructure (e g donor organisation), which improvements do you think are most important? (*Please tick appropriate box each row)*

	Very important	Important	Moderately important	Of little importance	Unimpor tant
Better and safe water delivery systems or pipes	☐	☐	☐	☐	☐
Install individual household water meters in Apartment customers	☐	☐	☐	☐	☐
Fix leaking taps and toilets of apartment customers (add government support)	☐	☐	☐	☐	☐
Fix leaking equipments of business (add government support)	☐	☐	☐	☐	☐
Subsidies to households by installing low flow toilet/s	☐	☐	☐	☐	☐
Subsided to business by water efficient technologies	☐	☐	☐	☐	☐
Free water audit for business	☐	☐	☐	☐	☐
Improve water conservation knowledge; encourage households and business to reduce their consumption	☐	☐	☐	☐	☐
Protect the security area of the Tuul River Basin	☐	☐	☐	☐	☐
Connect consumers in Ger areas to sewerage systems	☐	☐	☐	☐	☐
Recycle water	☐	☐	☐	☐	☐
Build/construct dam	☐	☐	☐	☐	☐
Others____ _	☐	☐	☐	☐	☐

29. Have you and any of your family members had any illness which you think was due to contamination or quality of water? (*Please tick appropriate box)*

☐ Yes ☐ no ☐ perhaps ☐ don't know

F. GENERAL INFORMATION

Finally, we would like to know a little bit more about your household information. This will be kept strictly confidential and is used to ensure that we have collected information from a wide variety of households.

30. What is the highest level of education from your members has achieved? (*Please tick appropriate box)*

☐ Primary ☐ High school ☐ University

☐ Technical training school ☐ No formal education ☐ Other ***(please specify)***

____

31. How many of the people who live in this house (including yourself) are; (*Please fill a number beside each category. For example, if two people in the house are employed, write the number "2" next to the word Employed.)*

_____Retired _____Unemployed _____Student
_____Employed _____ seeking job _____Healthcare appointee

32. How many of the people who live in this house do work in the following economic sectors? ***(****Please fill a number beside each category)*

_____ Hospitality industry
_____Communication Services
_____Cultural & Recreational Services
_____Educational Services
_____Government administration & Defence
_____Manufacturers
_____Personal & Other Services
_____Retail & Wholesale shops/stores
_____International organisation activities
_____ Agriculture, hunting, fishery industry
_____Construction
_____Finance
_____Electricity, gas production and Water Suppliers
_____Health & Community Services
_____Mining & Related Services
_____Rental, property and business services
_____Transport, Travel & Storage

33. What is the total, combined, monthly (taxable) income of your family? *(Please tick appropriate box)*

☐ < 100,000 Tugrug
☐ 100.000-299,999 Tugrug
☐ 300,000-499,999 Tugrug
☐ 500,000-699,999 Tugrug
☐ 700,000-1,000,000 Tugrug
☐ 1,100,000-$1,400,000 Tugrug
☐ 1,500,000- more Tugrug

Thank you for your cooperation and support

APPENDIX A-2: QUESTIONNAIRE FOR RESIDENTIAL USERS FOR APARTMENT AREAS

Water scarcity is one of Ulaanbaatar's most pressing issues. This study will identify changes water usage and usage behaviour of Ulaanbaatar's residential users towards water demand side policies. This survey is taken by JCU and the Governor's office of Ulaanbaatar, therefore, your respond will be remained at only purposed this project. Result of the survey will provide information that can be used to figure out appropriate options to postpone time of becoming water scarcity through your respond and to publish on international academic journals for presenting and expressing to international cooperation organizations and to support information to local government and researchers. If do you need more information about the study, could connect with Zula by an email to zulgerel.altai@my.jcu.edu.au.

A. Characteristics of household

34. How many people live in your house (*including yourself*)? ________________

35. How many of those people are *(please write the numbers on appropriate box)*:

☐ 0-14 years old ☐ 15-59 years old ☐ 60 + years old

B. Characteristics of properties/houses

36. Do your family live your own house/apartment or do your family rent it? (*Please tick)*

☐ Own ☐ Rent ☐ other

37. Type of house is it?(*Please tick an appropriate box)*

☐ House *(Please go to following section)* ☐ Ger ☐ Unofficial house

Which type of house, do you live in a house? (*Please circle the appropriate type)*

c. Apartment b. Modern house

c. Common lodging house[27] d. Dormitory

e. Donga f. Other ___________

38. How old is your house and/or your property? *(please write a number)*__________ years

39. What is the size of your house? _______________Square meters

40. From which water resources is your family supplied the water? *(Please tick the appropriate box)*

☐ Water infrastructure ☐ Water kiosk is connected to water network

☐ Protected well ☐ Water kiosk is not connected to water network

☐ Spring ☐ Water by the water truck

☐ Bottled water ☐ other

41. Is your house connected to the following utilities infrastructure networks? (*Please tick the appropriate box)*

To the water infrastructure ☐ Yes ☐ No

To the hot water infrastructure ☐ Yes ☐ No

To the sewerage system ☐ Yes ☐ No

42. Does your house have any plumbing system and water using appliances?

☐ Yes ☐ No

If yes how many taps, toilets and baths does your house have?(*Please write down the number in the appropriate box)*

☐ Baths ☐ Taps ☐ Toilets

43. Does your house have any water metering?

☐ Yes ☐ No ☐ don't know

If, Yes, which type of water meters is it?

☐ sub metering ☐ universal metering

If, your home has sub water meter at home, how many water meters? (*Please write down the number in the appropriate box)*

☐ sub water meters on the cold water pipeline ☐ sub water meters on the hot water pipeline

[27] Which has one common toilet for each floor

C. Water usage

44. Approximately how many cubic metres water did your house use in the last month? (*Please tick appropriate box)*

☐0-3 ☐4-6 ☐7-9 ☐10-12 ☐13-15 ☐16-20 ☐21-25 ☐ don't know

Approximately, how much water does your household use per month in the cold and warm seasons? *(Please write down the number)*

Approximately monthly _____ cubic meters/litres water in the cold season and
Approximately monthly _____ cubic meters/litres water in the warm season

45. Does your family use water for any followings? *(if yes please write down the monthly using number)*

a. for irrigation ☐Yes ☐No If yes, how many time a week? ☐
b. for cleaning carpets ☐Yes ☐No If yes, how many time a season? ☐
c. for washing the car ☐Yes ☐No If yes, go to next question.

46. If your family has a car, where is it washed? (*Please tick the appropriate box)*

☐Carwash service ☐At home ☐other

How many times a week do you wash the car? *(Please write down the number)*

_______ times a week in a cold season _______ times a week in a warm season

47. Does your family have a washing machine?

☐Yes ☐No

If yes, what type of washing machine do you have? (*Please tick appropriate box)*

☐Twin Tub ☐Front Loader ☐Other

48. How many times does your family wash the clothes and beddings in a week? (*Please tick appropriate box)*

☐rarely ☐once a week ☐twice a week ☐triple a week

☐4 times a week ☐5 times a week ☐7 times a week ☐once a fortnight

49. Does your house/apartment have any shower? (*Please tick appropriate box)*

☐No *(Please go to next question)*☐Yes (*Please write the number of showers)*

How many times approximately does each person shower in a week? (*Please write the number of showers)*

	once	twice	triple	4 times	5 times	6 times	7times	more
In the warm season	☐	☐	☐	☐	☐	☐	☐	☐
In the cold season	☐	☐	☐	☐	☐	☐	☐	☐

On average, how long does each person spend in the shower? *(If different for individuals please write the number in appropriate boxes)*

☐Less than 5 minutes ☐5 – 10 minutes ☐10-15 minutes
☐15 – 20 minutes ☐25 – 30 minutes ☐More than 30 minutes

50. Does your house have a bathtub? (*Please tick appropriate box)*

☐Yes (what type of bath_________)☐No *(Please go to next question)*

If yes, how many times approximately does each person bathe in a week?*(Please tick appropriate box)*

	once	twice	triple	4 times	5 times	6 times	7times	more
In the warm season	☐	☐	☐	☐	☐	☐	☐	☐
In the cold season	☐	☐	☐	☐	☐	☐	☐	☐

51. Does your house have one or more dual flush toilet(s)? **(***Please tick appropriate box)* ☐Yes
☐No*(Please go to next question)*

52. Does your house have any leaking toilet?

☐Yes ☐No *(Please go to next question)*

If yes, how many toilets leak? ☐*(Please write the number of leaking toilets)*

Is it ☐ dripping or ☐ running

53. Does your house have any leaking taps? (*Please tick the appropriate box)*

☐Yes ☐No *(Please go to next question)*

If yes, how many taps leak? ☐ (*Please write the number of the taps in the box)*

Is it ☐ dripping or ☐ running

D. Knowledge for price of water

54. Do you know the price for water per litre and for hot water per person? *(Please tick an appropriate box)*

Cold water (per litre) ☐ 20 mungu ☐ 50mungu ☐ 1 tugrug ☐ 2 tugrug

Hot water (per person) ☐ 1000tug ☐ 1500tug ☐ 2000tug ☐ 2500tug

55. On average, how much does your family approximately pay monthly for following utilities costs?*(Please write approximate amount in Tugrug)*

a. Cold water cost tug **c.** For shower tug

d. Electricity tug **d.** Heating tug

56. How much did you pay this year compared to last year?

	The comparison with previous year's cost			
	More	**same**	**less**	**don't know**
Water	☐	☐	☐	☐
Hot water	☐	☐	☐	☐
Electricity	☐	☐	☐	☐
Heating	☐	☐	☐	☐
Other _____________	☐	☐	☐	☐

57. Do you and your family need any information on your water bill?

☐ Yes ☐ No ☐ do not know

If yes, please indicate what type of additional information about you would like to have included on your bill? ____

E. PRICE POLICIES

58. Please tell us whether you think your household would use more or less waterif the price of water, monthly income of your household, and increasing family member were to change? *(Please tick appropriate box* for each item*)*

	We would probably use				
	LESS WATER				**MORE WATER**
	Less than half of what we use now	Probably use a little less	No change	probably use a little more	more than twice as much as we use now
If water price increased twice the current price	☐	☐	☐	☐	☐
If water price increased by 50%	☐	☐	☐	☐	☐
If water price increased by 10%	☐	☐	☐	☐	☐
If water price decreased by 10%	☐	☐	☐	☐	☐
If water price decreased by 50%	☐	☐	☐	☐	☐
If water is free	☐	☐	☐	☐	☐
If your household's income increased by 100%	☐	☐	☐	☐	☐
If your household's income decreased by 50%	☐	☐	☐	☐	☐
If your household's member increased by one adult	☐	☐	☐	☐	☐

59. If the water price structure could be changed which structure would you prefer to pay? (*This question is only for apartment area's respondent. Please tick the your choice*)

☐ Uniform tariff ☐ IBT ☐ DBT ☐ Don't know

60. The following are some possible water pricing policy changes. Please indicate you preference to willingness to accept each policy:

	We would agree				
	Strongly agree	agree	undecided	disagree	Strongly disagree
When water is scarce, businesses should pay more for water than businesses	☐	☐	☐	☐	☐
When water is scarce, residents should pay a zoning price rather than current price.	☐	☐	☐	☐	☐
When water is scarce, businesses should pay a zoning price rather than current price.	☐	☐	☐	☐	☐
When water is scarce, residents should pay more according to seasonal effects.	☐	☐	☐	☐	☐
When water is scarce, businesses should pay more according to seasonal effects.	☐	☐	☐	☐	☐
Water price should be correlated with annual income of households and businesses	☐	☐	☐	☐	☐
Other ______________________	☐	☐	☐	☐	☐

F. WATER SAVING HABITS AND NON PRICE POLICIES

61. Do you and your family members have any of the following water saving habits:

	We do				
	Always	Usually	About half the time	seldom	never
Encouraging children turning taps off	☐	☐	☐	☐	☐
Using a stored water in a sink for washing dishes	☐	☐	☐	☐	☐
Not rinsing dishes after washing	☐	☐	☐	☐	☐
turning tap off while soaping hands	☐	☐	☐	☐	☐
Use a cup of water for brushing teeth	☐	☐	☐	☐	☐
Check taps are turned off	☐	☐	☐	☐	☐
Fix dripping/leaking taps	☐	☐	☐	☐	☐
Reducing water level of washing machine	☐	☐	☐	☐	☐
Turn shower off while soaping up	☐	☐	☐	☐	☐
Have short showers	☐	☐	☐	☐	☐
Others_________________________	☐	☐	☐	☐	☐

62. Imagine the Ulaanbaatar government had more money to spend on water infrastructure (e g donor organisation), which improvements do you think are most important?*(Please tick appropriate box each row)*

	Very important	Important	Moderately important	Of little importance	Unimportant
Efficient and safety water delivery systems or pipes	☐	☐	☐	☐	☐
Install sub water meters in the apartment households	☐	☐	☐	☐	☐
Fix leaking taps and toilets of apartment households	☐	☐	☐	☐	☐
Fix leaking water using equipments of business users	☐	☐	☐	☐	☐
Installing low flow toilet/s to the apartment households	☐	☐	☐	☐	☐
Water efficient technologies to the business users	☐	☐	☐	☐	☐
Free water audit for business users	☐	☐	☐	☐	☐
Improve water conservation knowledge; encourage households and business to reduce their consumption	☐	☐	☐	☐	☐
Protect the Tuul River Basin	☐	☐	☐	☐	☐
Ger areas households are connected with sewerage systems	☐	☐	☐	☐	☐
Construct water reuse plant	☐	☐	☐	☐	☐
Construct dams	☐	☐	☐	☐	☐
Others______________________________________ _	☐	☐	☐	☐	☐

63. Have you and any of your family members had any illness which you think was due to contamination or quality of water? (*Please tick appropriate box)*

☐ Yes ☐ no ☐ perhaps ☐ don't know

G. GENERAL INFORMATION

Finally, we would like to know a little bit more about your household information. This will be kept strictly confidential and is used to ensure that we have collected information from a wide variety of households.

64. What is the highest level of education from your household members has achieved? (*Please tick appropriate box)*

☐ Primary ☐ High school ☐ University
☐ Technical training school ☐ No formal education ☐ Other ***(please specify)*** ____________________

65. Can you please indicate current status of your family members by following categories? Please indicate by numbers how many of the people who live in this house (including yourself) are; (*Please fill a number beside each category. For example, if two people in the house are employed, write the number "2" next to the word Employed.)*

_____Retired _____Unemployed _____Student
_____Employed _____ seeking job _____Healthcare appointee

66. How many of the people who live in this house do work in the following economic sectors? ***(Please fill a number beside each category)***

_____ Hospitality industry
_____Communication Services
_____Educational Services
_____Government administration & Defence
_____Manufacturers
_____Personal & Other Services
_____Retail & Wholesale shops/stores
_____International organisation activities
_____ Agriculture, hunting, fishery industry
_____Construction
_____Finance
_____Electricity, gas production and Water Suppliers
_____Health & Community Services
_____Mining & Related Services
_____Rental, ppropery and business services
_____Transport, Travel & Storage

67. What is the total, combined, monthly (taxable) income of your family? *(Please tick appropriate box)*

☐< 100,000 Tugrug ☐200,000-400,000 Tugrug
☐400,000-500,000 Tugrug ☐600,000-800,000 Tugrug
☐800,000-1,000,000 Tugrug ☐1,100,000-$1,400,000 Tugrug ☐1,500,00

Thank you for your cooperation and support

APPENDIX A-3: QUESTIONNAIRE FOR NON-RESIDENTIAL USERS

Questionnaire for business consumers

Water scarcity is one of Ulaanbaatar's most pressing issues. Using water demand side policies, this study will identify changes in attitudes towards water usage and usage behaviour of Ulaanbaatar's industries. This survey will be a joint undertaking by JCU and the Governor's office of

Ulaanbaatar, and your responses will remain confidential, utilised for the purpose of this project only. The result of the survey will provide information that can be used to develop appropriate options to postpone water scarcity. Further, results will be published in international academic journals for to the promotion of international cooperation between organizations and to support information for local government and researchers. If you need additional information about the study, please feel free to contact Zula by email at the following address: zulgerel.altai1@my.jcu.edu.au.

A. Basic information

1. Where is your company located? (*please write the district name*) ______________

2. What type of company is it? (*please tick appropriate box*)

☐	Government	☐	Industries	☐	Other

3. From the list below, please select the economic sector your company represents? (*please tick appropriate box*)

_____ Hospitality industry
_____ Agriculture, hunting, fishery industry
_____Communication Services
_____Construction
_____Cultural & Recreational Services
_____Finance
_____Educational Services
_____Electricity, gas production and Water Suppliers
_____Government administration & Defence
_____Health & Community Services
_____Manufacturers
_____Mining & Related Services
_____Personal & Other Services
_____Rental, property and business services
_____Retail & Wholesale shops/stores
_____Transport, Travel & Storage
_____International organisation activities
_____Other

B**. water resource, treatment, infrastructure and equipment**

3. Where does your company obtain most of water from the following resources? (*please tick the appropriate box*)

☐Water infrastructure ☐Water kiosk is connected to water network
☐Protected well ☐Water kiosk is not connected to water network
☐ Self source supplement ☐Water by the water truck

4. Could you describe your company's water equipment capacity? *(Please tick the appropriate box and indicate the number of years in the space provided)*

a. Does your company have its own well? ☐Yes ☐ No ☐do not know *(please go to b)*

If yes, when was the well installed? ____ (year, eg. 1992)

How much longer can it be used? ____year/s

Is the well needed the improvement? ☐ Yes ☐ no ☐do not know

b. Does your company have own water pipe system? ☐Yes ☐ No ☐do not know (please go to c)

If yes, when was the pipe system installed? ____ (year, eg.1992)

How long is the water pipe system of your company? _____ km/s

c. Does your company have its own sewerage system? ☐Yes ☐ No ☐do not know (go to d)

If yes, when was the sewerage system installed? ____ (year, eg. 1999)

How long is the sewerage pipe system of your company? _____ km

5. If your company extracts its own water, which is the primary source?
   a. Where from? *(please tick as many as apply)*

☐ Groundwater well ☐ Surface water ☐ other ______

   b. Does your company reuse or recycle used water? (*please tick the appropriate box as many as apply*)

☐ reuse _____ ☐ recycle ______ ☐ other ______

   c. If your company reuses water, does it achieve acceptable water quality standards?

☐ Drink water standard ☐ water standard for industry ☐ do not know

6. What is the capacity of self -supply water system of your company? (*Please use numbers*)
______ Hourly capacity of the equipment _____ approximate daily usage hours ☐ do not know

7. By which company of waste water of your company is treated? *(Please tick as many as needed)*

☐ USUG ☐ self -treated ☐ both ☐ other _________________________

8. If self-treated, would you please provide the following information?
   a. What is the treatment plant capacity? _______________
   b. Is the treatment plant used only by your company?

☐ yes ☐ no (if no, please complete the following questions)

(*Please use numbers in the boxes below*)

☐ how many other companies use your treat ment plant?

☐ what is the annual amount of waste water treated?

C. water usage

9. Utilising company data from 2010, please provide the annual amount of your company's supplied water (approximates only) per the water usage categories below (*Please tick the appropriate box in each row*)

Type of water usages by KL	< 100	101<1000	1001~5000	5001~10000	10001<
Production process					
Cooling					
Production process					
Steaming					
Other miscellaneous usage					
Water lose					
Total water usage					

10. Does your company have any water meter?

☐ **yes we do. If yes, please tell us where the water meter/s is/are located.**

☐ universal water meter on main water pipe
☐ on each production system
☐ only on the office water system
☐ on the water recycling line
☐ on the treated sewerage pipe
☐ on the main sewerage pipe

☐ **no** ☐ **do not know**

11. Does your company obtain enough information on the water bill to allow you to make informed decisions about future water usage?

☐ Yes ☐ No ☐ do not know

If no, please indicate what type of additional information would be useful to have included on your bill, and please indicate the level of usefulness *(Please tick the appropriate box of each row)*

	My company does				
Appropriate additional information on the water bill	Very useful	useful	No opinion	Less useful	useless
Water price	☐	☐	☐	☐	☐
Amount of water	☐	☐	☐	☐	☐
Comparison of water usages between months and years	☐	☐	☐	☐	☐
Water price calculation	☐	☐	☐	☐	☐
Water quality	☐	☐	☐	☐	☐
Information on Ulaanbaatar city's current water resource	☐	☐	☐	☐	☐
Information about water saving technology and behaviours	☐	☐	☐	☐	☐
Other ____________________________	☐	☐	☐	☐	☐

D. water price and water fee

12. Do you know per kl price and overall water fee of your company? *(Please tick the appropriate box)*

<u>Water price (per KL)</u>

☐300 tug ☐500 tug ☐550 tug ☐600tug ☐1000tug ☐don't know or ☐ ______tug

<u>Water fee (per KL)</u>

☐30 tug ☐50 tug ☐55 tug ☐60tug ☐100tug ☐don't know or ☐ _______tug

E. Water saving techniques

13. Does your company use any of the following techniques?

	My company does				
	Always	Usually	About half the time	seldom	never
Using water efficient equipment for all production processes	☐	☐	☐	☐	☐
Having regular water audits for water and sewerage systems	☐	☐	☐	☐	☐
Fixing leaking equipment and pipes as per industry requirement	☐	☐	☐	☐	☐
Regular checks for tap and toilet leakages	☐	☐	☐	☐	☐
Reusing water	☐	☐	☐	☐	☐
Treating reused water as per the standard	☐	☐	☐	☐	☐
Reducing amount of sewerage water	☐	☐	☐	☐	☐
Reducing water less through leaking	☐	☐	☐	☐	☐
Other water reducing techniques ____________________	☐	☐	☐	☐	☐

F. **Water price policies**

14. Would your business use more or less waterif the price of water were to change?*(Please tick appropriate box for each scenario)*

	We would probably use

	LESS WATER				MORE WATER
	Half as much as we use now	a little less	No change	a little more	twice as much as we use now
If water price decreased by 10%	☐	☐	☐	☐	☐
If water price decreased by 50%	☐	☐	☐	☐	☐
If water is free	☐	☐	☐	☐	☐
If water price increased by 10%	☐	☐	☐	☐	☐
If water price increased by 50%	☐	☐	☐	☐	☐
If water price increased twice the current price	☐	☐	☐	☐	☐
If your business's income doubled	☐	☐	☐	☐	☐
If your business's income decreased by 50%	☐	☐	☐	☐	☐
If VAT decreased by 10%	☐	☐	☐	☐	☐
If VAT decreased by 10%	☐	☐	☐	☐	☐
If the number of employee increased by a single person	☐	☐	☐	☐	☐

15. The following are some possible water pricing policy changes. Please indicate your willingness to accept each policy: *(Please tick appropriate box for each policy)*

	We would agree				
	Strongly agree	agree	undecided	disagree	Strongly disagree
When water is scarce, residents should pay more for water than businesses	☐	☐	☐	☐	☐
When water is scarce, residents should pay a zoning price rather than current price.	☐	☐	☐	☐	☐
When water is scarce, businesses should pay a zoning price rather than current price.	☐	☐	☐	☐	☐
When water is scarce, residents should pay more according to seasonal effects.	☐	☐	☐	☐	☐
When water is scarce, businesses should pay more according to seasonal effects.	☐	☐	☐	☐	☐
Water price should be correlated with company's annual income	☐	☐	☐	☐	☐
Other ______________________	☐	☐	☐	☐	☐

16. If the water price structure could be changed, which payment structure would you prefer? (*please tick the appropriate box*)

☐ Uniform tariff ☐ IBT ☐ DBT ☐ Do not care ☐ Do not know

H. Non price policies

17. Imagine the Ulaanbaatar government had more money to spend on water infrastructure (e g donor organisation), which improvements do you think are most important? (*Please tick appropriate box in each row)*

	Very important	Important	Moderately important	Of little importance	Unimportant
Better and safe water delivery systems	☐	☐	☐	☐	☐

Connect the water kiosks to water systems	☐	☐	☐	☐	☐
Installing sub water metering to households	☐	☐	☐	☐	☐
Fix leaking taps and toilets of households	☐	☐	☐	☐	☐
Fix leaking water using equipments of businesses	☐	☐	☐	☐	☐
Installing low flow toilet/s to households	☐	☐	☐	☐	☐
Installing water efficient equipment	☐	☐	☐	☐	☐
Free water audit for businesses	☐	☐	☐	☐	☐
Information and education campaign	☐	☐	☐	☐	☐
Protect the Tuul River Basin	☐	☐	☐	☐	☐
Ger areas connect to sewerage systems	☐	☐	☐	☐	☐
Building a recycling plant	☐	☐	☐	☐	☐
Building a dam	☐	☐	☐	☐	☐
Others_______________________________ _	☐	☐	☐	☐	☐

18. Has your company experienced any technology difficulties as a result of poor water quality?

☐ yes ☐ no ☐ maybe ☐ do not

19. How many permanent staff does your company employ?

☐ 0-9 ☐ 10-19 ☐ 20-29 ☐ 30-39 ☐ 40-49

☐ 50-99 ☐ 100-199 ☐ 200-499 ☐ 500-999 ☐ 1000-more

20. In last 2 years, how much is the company's annual approximately income/revenue in million tugrugs?

☐ 0-4 ☐ 5-9 ☐ 10-19 ☐ 20-49

☐ 50-499 ☐ 500-4999 ☐ 5000-9999 ☐ 10000- more

Thank you for your cooperation

APPENDIX B: DATA COLLECTION

APPENDIX B-1 INFORMATION SHEET

Urban water demand management in Ulaanbaatar, Mongolia

The study is being conducted by a PhD student, **Zulgerel Altai,** under supervision of A/Prof. Natalie Stoeckl and A/Prof. David King of the School of Business, James Cook University, Townsville, Australia and also under the Mongolian supervision of professor T. Dorj of the Facility of Economic and Management of the Humanity University of Mongolia and A/Prof B. Bayamba of the Mongolian National Development Institute, Ulaanbaatar, Mongolia. The study will provide some policy and management practices for the resolution of water scarcity, one of Ulaanbaatar's most pressing issues.

You are invited to take part in this study in order to offer a possible solution to the water scarcity of Ulaanbaatar, Mongolia. This information should give people a better understanding of the way to reduce water consumption and will help people answer questions such as: What kind of personal contribution can be made to help to enhance the water availability in Ulaanbaatar? **With an increase in price, how would your family vary your water use?**

To do this, we need some information about the water consumption and control of water usage of Ulaanbaatar households. We don't need detailed water usage information – we just need to know (roughly) how can households reduce/increase their water usage and what kind of policy do households expect from the government, in particular through price or non price policies to counter the water scarcity issue. Your contribution will help to influence the government's updating of the water policy.

The interview should not take more than 20 - 30 minutes. We (I or other assistants) will ask respondents a series of questions, and record their answers. Before the interview, we will provide information highlighting Ulaanbaatar's water issues, explaining the project and detailing respondents' contributions through their voluntary participation.

We plan to collect this information through a face to face interview, and hope that you will agree to participate. This weekend, members of the research team will visit you. If you agree to help a day and time that is convenient for you (or one of your 'nominees') to answer the questions will be arranged.

Data obtained in this survey will be treated as strictly confidential. No information will be attributed to any single household, and results will be released in data form only. Responses to the survey will be stored separately from the names and addresses of individuals, so that no link can be made between the Government and you. The data from the study will be used in research publications. You will not be identified in any way in these publications.

You need to read this Information Sheet carefully, If, you agree to participate in this survey, please answer each question on the questionnaire.

It would be much appreciated if you could accept this invitation to participate in this study. If you have any questions about this study, please contact Ms Zulgerel Altai, Prof.T Dorj, A/Prof. B Bayamba, and/or A/Prof Natalie Stoeckl, A/Prof David King.

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APPENDIX B-2: SELECTED KHOROOS INFORMATION AND RESEARCH ASSISTANTS

Information about selected khoroos and name of research assistants

Districts	# Khoroo	# HH	# population	apartment HH's %	Ger HH's %	Data 2010	Data 2011	Name of the Governor
Bayangol	1	3030	12636	99%	1%	25	20	N.Monkhtungalag
	6	3452	12701	100%		25	20	P.Erdenebaatar
	9	3368	12878	22%	78%	20		T.Monhkzaya
Bayanzurkh	2	3504	14700	0%	100%	20		S. Davaakhuu
	16	3115	14152	100%		24	20	B. Munhkbayar
	22	3154	12896	11,28	88,72%	21	20	U. Davaajav
	23	3430	13674		100%	20		Ts.Oyuun
Songino - Khairkhan	1	3177	13165		100%	20		B. Narantuya
	3	2867	13547		100%	20		G.Tserendulam
	14	2740	9680	63%	37%	22	22	H.Erdenetuya
	17	1742	6777	85%	15%	21		G. Ludenma
	18	2451	10616	100%	0%	25	21	D. Enkhjargal
Sukhbaatar	1	1190	4297	100%	0%	25	20	L.Zagdsuren
	7	2388	7797	100%		25	20	G. Ulziiburen
	8	2750	11040	100%	0%	24	21	P.Javzmaa
	9	2500	9459	0%	100%	20		N. Gantsatasral
	11	2090	10047	0%	100%	19		Ch.Khandsuren
Chingeltei	3	1223	4822	100%		24		Ch.Chimedtsogzol
	4	1257	5292	100%		25		A.Tangad
	6	1480	5935	100%		23		G. Bolormaa
	12	2707	12524		100%	20		Ch.Oyuuntseteg
	17	2816	11614		100%	20		B.Sarangoo
Khan Uul	1	3525	11954	100%		25	20	R.Ganbold
	3	2176	8634	97%	3%	23	21	D. Purevsuren
	4	1839	6900	3%	97%	20		Yo.Tsatsraltuya
	9	4040	13680		100%	20		T.Otgonbayar
Students of HUM						22		

#- number

HH- household

APPENDIX B-3: INTERVIEWED PEOPLE

List of interviewed people

	name	position
1	L. Gansukh	Minister of Nature, Environment, and Tourism
2	Kh. Battulga	Minister of Road, Transportation, Infrastructure and Urban Development
3	T. Badamjunai	Minister of Food, Agriculture and Light Industry
4	G. Munkhbayar	Mayor of Ulaanbaatar city
5	B. Munkhbaatar	Deputy mayor of Ulaanbaatar city
6	D. Dorjsuren	Secretary General of National Water Committee, Mongolia
7	G. Myagmar	Director of Construction Housing and Public Utilities Policy Department of Ministry of Road, Transportation, Infrastructure and Urban Development
8	Z. Batbayar	Head of Water Agency of Ministry of Nature, Environment, and Tourism
9	Ya. Ariunzul	Head of Monitoring and Evaluation department of General Agency for Specialized Inspection of Mongolia
10	Yu. Delgermaa	Head of Agency of Environment Conservation of Ulaanbaatar
11	T. Bilegt	Head of City Council of Ulaanbaatar city, Mongolia
12	B. Purevjav	Head of Water Supply and Sewerage Authority of Ulaanbaatar
13	L. Lkhamaasuren	Head of Department of Planning, Finance and Economics, Water Supply and Sewerage Authority of Ulaanbaatar
14	B. Oyun	Project coordinator, Water Supply and Sewerage Authority of Ulaanbaatar
15	T. Tuya	Head of Department of Customers service, Water Supply and Sewerage Authority of Ulaanbaatar
16	B. Ariunbold	Head of the Democratic Party fraction of City Council of Ulaanbaatar city
17	T. Enkhtuvshin	Head of National Agency for Meteorology and Environment Monitoring
18	N. Battur	Officer of National Agency for Meteorology and Environment Monitoring
19	S. Demberel	Head of Mongolian National Chamber of Commerce and Industry
20	S. Chuluunhuyag	Professor of/Head of Department Environment Engineering, School of Civil Engineering, Mongolian University of Science & Technology.

21	D. Basandorj	Professor, Director of Integrated Water Management Training Centre, Mongolian University of Science & Technology.
22	L. Janchivdorj	Head of Water sector of Institute of Geoecology, Mongolian Academy of Sciences.
23	D. Odontsetseg	Researcher of Water sector of Institute of Geoecology, Mongolian Academy of Sciences.
24	L. Badamkhorloo	Director of "Ulaanbaatar service improvement-II" project management team unit
25	G. Otgonbayar	National project manager of Water and Sanitation Project, UNDP
26	G. Dolgorsuren	Project General Coordinator "Strengthening Integrated Water Resources Management in Mongolia" project
27	P. Batima	National Coordinator of "Strengthening Integrated Water Resources Management in Mongolia" project
28	J. Gerelchuluun	Economist of "Strengthening Integrated Water Resources Management in Mongolia" project
29	B. Bunchingiv	Rural Development Specialist, UNDP in Mongolia

APPENDIX C: RERERACH METHODOLOGY

APPENDIX C-1: SENSITIVITY ANALYSIS OF HYPOTHETICAL WATER USAGE CHANGES OF BUSINESS USERS

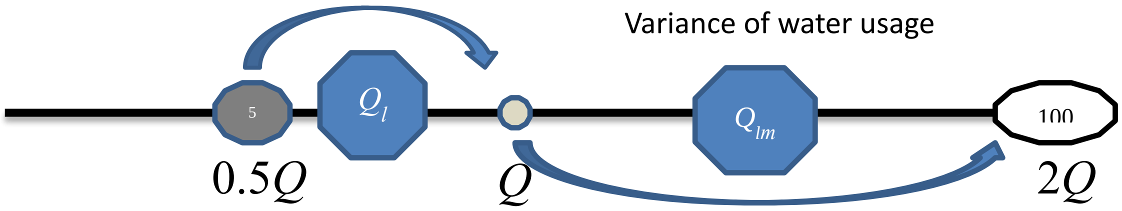
The consideration of changes in price and demand is policy relevant but historically unobservable for the water users of Ulaanbaatar. The panel data is figured out by pooling the hypothetical and stated (respondent indicated) data to augment the information on estimation of demand of purchased water. The hypothetical data can be determined by interpretation of 5 prospective changes of water usage (see Table: The Question). It is reasonable to expect that contingent scenario that we pose will appeal plausible (and easier to predict their variance of usage) to respondents.

Table: The Question

	We would probably use				
	LESS WATER				**MORE WATER**
	twice as less as we use now	Probably use a little less	No change	probably use a little more	twice as much as we use now
If water price decreased by 10%	☐	☐	☐	☐	☐
If water price decreased by 50%	☐	☐	☐	☐	☐

CB data problem might be that recommended/offered data sets lack sufficient variation in demand; therefore we used the sensitivity analysis to increases quantification of changes percentage of hypothetical consumption. The question is asked if the price increase in certain percentage how would your water consumption change, the respondents indicate their changes from twice as less as we use now (Q_{lh}), probably use a little less (Q_{ll}), no change (Q), probably use a little more (Q_{lm}), twice (Q_l). The no change (Q) can beequal the current usage of a respondent. Twice as less as we use now, which is equal 50% of the current usage (0.5Q), and twice as much as we use of now, which is equal 200% of current usage (2Q), are obviously and creditable figured out (see Figure 53Changes of water consumption).

FIGURE 53CHANGES OF WATER CONSUMPTION



An assumption, scenario A, could be that the little more and the little less plausibly can be symmetrically equal presented. Table2: Frequency Percentages of responses of water usage changes in price policies shows percentages of responses of water usage changes in price policies. The respondents indicate their usages differently: 26.5% of the respondents indicate their water usage would be decreased the price increases by 10%, but 16.9% of respondents indicate their water usage would be increased the price decreased by 10%. Thus we can result that the symmetric price changes do not affect asymmetrically usage changes, moreover the little less and the little more are not represented asymmetrical.

Table2: Frequency Percentages of responses of water usage changes in price policies

	0.5Q	Q_{ll}	*Q*	Q_{lm}	*2Q*
1.1P	5.0%	26.5%	66.3%	1.9%	0.3%
1.5P	14.6%	46.7%	35.6%	1.9%	1.1%
2P	29.8%	35.6%	30.9%	3.0%	0.6%
0.9P	3.9%	5.2%	71.5%	16.9%	2.5%
0.5P	3.9%	7.2%	48.3%	31.2%	9.4%
No P	2.8%	5.0%	41.4%	21.3%	29.6%

If the little less and the little more are not asymmetric, the little less can be represented Q_{ll} by between *0.5Q* and *Q* and the little more Q_{lm} between *Q* and *2Q*. Scenario B, 'obvious solution' is to conduct sensitivity analysis using ranges:

Table 3: Scenarios

	twice as less as we use now	Probably use a little less	No change	probably use a little more	twice as much as we use now
Most inelastic scenario	*0.5Q*	*Q*	*Q*	*Q*	*2Q*
Possible elasticities range	*0.5Q*	*0.5Q to Q*	*Q*	*Q to 2Q*	*2Q*
Most elastic scenario	*0.5Q*	*0.5Q*	*Q*	*2Q*	*2Q*

- Scenario 1 – the little less Q_{ll} might be set close to Q 'the current water use', which is almost equal to Q_{ll} and no or very small change differences between 'no change' and 'the little less'. In this case the extreme is to set $Q_{ll} = Q$, the price elasticity is able to be the most inelastic on water demand.
- Scenario 2 – the little less Q_{ll} might be set 0.9Q
- Scenario 3 – the little less Q_{ll} might be set 0.75Q
- Scenario 4 – the little less Q_{ll} might be set 0.6Q
- Scenario 5 – the little less Q_{ll} might be set close to 0.5Q, no or very small difference between 'the twice as less as current water use' and 'the little less', but there can be a very large difference between 'the little less' and 'no change' In this case the extreme is to set Q_{ll} = 0.5Q, the price elasticity is able to be the most elastic on water demand.

The plausible range of elasticities might be estimated by scenario 3, scenario 4, and scenario 5.

In the literature, most price policies are considered for identifying attitudes of the consumers' water usage behaviour to increase rate and change its structure. So in the study area, the government or the municipality might be consider attitudes of increasing price policies to business users, then only 2 CB questions, increasing prices by 10% (1.1P) and 50% (1.5P), are conducted sensitivity analysis. Reasons are that the response 'the little more' is avoided and the less observations (2.2% to 3.6% of the total business responses) are out off the data.

Each scenario is panelised by selected price policies. The data of explanatory variables are converted into natural logarithm.

$$lnQ_{jk} = \beta_1 + \beta_2 lnMP_{jk} + \beta_3 lnY_{jk} + \beta_4 lnEmp_{jk} + \beta_5 lnWshr_{jk} + \beta_6 P_{knowjk} + \beta_7 B_{reformjk} + \varepsilon_{jk}$$

$_k$– kth scenario

Table 4: Price elasticties and its bounder

CB scenarios	PeD	bounder	
Scenario 2 (0.6Q)	-0.79	-1.148	-0.432
Scenario 3 (0.75Q)	-0.545	-0.896	-0.192
Scenario 4 (0.9Q)	-0.341	-0.691	0.008

Table 4: Price elasticties and its bounder presents the results of CB scenarios, the price elasticities of water demand with the scenarios are unlikeness the scenarios and explicitly inelastic, in addition, the price elasticities of the scenario 4 (-.34) and the scenario 2 (-.79) vary almost doubled price elasticity. The selected scenarios can plausibly represent Q_{ll} 'the little less of current water use', while the bounder of the price elasticity is between -1.148 (the most elastic) and 0.008 (the most inelastic).

APPENDIX D: MODELLING NON-RESIDNETIAL WATER DEMAND

APPENDIX D-1: A SUMMARY OF VARIABLES OF NON-RESIDENTIAL WATER DEMAND ESTIMATION

Variable	Unit	Function	Country	Studies	Year
Q/OUT	Output	Cost function	USA	Grebenstein C, & Field, B	1979
	Output	Translog cost function	USA	Babin, F & Willis, C	1982
	Output	Translog cost function	British Columbia	Renzetti, S	1988
	Income per capita	GLS	Columbus, USA	Schneider, M & Whitlacth, E	1991
	Production (dollar value of output or size	Translog cost function	California, USA	Hanemann, M	1993

	of labour force)				
	Firm's level of output	Translog cost and subcost function (3SLS)	Canada	Dupont, D & Renzetti, S	1998
	Output - number of employees	GLS & OLS	Hawaii, USA	Malla, P & Gopalakrishman, G	1999
	Value added per production employee	Translog cost function	Kenyan	Onjala, J	2001
	Output/sales	Linear and log-log OLS	Sri Lanka	Hussain, I & Barker, R	2002
	Measure of production and pollution emissions	Translog cost function SUR and FGLS	France	Reynuad, A	2003
	Annual production value	Cost function SUR	Brazil	Feres, A & Reynaud, A	2005
	The level of output (regional gross added value)	Production function (with dynamic panel data)	Zaragoza, Spain	Arbues, F & Valicas, G	2010
	Production of output	Cobb-Douglas demand function	Korean, Manufactu ring industry	Ku, S & Yoo, S	2012
	Intermediate input	Cobb-Douglas demand function	Korean, Manufactu ring industry	Ku, S & Yoo, S	2012
Q/W	Water for cooling, Processing, Steam generation and sanitation	Cost function OLS	USA	De Rooy, J	1974
	Water	Cost function	USA	Grebenstein C, & Field, B	1979
	Intake water	Cost function	Arkansas, USA	Ziegler, J & Bell, S	1984
	Intake, Treatment, Recirculation Discharge quantities	Translog cost function	British Columbia	Renzetti, S	1988 (industrial) 1992 (manufacturin g)
	Annual average consumption	GLS	Columbus & Ohio, USA	Schneider, M & Whitlacth, E	1990
	Water intake in an establishment	Translog cost function	California, USA	Hanemann, M	1993
	Intake, Treatment, Recirculation	Translog cost and subcost function	Canada	Dupont, D & Renzetti, S	1998

	Discharge quantities	(3SLS)			
	Gross water consumed	Translog cost function	Kenyan	Onjala, J	2001
	Unit	**Function**	**Country**	**Studies**	**Year**
	Monthly average consumption	Linear and log-log OLS	Sri Lanka	Hussain, I & Barker, R	2002
	Water	Cost function SUR (seemingly unrelated regression)	Brazil	Feres, A & Reynaud, A	2005
	Daily intake water use	Cost function	Northern Taiwan	Chan	2006
	Quantity of water consumed	Cobb-Douglas demand function	Sri Lanka	Dharmaratna & Parasnis	2010
	Daily water consumption	Koyck flow adjustment demand model (with dynamic panel data)	Zaragoza, Spain	Arbues, F & Valicas, G	2010
P	Price average cost of intake water	Cost function	Arkansas, USA	Ziegler, J & Bell, S	1984
	lnP - intake price, price of water treatment prior to use, price of recirculation, price of water treatment prior to discharge	Translog cost function	British Columbia	Renzetti, S	1988
	Marginal price	GLS	Columbus, USA	Schneider, M & Whitlacth, E	1991
	Prices of water intake, water treatment prior to use, water discharge,	Translog cost and subcost function (3SLS)	Canada	Dupont, D & Renzetti, S	1998 2001 (
	Price (tariff)	Translog cost function	Kenyan	Onjala, J	2001
	Price of industrial water	Linear and log-log OLS	Sri Lanka	Hussain, I & Barker, R	2002
	Price of water	Linear OLS	Hawaii, USA	Cox, L , J & and Gopalakrishnan, C	2003 (visitor industry)
	Marginal price	Cost function Random effects model	Western USA	Moeltner, K & Stoddard, S	2004
	Shadow price Average price	Cost and input distance function	India	Kumar, S	2004
	Average price	Cost function	Northern Taiwan	Chan	2006
	Shin price (perceived price)	Koyck flow adjustment demand model (with	Zaragoza, Spain	Arbues, F & Valicas, G	2010

		dynamic panel data)			
	Average price of water	Cobb-Douglas demand function	Sri Lanka	Dharmaratna & Parasnis	2010
W/L/E	Employment	Cost function OLS	USA	De Rooy, J	1974
	Labour	Translog cost function	USA	Grebenstein C, & Field, B	1979
	Production and non production employees	Translog cost function	USA	Babin, F & Willis, C	1982
	Labour (average number of daily employees & of man hours)	Linear prediction function OLS	USA	Kim, J & McCuen, R	1979
	Number of employees in the establishment (output)	Translog cost function	California, USA	Hanemann, M	1993
	Number of employees	Linear and log-log OLS	Sri Lanka	Hussain, I & Barker, R	2002
	Labour cost	Translog cost function SUR and FGLS	France	Reynuad, A	2003
	Number of employees	Cost function SUR	Brazil	Feres, A & Reynaud, A	2005
	Number of workers	Production function (with dynamic panel data)	Zaragoza, Spain	Arbues, F & Valicas, G	2010
	Unit	**Function**	**Country**	**Studies**	**Year**
	Labour	Cobb-Douglas demand function	Korean, Manufacturing industry	Ku, S & Yoo, S	2012
K/Age	Technology	Cost function OLS	USA	De Rooy, J	1974
	Capital	Cost function	USA	Grebenstein C, & Field, B	1979
	Number of drinking fountains	Linear prediction function OLS	USA	Kim, J & McCuen, R	1979
	The gross area, sales area, length shop	Linear prediction function OLS	USA	Kim, J & McCuen, R	1979
	Capital service	Translog cost function	USA	Babin, F & Willis, C	1982
	Average age of plant and equipment	Cost function	Arkansas, USA	Ziegler, J & Bell, S	1984
	Units in the hotels	Linear OLS	Hawaii, USA	Cox, L , J & and Gopalakrishnan, C	2003 (visitor industry)

	Capital assets age	Cost function Random effects model	Western USA	Moeltner, K & Stoddard, S	2004
	Area - Size of golf courses in acre	Linear OLS	Hawaii, USA	Cox, L , J & and Gopalakrishnan, C	2003 (visitor industry)
	Capital	Cost function SUR	Brazil	Feres, A & Reynaud, A	2005
	Surface area if business premises (m^2)	Production function (with dynamic panel data)	Zaragoza, Spain	Arbues, F & Valicas, G	2010
	Capital	Cobb-Douglas demand function	Korean,	Ku, S & Yoo, S	2012
TC/MC/ Cnet/Ca uto	Total cost	Translog cost function	USA	Babin, F & Willis, C	1982
	Marginal cost	Cost function	Arkansas, USA	Ziegler, J & Bell, S	1984
	Cost of network water Cost of autonomous water	Translog cost function SUR and FGLS	France	Reynuad, A	2003
	Daily water intake cost	Cost function	Northern Taiwan	Chan	2006
	Total cost	Cost function	Northern Taiwan	Chan	2006
E	Energy	Cost function	USA	Grebenstein C, & Field, B	1979
	Energy ($ by 1000000Kcal)	Cost function SUR	Brazil	Feres, A & Reynaud, A	2005
M	Material ($ by unit of material index)	Cost function SUR	Brazil	Feres, A & Reynaud, A	2005
N	Number of industrial connection	Cobb-Douglas demand function	Sri Lanka	Dharmaratna & Parasnis	2010
	Number of industrial and commercial connection	Linear and log-log OLS	Sri Lanka	Hussain, I & Barker, R	2002
Tem	Average monthly temperature	Linear and log-log OLS	Sri Lanka	Hussain, I & Barker, R	2002
	Climate – seasonality index	Cost function Random effects model	Western USA	Moeltner, K & Stoddard, S	2004
	Average monthly temperature	Cobb-Douglas demand function	Sri Lanka	Dharmaratna & Parasnis	2010
RF	Average monthly rainfall	Linear and log-log OLS	Sri Lanka	Hussain, I & Barker, R	2002
	Annual rainfall	Linear OLS	Hawaii, USA	Cox, L , J & and Gopalakrishnan, C	2003 (visitor industry)
	Average monthly	Cobb-Douglas demand	Sri Lanka	Dharmaratna & Parasnis	2010

	rainfall	function			

Aggregate data estimation mostly used temperature, number of connection with public supply network, rainfall

APPENDIX C-2: NON-RESIDENTIAL WATER DEMAND ESTIMATION USING DIFFERENT TECHNIQUES IN DIFFERENCE SCENARIOS (EFFECT BASED ON CB)

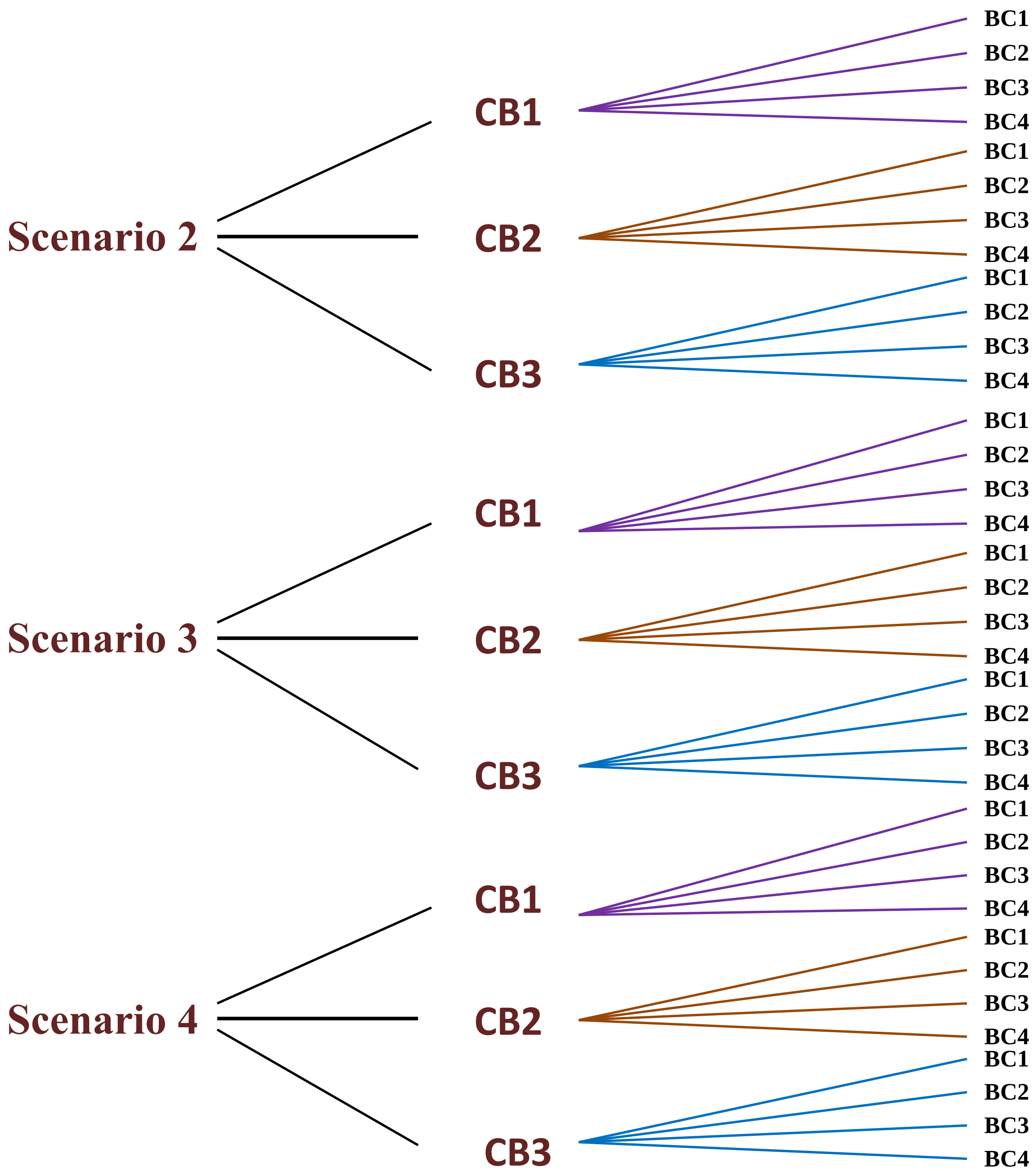
		Variables	Fixed effects (OLS)			random effects (GEE&PA)			Hausman test	random effects (GLS)			Hausman test
			coefficient	Std.	p value	coefficient	Std.	p value		coefficient	Std.	p value	
CB variant factors	Scenario 2	constant	8.103	0.154	0	8.104	0.159	0		8.112	0.155	0	
		lny	-0.015	0.011	0.189	-0.015	0.011	0.185		-0.015	0.011	0.182	
		lne	0.276	0.024	0.244	0.027	0.024	0.246		0.027	0.024	0.258	
		lnwshr	0.041	0.088	0.639	0.039	0.087	0.645		0.035	0.088	0.691	
		Pknow	0.34	0.088	0	0.34	0.087	0		0.339	0.088	0	
		Breform	-0.016	0.07	0.815	-0.015	0.07	0.828		-0.013	0.071	0.857	
		R square	0.029			0.8572				0.3207			
		Adj R2	0.021										
		F statistic	3.61										
		F test	4.002										
		Wald (chi)				18.19			0.19	18.01			-1.43
		Prob>chi2				0.003			0.9992	0.003			
	Scenario 3	constant	8.067	0.154	0	8.067	0.164	0		8.081	0.155	0	
		lny	-0.015	0.011	0.2	-0.015	0.011	0.196		-0.015	0.011	0.191	
		lne	0.028	0.023	0.234	0.028	0.024	0.236		0.027	0.024	0.255	
		lnwshr	0.028	0.88	0.748	0.026	0.088	0.762		0.019	0.088	0.828	
		Pknow	0.327	0.088	0	0.327	0.088	0		0.326	0.088	0	
		Breform	-0.004	0.07	0.955	-0.003	0.07	0.966		0.001	0.071	0.984	
		R square	0.036			0.8628				0.4918			
		Adj R2	0.028										
		F statistic	3.42										
		F test	6.776										
		Wald (chi)				17.23			0.14	17			-1.37
		Prob>chi2				0.004			0.9996	0.005			
	Scenario 4	constant	8.025	0.155	0	8.024	0.174	0		8.043	0.011	0	
		lny	-0.014	0.011	0.216	-0.014	0.011	0.213		-0.015	0.024	0.205	
		lne	0.029	0.024	0.227	0.029	0.024	0.228		0.027	0.9	0.256	

		lnwshr	0.012	0.088	0.895	0.01	0.088	0.907		-0.001	0.09	0.995	
		Pknow	0.311	0.088	0	0.311	0.088	0		0.31	0.072	0.001	
		Breform	0.122	0.071	0.863	0.013	0.071	0.853		0.02	0.158	0.784	
		R square	0.046			0.8572				0.6125			
		Adj R2	0.039										
		F statistic	3.15										
		F test	11.167										
		Wald (chi)				18.19			0.09	15.61			-1.38
		Prob>chi2				0.0027			0.9999	0.008			

APPENDIX C-2: NON-RESIDENTIAL WATER DEMAND ESTIMATION USING DIFFERENT TECHNIQUES IN DIFFERENCE SCENARIOS (EFFECT BASED ON BC)

		Variables	Fixed effects (OLS)			random effects (GEE&PA)			Hausman test	random effects (GLS)			Hausman test
			coefficient	Std. er	p value	coefficient	Std. er	p value		coefficient	Std. er	p value	
BC variant factors	Scenario 2	constant	10.595	0.711	0	10.575	0.71	0.001		10.51	0.715	0	
		lnp	-0.61	0.105	0.001	-0.361	0.102	0.126		-0.64	0.106	0.001	
		lny	-0.018	0.011	0.117	-0.017	0.011	0.325		-0.015	0.011	0.187	
		lne	0.022	0.024	0.347	0.023	0.023	0.996		0.027	0.023	0.245	
		lnwshr	-0.008	0.088	0.924	0.001	0.088	0		0.04	0.087	0.646	
		Pknow	0.304	0.088	0.001	0.311	0.088	0.657		0.339	0.087	0	
		Breform	-0.034	0.07	0.625	-0.031	0.069	0		-0.01	0.7	0.822	
		R square	0.042			0.8479				0.3523			
		Adj R2	0.034										
		F statistic	4.71		0.0001								
		F test	7.25		0.0007								
		Wald (chi)				28.73			1.46	29.98			18.91
		Prob>chi2				0.0001			0.9622	0			0.0043
	Scenario 3	constant	11.205	0.711	0	11.184	0.711	0		11.116	0.715	0	
		lnp	-0.457	0.105	0	-0.458	0.105	0		-0.461	0.105	0	
		lny	-0.018	0.011	0.121	-0.017	0.011	0.129		-0.015	0.011	0.198	
		lne	0.022	0.024	0.343	0.23	0.023	0.322		0.028	0.024	0.238	
		lnwshr	-0.025	0.088	0.776	-0.017	0.088	0.849		0.026	0.088	0.767	
		Pknow	0.29	0.088	0.001	0.296	0.088	0.001		0.327	0.088	0	
		Breform	0.022	0.07	0.756	-0.019	0.07	0.789		-0.002	0.07	0.972	
		R square	0.049			0.848				0.386			
		Adj R2	0.042										

		F statistic	5.77		0								
		F test	7.98		0.0004								
		Wald (chi)				35.09			1.38	36.149			21.67
		Prob>chi2				0			0.9671	0			0.0014
	Scenario **4**	constant	11.941	0.718	0	11.921	0.718	0		11.847	0.723	0	
		lnp	-0.573	0.106	0	-0.574	0.106	0		-0.578	0.107	0	
		lny	-0.017	0.011	0.128	-0.017	0.01	0.136		-0.014	0.011	0.213	
		lne	0.022	0.024	0.345	0.023	0.024	0.324		0.028	0.024	0.235	
		lnwshr	-0.046	0.089	0.604	-0.038	0.088	0.667		0.008	0.088	0.929	
		Pknow	0.271	0.089	0.002	0.277	0.088	0.002		0.311	0.088	0	
		Breform	-0.006	0.071	0.937	-0.003	0.07	0.97		0.015	0.071	0.834	
		R square	0.058			0.866				0.388			
		Adj R2	0.051										
		F statistic	7.3		0								
		F test	8.79		0.0002								
		Wald (chi)				44.27			0.09	45.08			24.97
		Prob>chi2				0			0.9999	0			0.0003


Scenario 2
CB1
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Scenario 3
CB1
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Scenario 4
CB1
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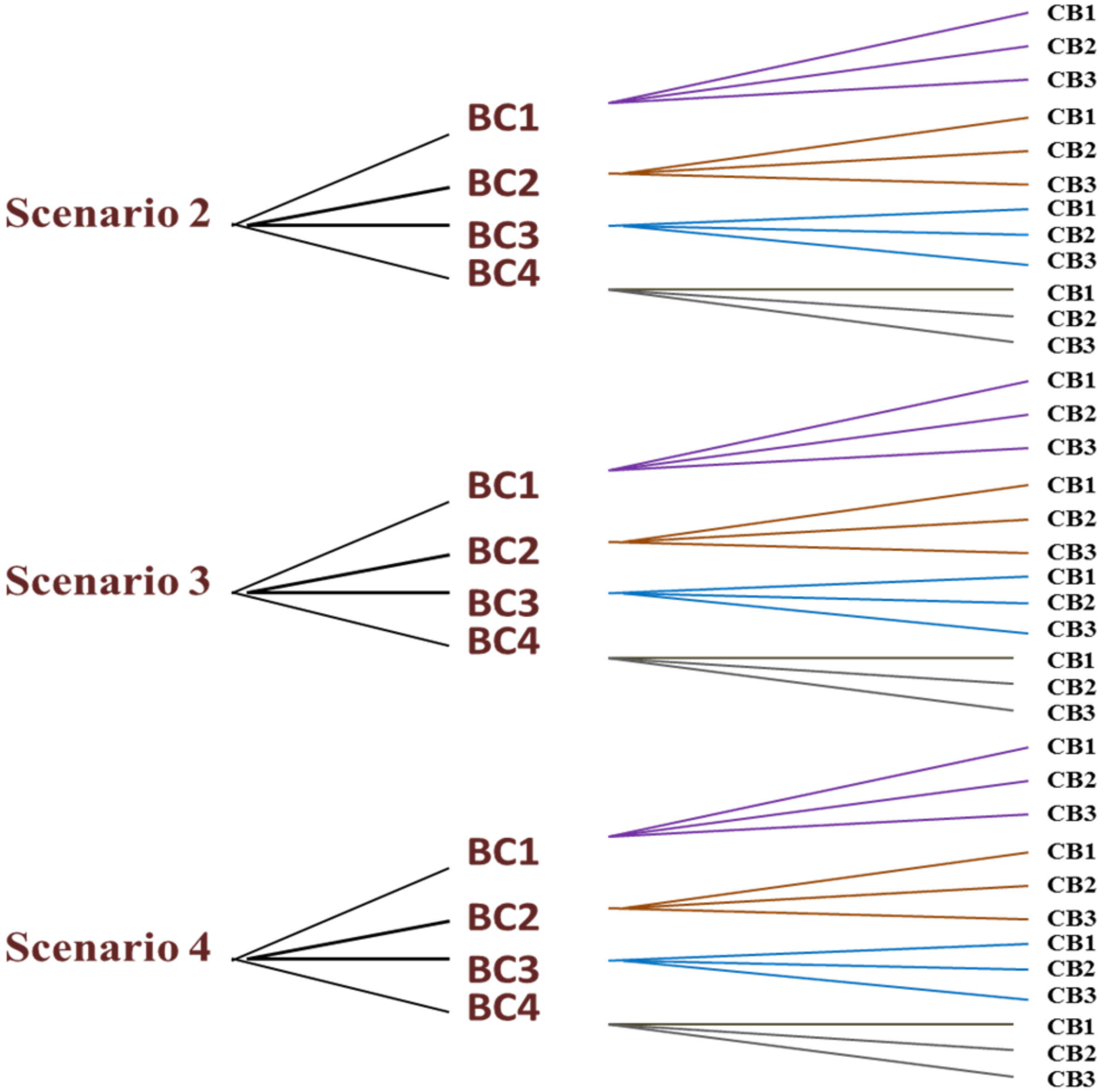
APPENDIX D-3: THE RESULTS OF THE FIXED EFFECTS MODEL WITH THE FACTOR CB BY THE AGGREGATE AND EACH BUSINESSES GROUP BC1-MANUFACTURING; BC2- COMMERCIAL; BC3- GOVERNMENTAL; AND BC4 SCHOOL AND HEALTH) (6 Mar 2012)

	variables	aggregate coefficients	BC	CB -1 coefficients		aggregate coefficients	CB-2 coefficients		aggregate coefficients	CB – 3 coefficients
scenario 2	Intercept	8.102 (.154)	B1	7.555 (.281)	scenario 3	8.067 (.154)	7.524 (.279)	scenario 4	8.025 (.155)	7.484 (.281)
			B2	8.301 (.266)			8.269 (.266)			8.230 (.268)
			B3	8.659 (.379)			8.591 (.382)			8.518 (.389)
			B4	8.276 (.372)			8.278 (.372)			8.256 (.378)
	β1 (lny)	-.015 (.011)	B1	.040 (.019)		-.015 (.011)	.039 (.019)		-.014 (.011)	.040 (.019)
			B2	-.055 (.019)			-.053 (.019)			-.050 (.019)
			B3	-.023 (0.32)			-.027 (0.32)			-.032 (0.32)
			B4	.012 (.024)			.014 (.024)			.017 (.025)
	β2 (lnE)	.028 (0.24)	B1	.036 (.038)		.028 (0.024)	.038(.038)		.029 (0.24)	.040 (.038)
			B2	.078 (.042)			.077 (.042)			.076 (.042)
			B3	-.038 (.067)			-.030 (.067)			-.022 (.069)
			B4	-.184 (.055)			-.190 (.055)			-.199 (.056)
	β3 (lnWshr)	.041 (.088)	B1	.212 (.174)		.028 (.088)	.204 (.174)		.011 (.088)	.196 (.174)
			B2	-.126 (0.146)			-.141 (0.146)			-.162 (0.147)
			B3	.004 (0.242)			-.002 (0.244)			-.016 (0.242)
			B4	.221 (.182)			.194 (.182)			0.162 (.185)
	β4 (Pknow)	0.339 (.088)	B1	.499 (.140)		0.327 (.088)	.473 (.139)		0.311 (.088)	.044 (.140)
			B2	.074 (.153)			.062 (.153)			.045 (.154)
			B3	.153 (.243)			.153 (.245)			.149 (.250)
			B4	.221 (.197)			1.083 (.197)			1.068 (.201)
	β5 (Breform)	-.016 (.07)	B1	.187 (.106)		-.004 (.07)	.215 (.106)		-.012 (.07)	.249 (.106)
			B2	.024 (.146)			.032 (.146)			.041 (.147)
			B3	-.074 (.189)			-.078 (.191)			-.082 (.195)
			B4	-.489 (.128)			-.477 (.128)			-.459 (.130)


CB1
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Scenario 3
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CB3
BC1
CB1
CB2
BC2
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Scenario 4
CB1
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APPENDIX D-4:THE RESULTS OF THE FIXED EFFECTS MODEL WITH THE FACTOR BC BY THE AGGREGATE AND EACH BC (BC1- MANUFACTURING; BC2- COMMERCIAL; BC3- GOVERNMENTAL)

	variables	aggregate coefficients	BC	CB -1 coefficients		aggregate coefficients	CB-2 level coefficients		aggregate coefficients	CB-3 level coefficients
scenario 2	Intercept	10.55 (0.715)	BC1	9.336 (1.175)	**scenario 3**	11.161 (0.715)	9.776 (1.17)	**scenario 4**	11.9	10.294 (1.178)
			BC2	11.865 (1.258)			12.497 (1.258)			13.268 (1.271)
			BC3	8.694 (1.878)			9.371 (1.89)			10.205 (1.928)
			BC4	10.523 (1.356)			11.367 1.357)			12.385 (1.383)
	β1 (lnp)	-0.358 (0.106)	BC1	-0.27 (0.173)		-0.455 (0.106)	-.341 (0.172)		-0.573 (0.107)	-.425 (.174)
			BC2	-0.539 (0.185)			-.640 (0.186)			-.763 (.188)
			BC3	-0.007 (0.281)			-.120 (0.283)			-.256 (.289)
			BC4	-0.340 (0.199)			-.467 (0.200)			-.619 (.203)
	β2 (lny)	-0.015 (0.011)	BC1	.040 (.019)		-0.015 (0.011)	.039 (.019)		-0.015 (0.011)	.039 (.019)
			BC2	-.056 (.019)			-.054 (.019)			-.051 (.019)
			BC3	-.022 (0.32)			-.027 (0.32)			-.032 (0.32)
			BC4	.013 (.024)			.014 (.024)			.017 (.025)
	β3 (lnE)	0.02 (0.239)	BC1	.0036(.038)		0.021 (0.024)	.038(.038)		0.021 (0.024)	.040 (.038)
			BC2	.078 (.042)			.076 (.042)			.075 (.042)
			BC3	-.036 (.066)			-.029 (.067)			-.022 (.068)
			BC4	-.184 (.054)			-.190 (.055)			-.201 (.056)
	β4 (lnWshr)	-.001 (0.09)	BC1	.215 (.174)		0.017 (0.09)	.204 (.173)		-0.039 (0.091)	.193 (.174)
			BC2	-.127 (0.146)			-.141 (0.146)			-.163 (0.147)
			BC3	.012 (0.241)			.002 (0.244)			-.017 (0.247)
			BC4	0.221 (.181)			0.193 (.181)			0.163 (.184)
	β5 (Pknow)	0.332 (0.087)	BC1	.499 (.140)		0.319 (0.088)	.473 (.139)		0.302 (0.088)	.0441 (.140)
			BC2	0.078 (.153)			.067 (.153)			0.052 (.155)
			BC3	.152 (.242)			.152 (.243)			0.149 (.249)
			BC4	1.096 (.196)			1.080 (.196)			1.062 (.199)
	β6 (Breform)	-.048 (0.071)	BC1	.186 (.106)		-0.034 (0.071)	.214 (.105)		-0.016 (0.072)	.249 (.106)
			BC2	0.029 (.146)			.037 (.146)			.048 (.147)
			BC3	-.078 (.189)			-.080 (.190)			-.082 (.194)
			BC4	-.489 (.127)			-.477 (.127)			-.460 (.130)

APPENDIX D-4: THE RESULTS OF THE RANDOM EFFECTS MODEL WITH THE FACTOR CB BY THE AGGREGATE AND EACH BUSINESS GROUP (BC1- MANUFACTURING; BC2- COMMERCIAL; BC3- GOVERNMENTAL)

	variables	aggregate coefficients	BC	BC level coefficients		aggregate coefficients	BC level coefficients		aggregate coefficients	BC level coefficients
scenario 2	Intercept	8.112 (.155)	BC1	9.336 (1.175)	**scenario 3**	8.081 (0.155)	9.776 (1.17)	**scenario 4**	8.043 (.012)	10.294 (1.178)
			BC2	11.865 (1.258)			12.497 (1.258)			13.268 (1.271)
			BC3	8.694 (1.878)			9.371 (1.89)			10.205 (1.928)
	β1 (lny)	-.015 (.011)	BC1	.040 (.019)		-0.015 (0.011)	.039 (.019)		-0.015 (0.011)	.039 (.019)
			BC2	-.056 (.019)			-.054 (.019)			-.051 (.019)
			BC3	-.022 (0.32)			-.027 (0.32)			-.032 (0.32)
	β2 (lnE)	.027 (.024)	BC1	.0036(.038)		0.027 (0.024)	.038(.038)		0.027 (0.995)	.040 (.038)
			BC2	.078 (.042)			.076 (.042)			.075 (.042)
			BC3	-.036 (.066)			-.029 (.067)			-.022 (.068)
	β3 (lnWshr)	.035 (0.088)	BC1	.215 (.174)		0.019 (0.088)	.204 (.173)		-0.001 (0.091)	.193 (.174)
			BC2	-.127 (0.146)			-.141 (0.146)			-.163 (0.147)
			BC3	.012 (0.241)			.002 (0.244)			-.017 (0.247)
	β4 (Pknow)	0.339 (0.088)	BC1	.499 (.140)		0.326 (0.088)	.473 (.139)		0.031 (0.072)	.0441 (.140)
			BC2	0.078 (.153)			.067 (.153)			0.052 (.155)
			BC3	.152 (.242)			.152 (.243)			0.149 (.249)
	β5 (Breform)	-.013 (0.071)	BC1	.186 (.106)		0.001 (0.071)	.214 (.105)		-0.02 (0.158)	.249 (.106)
			BC2	0.029 (.146)			.037 (.146)			.048 (.147)
			BC3	-.078 (.189)			-.080 (.190)			-.082 (.194)

APPENDIX E: WATER CONSUMPTION OF END USERS OF ULAANBAATAR

This thesis estimated the annual water consumption for an average firm/organisation (non-residential users) and monthly water consumption for an average household (residential users). Urban water use is usually shown to be highly sensitive to seasonal fluctuations, but Ulaanbaatar's residential water consumption did not show any seasonality variation.

The non-residential users were grouped into manufacturing, commercial and government users. According to annual non-residential water consumption, the government organizations including schools, hospitals and other administrative organizations used more water than industrial and commercial firms. The component of water use for non-residential users is not identified, while most participants did not have any water metering, so there was no information about that component. This confirms that non-residential users cannot pay any attention to their water use as they have no appropriate information.

Monthly residential water consumption is defined by ger and apartment area households including metered and non-metered households. An average ger area household consumes 6.5m3 water, which includes indoor (18% of the water) and outdoor use (82% for having showers at public bathing houses). A ger area dweller uses about 40 to 56 lpd water. This confirms that Mongolia has achieved its aim of a basic water requirement for residents of ger areas and the basic water requirement of WHO (Gleick 1998) as well. The ger area dwellers' daily water consumption can be defined in two ways. One was determined by the amount purchased from water kiosks (9.15 lpd on average), which was stated as being the same as the consumption (8.75 lpd) for consumers of the piped kiosks, in ger areas in the USUG report (2011), and 15 lpd for the non-piped dwellers of Jakarta (Crane, 1994). It appears that according to the ger area dwellers, water consumption was about (2 times less) half as much as the basic water requirements for human activities according to the World Health Organization (Brian, 2005), and around 2.5 times less than the Mongolian standard for basic water consumption of ger area dwellers (MOUB and Ltd, 2006), and about 5 times less than the basic water requirement by Gleick's determination (Gleick, 1996). Another way to define water consumption of ger area dwellers is to demonstrate the water used when using the public showers. According to ger area households, the component of consumption is about 20% carried out from water kiosks and the rest of their usage is not at their home, but somewhere else (apartment areas HH and/or public shower) for shower and cleaning bedding and clothes. Overall, the ger area dweller's water consumption was 56 lpd, which has achieved the intermediate standard of the WHO (Howard and Bartram, 2003), but the usage was not only at home. This demonstration is one of the main findings of this study, as it shows that the water usage is already achieving the Mongolian Standard for the basic water requirement for ger area dwellers and meets Glieck's basic water requirement too.

A comparison of water consumption per person per day (in litre-lpd) with other developing countries shows that for the apartment residents, daily consumption (115 lpd to 125 lpd) is close to the consumption of 120 lpd in Buon Mathuot, Vietnam (Cheesman and Bennett, 2008); 130 lpd in Salatiga, Indonesia (Rietveld et al., 2000b); and 135 lpd in medium-sized cities of Southwest Sri Lanka (Nauges and Berg, 2009). The metered household consumption is almost the same as developed countries' usage. From the estimation of household water consumption for apartment areas, there is no a significant difference between metered and non-metered households. But the aggregate average consumption for residential consumers of USUG and OSNAAG is higher than this study. This shows that the non-metered households state their consumption as being less than real use probably because of leakage of taps and toilets, and external use such as non-family people frequently having showers. The study of Maddaus O W (Jones and Morris) showed that during the winter time, water use is about the same for metered and un-metered households. This confirms that the indoor water use for both household groups is supposed to be the same.

One of the key findings for providing information about demand management tools is that the 'end use pattern' of water was a breakdown of the total household water usage[28] in a single family consumption such as showers and bathing (23%), washing machine use (3%), toilet use (33%), leakage (5%) and miscellaneous (35%) including kitchen, dishwashing, and cleaning; these proportions vary depending on the household's size and living areas. The micro-component of Ulaanbaatar apartment household water usage shows that the households have a slightly lighter frequency of using washing machines than in Memon and Butler's (2006) study, but water for toilet and shower and bathing was the same as in their study. Furthermore water for taps was larger than their study (Falkenmark et al., 2007). The frequency of using the laundry, showering and bathing for Ulaanbaatar residential users is obviously less than urban centres of developing countries, but the water using appliances are not labelled as to their water efficiency. There was a decrease in the total volume consumed in larger households due to the economies of scale that arise from the use of washing machines and lower frequency of persons taking showers.

[28]The usages per household and per person are not significantly different between the estimations for the warm and cold seasons.

APPENDIX F: OUTPUTS OF RESIDENTIAL WATER DEMAND (USING DIFFERENT TECHNIQUES)

APPENDIX F-1: OUTPUTS OF LINEAR REGRESSION OF RESIDENTIAL WATER DEMAND ESTIMATION EACH YEAR AND A TYPE OF SETTLEMENTS

Variable	Ger	Apartment 2010			Apartment 2011			Apartment		
		Aggregate	Metered	Unmetered	Aggregate	Metered	Unmetered	Aggregate	Metered	Unmetered
cons	625.71	2965.38	5552.49	538.38	1551.76	-259.38	5017.563	10126.43	13527.68	7105.71
Num	76.67	3113.36	3631.61	3022.31	3200.75	3183.43	3291.478	3140.73	3302.9	3080.38
Y	0.00007	0.00015	-0.00038	0.00027	0.00008	0.00038	-0.00039	0.0001	0.00028	0.00007
MP	~	omitted	omitted	~	omitted	omitted	~	-34346.74	-45029.92	~
FR	~	-0.666	~	omitted	0.17	~	omitted	-3.324	~	-2.313
Edu	-50.17	403.24	-1012.45	777.49	-80.861	145.204	-406.41	211.46	-353.78	526.82
Wshr	-41.88	39.89	-645.51	128.75	-237.884	284.535	-1073.47	-42.69	86.82	-132.39
KnP	304.77	28.49	omitted	65.06	-491.974	-147.13	-1095.08	-224.48	-306.17	-49.92
Bref	-13.81	456.15	1531.28	355.84	359.82	-242.81	1122.46	412.44	159.38	590.82
F test	(6, 253) 2.79	(7, 381) 54.94	(5, 49) 14.69	(6, 327) 52.49	(7, 285) 92.12	(6. 164) 64.52	(6. 115) 46.56	(7. 674) 127.71	(7. 218) 65.89	(7. 448) 77.41
P	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R2	0.039	0.493	0.600	0.491	0.693	0.691	0.693	0.566	0.679	0.540
PeD	~	~	~	~	~	~	~	(-0.175; **-0.196;** -0.216)	(-.777; **-0.789;** -.801)	
FReD	~	~	~	~	~	~	~	(-0.347; **-0.386;** -0.366)		(-.375; **-0.378;** -.381)
YeD	0.028	0.0045	-0.008	-0.012	0.004	0.018	-0.021	-0.0001	0.011	0.002
NeD	0.346	0.804	0.875	0.95	0.917	0.927	0.921	0.868	0.913	0.818

The shaded coefficients are not significant

APPENDIX F-2: RANDOM PARAMETER MODEL OF APARTMENT HOUSEHOLDS 2010 IN COMBINED METERED AND NON-METERED HOUSEHOLDS' DATA BY HOUSEHOLDS' INCOME LEVEL

	low income household					mid income household					high income household				
	mean	P	1.1P	1.5P	2P	mean	P	1.1P	1.5P	2P	mean	P	1.1P	1.5P	2P
Num	3.612	3385.72	1953.14	1858.49	1643.57	4.244	3171.62	2436.46	2299.19	2425.912	5.1	3772.52	3098.46	3488.6	3164.42
Income	114286	0.0076	0.00822	0.01067	0.0072	490488	5.6E-05	0.00034	0.0003	0.0011	1750000	-0.0013	-0.0032	-0.0046	-0.002
Edu	3.16	-194.43	4.543	-148.21	144.208	2.635	493.354	426.639	304.061	363.313	3	748.101	2516.03	2093.29	993.793
Wshr	2.556	274.396	1777.7	1594.23	1447.75	2.761	142.802	1275.94	874.747	865.897	2.96	254.239	801.352	435.751	464.173
Know	0.102	1693	452.442	241.75	-218.98	0.103	3.389	603.574	485.613	81.942	0	-762.68	-496.25	-111.98	-718.84
B ref	0.735	1787.4	1824.32	2022.54	1887.36	0.735	461.046	176.982	262.834	491.243	0.6	2710.14	2177.02	2654.3	2915.85
Constant		-115.89	-4499.4	-4405.7	-4153.6		882.054	-2825.7	-1839	-2878.602		-3861.4	-8062.3	-7509	-6147.1
Consumption		14555.3	9439.99	8644.26	8126.82		16403.4	12520.7	11525.5	11674.08		17796.4	13366.1	11395.1	12561.3
Dif Q %			-35.1%	-8.4%	-6.0%			-23.7%	-7.9%	1.3%			-24.9%	-14.7%	10.2%
Difference P %			10.0%	36.4%	33.3%			10.0%	36.4%	33.3%			10.0%	36.4%	33.3%
Price elasticity			-3.514	-0.232	-0.180			-2.367	-0.219	0.039			-2.489	-0.406	0.307
per person Q		4029.71	2613.51	2393.21	2249.95		3865.07	2950.21	2715.72	2750.726		3489.49	2620.81	2234.33	2463
Price elasticity					-0.442					-0.288					-0.294

APPENDIX F-3: OUTPUTS IF RPM OF NON-METERED HOUSEHOLDS' WATER DEMAND BY HOUSEHOLDS' INCOME LEVEL (USING 2010 SAMPLES)

	lower than mid income household					higher than mid income household				
	mean	P	1.1P	1.5P	2P	mean	P	1.1P	1.5P	2P
Num	4.049	2681.4	2158.54	2113.19	2116.46	4.698	3477.8	2904.86	3302.01	2862.777
Income	303617	0.0036	0.00365	0.00357	0.00458	1138095	-0.0004	-0.0018	-0.0032	-0.000056
Edu	2.59	775.367	592.397	489.852	752.296	2.857	554.899	2302.69	1927.37	651.363
Wshr	2.702	330.395	1234.82	986.003	708.59	2.846	264.522	760.26	404.675	460.518
Know	0.119	-194.04	-281.94	-304.66	-399.28	0.111	-2.603	222.121	614.586	154.037
B ref	0.774	466.333	-1726.9	-1157.3	-1690.5	0.841	2786.82	2291.24	2779.29	3025.46
Constant		196.458	-1355.4	-1481.5	-1603.5		-3229.2	-8294.6	-7911.7	-6393.146
Consumption		15385.3	11993.3	11159.6	10863.7		17392.8	13997.9	13023.1	12725.54
Dif Q %			-22.0%	-7.0%	-2.7%			-19.5%	-7.0%	-2.3%
Dif P %			10.0%	36.4%	33.3%			10.0%	36.4%	33.3%
PeD			-2.205	-0.191	-0.080			-1.952	-0.192	-0.069

APPENDIX F-4: OUTPUTS IF RPM OF METERED APARTMENT HOUSEHOLDS' DEMAND BY INCOME LEVEL (2011)

	lower than mid income household					higher than mid income household				
	mean	P	1.1P	1.5P	2P	mean	P	1.1P	1.5P	2P
Num	3.385	3461.31	3387.09	3084.93	2661.53	4.341	3113.91	3076.18	3329.82	3118.858
Income	453846	0.00093	0.00037	-0.0023	-0.0019	1153409	-0.0006	0.00057	-0.0016	-0.00094
Edu	2.538	-404.27	-360.54	-84.093	440.34	2.818	-709.11	-1272.2	-1344.3	-659.951
Wshr	3.128	-1191.4	-1254.9	-901.25	-963.5	3.307	-673.76	-571.51	-221.16	-1041.95
Know	0.026	-1838	-1724.1	-1370.1	-1211.2	0.045	-138.08	515.507	1230.14	961.745
B ref	0.718	148.418	1366.06	1052.07	926.786	0.818	-1128.5	-1286.2	-1586.3	-1572.08
Constant		3889.5	3800.51	3359.53	3141.9		7477.39	6563.21	5617.59	6031.41
Consumption		11334.2	11529.3	10436.3	10040.2		15101	14070.4	12430.6	11938
Dif Q %			1.7%	-9.5%	-3.8%			-6.8%	-11.7%	-4.0%
Dif P %			10.0%	36.4%	33.3%			10.0%	36.4%	33.3%
PeD			0.172	-0.261	-0.114			-0.682	-0.321	-0.119

APPENDIX F-5: OUTPUTS OF RPM OF METERED APARTMENT HOUSEHOLDS' WATER DEMAND BY INCOME LEVEL (USING 2011 DATA)

	lower than mid income household					higher than mid income household				
	mean	P	1.1P	1.5P	2P	mean	P	1.1P	1.5P	2P
Num	3.815	3251.6	2961.8	2864.8	2902.1	4.5	3175.4	2379.1	1966.3	1919.11
Income	417961	0.0016	-0.0004	-0.0004	-0.0007	1108088	0.0026	0.0044	0.0016	0.0019
Edu	2.534	186.34	53.856	81.805	24.704	2.882	-709.21	-907.72	-1409.8	-1743.01
Wshr	3	428.41	623.27	362.64	304.72	2.934	-45.642	-94.655	-76.089	-75.2967
Know	0.058	87.361	-1186.2	-879.5	-901.81	0.0588	-2031.4	-1474.8	-689.91	-452.226
B ref	0.845	135.42	-143.58	-62.131	-123.5	0.823	-1152.7	-267.34	-268.26	-194.57
Constant		-1249.9	-801.12	-925.31	-845.68		4172.3	5772.0	6261.5	6373.29
Consumption		13098.	12147	11024.	10753.		15496.	13753.	12367.	11631.9
Dif Q %			-7.3%	-9.2%	-2.5%			-11.3%	-10.1%	-5.9%
Dif P %			10.0%	36.4%	33.3%			10.0%	36.4%	33.3%
PeD			-0.727	-0.254	-0.074			-1.125	-0.277	-0.178

APPENDIX G: PERCEPTIONS ABOUT EFFECTIVENESS OF URBAN WATER MANAGEMENT POLICIES

APPENDIX G-1: WATER SAVING HABITS BY HOUESHOLD SIZE AND BY USER GROUP

user group	HH size	Wsh1	Wsh2	Wsh3	Wsh4	Wsh5	Wsh6	Wsh7	Wsh8	Wsh9	Wsh10
Apartment 2010	1	2.00	4.50	3.63	2.50	2.63	3.38	2.38	3.50	1.38	1.88
	2	2.18	3.67	3.71	3.33	3.36	3.16	3.11	3.18	2.51	2.42
	3	1.99	3.73	3.38	3.13	3.33	3.55	3.05	3.01	2.23	2.21
	4	2.17	3.61	3.51	3.13	3.16	3.26	2.97	3.01	2.26	2.29
	5	2.20	3.73	3.73	3.14	3.47	3.55	3.04	3.27	2.23	2.23
	6	1.88	3.38	3.86	3.00	3.19	3.02	2.55	2.98	2.24	2.14
	7	1.74	3.95	3.32	3.47	3.74	4.11	3.26	3.53	1.84	2.11
	8	1.50	3.38	3.75	3.50	3.38	2.75	2.75	3.25	1.75	2.00
	9	1.00	3.00	1.50	2.00	1.50	2.00	2.00	5.00	2.00	2.00
	10	2.00	4.50	3.00	2.50	2.25	2.50	2.50	3.00	2.50	3.25
Apartment 2011	1	2.17	3.67	3.17	2.83	2.83	2.83	2.67	2.25	2.17	1.83
	2	2.14	3.58	3.30	3.14	3.30	3.49	2.91	3.07	2.07	1.93
	3	2.07	3.93	3.49	2.80	3.38	3.18	2.92	3.07	2.23	2.25
	4	1.78	3.49	3.64	3.16	3.09	3.09	2.93	3.00	2.26	2.30
	5	1.92	3.47	3.47	3.32	3.45	3.32	2.70	3.17	2.47	2.55
	6	1.91	3.59	3.82	3.59	3.77	3.36	2.73	2.95	2.50	2.55
	7	2.27	3.91	3.64	3.45	3.09	3.73	3.27	3.64	2.36	2.18
	8	2.50	3.13	3.00	2.63	2.63	3.13	2.75	2.75	2.38	2.50
Ger 2010	1	3.00	3.17			3.50			2.50		
	2	1.52	2.19			2.67			2.43		
	3	2.20	3.26			3.00			3.06		
	4	1.93	2.73			2.54			3.20		
	5	1.62	2.62			2.34			2.93		
	6	2.00	2.63			2.61			3.26		
	7	1.62	3.31			2.92			3.16		
	8	1.70	3.40			2.10			2.40		
	9	1.67	2.67			2.33			1.83		
	10	1.00	3.00			3.00			4.50		
	11	1.00	3.00			1.00			2.50		
	12	1.00	5.00			1.00			5.00		

APPENDIX G-2: RESIDENTIAL WATER SAVING HABITS BY INCOME INTERVAL AND BY USER GROUP

		n	Wsh1	Wsh2	Wsh3	Wsh4	Wsh5	Wsh6	Wsh7	Wsh8	Wsh9	Wsh10
Apartment 2010	Under 100000 T	32	1.88	3.22	3.31	3.03	3.2	3.34	2.94	2.97	2.06	2.28
	100000T ~ 199999T	61	2.16	3.67	3.69	3.13	3.36	3.43	2.92	3.16	2.26	2.66
	200000T ~ 399999T	95	2.03	3.82	3.34	2.97	3.21	3.37	2.73	3.07	2.03	2.01
	400000T ~ 599999T	83	2.25	3.81	3.81	3.25	3.36	3.30	3.04	3.23	2.46	2.39
	600000T ~ 799999T	43	2.02	3.65	3.81	3.51	3.42	3.42	3.37	3.12	2.44	2.26
	800000T ~ 999999T	35	1.83	3.54	3.49	3.29	3.17	3.20	3.17	3.15	2.20	2.20
	1000000T ~1500000T	24	2.21	3.88	3.88	3.13	3.33	3.71	2.96	3.38	2.08	1.92
	Over 1500000T	10	1.70	3.00	3.20	3.00	3.50	2.80	2.40	2.60	2.20	1.70
Apartment 2011	Under 100000 T	6	2.00	4.50	4.50	3.83	3.67	3.33	3.50	3.17	3.33	3.50
	100000T ~ 199999T	21	2.62	3.95	3.71	3.10	3.57	3.29	2.76	3.25	2.62	1.95
	200000T ~ 399999T	85	1.96	3.55	3.29	2.82	3.08	3.05	2.64	2.86	2.06	2.13
	400000T ~ 599999T	67	2.00	3.73	3.43	3.13	3.49	3.24	3.13	3.12	2.81	2.49
	600000T ~ 799999T	70	1.97	3.51	3.49	3.27	3.31	3.40	2.96	3.21	2.17	2.40
	800000T ~ 999999T	29	1.66	3.55	3.93	3.24	3.31	3.48	2.55	2.69	1.76	1.86
	1000000T ~1500000T	10	1.90	3.50	3.50	3.30	2.80	3.20	2.80	3.20	1.50	2.70
	Over 1500000T	3	2.50	4.00	3.50	4.00	4.50	4.00	3.50	4.50	2.50	2.50
Apartment 2011	Under 100000 T	30	1.77	2.43			2.50			3.33		
	100000T ~ 199999T	49	1.92	2.67			2.51			3.04		
	200000T ~ 399999T	91	1.89	2.92			2.64			2.96		
	400000T ~ 599999T	56	1.93	2.74			2.55			2.58		
	600000T ~ 799999T	20	1.45	3.60			2.70			3.70		
	800000T ~ 999999T	1	1.00	4.00			5.00			5.00		
	1000000T ~1500000T	2	1.00	1.50			3.00			1.00		
	Over 1500000T	2	1.50	2.50			1.00			5.00		

APPENDIX G-3: THE MOST EFFECTIVE USER GROUP EACH URBAN WATER MEASURE

	2010			2011			overall			difference		
	Overall	R	NR	Overall	R	NR	Overall	R	NR	Overall	R	NR
The highest attitudes user group	NR			NR			NR			NR		
Price measure	NR	NMHH	C	R	NMHH	C	NR	NMHH	G	R	NMHH	M
Operational and technical measure	R	Ger HH	M	NR	NMHH	C	NR	MHH	C	NR	NMHH	C
Socio political measure	R	Ger HH	M	NR	NMHH	C	NR	MHH	C	NR	NMHH	C
Supply side measure	R	Ger HH	M	NR	NMHH	C	NR	MHH	C	NR	NMHH	C

R-Residential users; NMHH-Non-metered households; MHH-Metered households; NR-Non-residential users; M-Manufacturing firms; C-commercial organizations; G-Governmental organizations

APPENDIX G-4: THE HIGHEST SCORE POLICY EACH USER GROUP

	2010	2011	Overall	Difference
All user	Building a recycling plant	Fixing underground pipes	Building a recycling plant	Fixing underground pipes
Residential user	Building a recycling plant	Fixing underground pipes	Building a recycling plant	Fixing underground pipes
Ger	Building a dam	Fixing underground pipes	Building a dam	Protecting the Tuul River basin
Apartment	Building a recycling plant	Fixing underground pipes	Building a recycling plant	Fixing underground pipes
Metered	Building a recycling plant	Fixing underground pipes	Building a recycling plant	Fixing underground pipes
Non-metered	Building a recycling plant	Fixing underground pipes	Building a recycling plant	Fixing underground pipes
Non residential	Building a dam	Information and education campaign	Building a recycling plant	Protecting the Tuul River basin
Manufacturing	Building a recycling plant	Protecting the Tuul River basin	Building a recycling plant	Protecting the Tuul River basin
Commercial	Building a dam	Protecting the Tuul River basin	Protecting the Tuul River basin	Fixing underground pipes
Governmental	Building a dam	Protecting the Tuul River basin	Building a recycling plant	Protecting the Tuul River basin

APPENDIX G-5: NON-RESIDENTIAL USERS' ATTITUDE TOWARDS POLICIES VERSUS RESIDENTIAL USERS' ATTITUDES

Respondents indicated their preference of operational – technical policies and price policies targeting to implement to residential users and non-residential users. There are not significant differences in fixing policy for targeting user groups.

Table: Mean of policy by each user group and each study year and T test (between groups)

	Policies	2010			2011		
		R	NR		R	NR	
R	Fixing policy	0.52	0.51	t=-.864; p=.388	0.83	0.73	t=-1.586; p=.113
	Installing	0.44	0.34	t=-2.035; p=0.042	0.88	0.77	t=-2.035; p=0.042
NR	Fixing policy	0.16	-0.03	t=-1.577; p=0.115	1.1	1.07	t=-0.636; p=0.525
	Installing	0.12	0.14	t=-1.929; p=0.054	1.23	0.99	t=-4.028; p=0.000

Shaded part presents mean of each policy to own user group.

Table: Preferred targeted user group each policy

	overall			overall		Residential		Non residential		
Policies	overall	2010	2011	Residential	Non residential	Metered	Unmetered	Manufacturing	Commercial	Governmental
Zonal price policy	R*	R*	NR*	R*						
Seasonality price policy	R*	R*		R*		R*	R*			
Fixing policy						R*				
Installing policy		R*		R*	NR*	R*				NR*

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