Impacts of water demand side policies on Mongolian residential users

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Abstract

The water industry in Ulaanbaatar, Mongolia, experiences water scarcity and managerial and economic problems due to global warming and financial crises. This paper explores several possible solutions by analysing householders’ stated attitudes towards and stated (predicted) responses to different demand side policies. Using data from a survey of approximately 660 households (HHs) in Ulaanbaatar, this research is a seminal study of Mongolian residential water demand and is the first time the contingent behaviour method (CBM) has been employed to estimate price elasticity of water demand in this country. The CBM is particularly useful in data-poor environments, where one cannot use actual data to generate estimates. In this study, researchers use stated responses to a series of hypothetical changes in price to generate estimates of the price elasticity of demand for water of different types of HHs, including residents of formal apartments and those living in informal Ger areas, are characterized by a low level of public services, including water and sanitation services of the city. Householders’ attitudes towards different price and non-price policies are also examined. The findings are of interest to those wishing to postpone water scarcity by better managing urban residential water demand – particularly in transit and developing economies.

Key words: contingent behaviour method, demand management policies, Ulaanbaatar, urban water demand management

INTRODUCTION

The capital city of Mongolia, Ulaanbaatar, will 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. 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 (Batimaa et al. 2008). The main aim of this paper is to offer a possible solution to postpone water scarcity, by investigating methods of decreasing residential water demand by changing water users’ behaviour through urban water demand management policies.

Demand management policies generally aim to promote the efficient use of scarce water resources. In doing this, they change the behaviour of water users is rather than making large physical investments such as building new dams and drilling new wells. In addition, water demand management policies often seek to improve the existing supply/demand in water scarce regions/cities (Griffin 2006).

In theory, residential water demand functions can be estimated using HH level data; the preferred approach is to do so with time series data, with a cross section of consumer groups and/or with both times series and cross sectional data by estimating different analysing techniques such as OLS and GLS. (Schefter & David 1985; Young 1996; Saleth & Dinar 2000). However, the study area does not have enough historical or cross-sectional data to estimate water demand using any of these...
‘preferred’ approaches. The study will use a contingent behaviour approach to determine the likely reaction of different types of householders (those living in apartments with articulated water supply and those living in Ger) to changes in water prices and to other demand management policies.

BACKGROUND

The biophysical environment

The total territory of Ulaanbaatar is 470,400 km$^2$. The Tuul River, which is 704 km long, flows southwest through Ulaanbaatar, and its basin cover only 3% of the Mongolian territory.

Natsagdorj et al. confirm that Mongolia is highly vulnerable to anticipated impacts of climate change on water resources (Natsagdorj et al. 2005). Ulaanbaatar has a semi-arid climate, with hot dry summers (reaching 34 degrees C) and cold winters (sometimes down to $-39.5$ degrees C). The annual average precipitation varies from just 243–402 mm in Ulaanbaatar and its surrounds (Sarantsuya et al. 2002) and the Tuul River is completely frozen from December to February. Ulaanbaatar’s water supplies depend wholly on groundwater (Batima et al. 2004; Batimaa et al. 2008) drawn from an alluvial aquifer extending along the bed of the Tuul River.

Davaa et al. 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 & Erdenetuya 2007; Miguel & Medina 2007). Annual precipitation has decreased by 30–90 mm and the ice thickness of surrounding glaciers has decreased by 40–100 cm 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. Chuluunhuyag’s (2004) study concludes that Mongolia is highly vulnerable to the anticipated impacts of climate change on water resources, and that future scenarios regarding Ulaanbaatar’s water supply are somewhat tenuous (Basandorj & Altanzagas 2008; Chuluunhuyag 2008).

The demographic environment

As is evident from the preceding discussion, Ulaanbaatar’s water resources are sensitive to environmental changes, such as those related to longer-term changes in climate, and also those related to shorter term fluctuations in precipitation. But water resources are also under pressure from both social and economic change.

Ulaanbaatar is the capital city of Mongolia, and was established in 1639. However, urbanization 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 and 650,000 in 1998 (UBSO 2007a). 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; however, this growth rate excludes migration from rural areas. Every year approximately 7,500 HHs or 78 people per day settle in Ulaanbaatar. Many migrants leave the countryside to reach the capital city, hoping to find a job or better living conditions. By the 2000 census, one-third of Ulaanbaatar’s population had migrated from rural areas. Further, the population growth rate of the city has been increasing exponentially as a consequence of severe weather conditions such as extreme winters that devastate livestock and crops, and land privatization policies. The Ulaanbaatar statistical yearly report of 2009 estimates the population of Ulaanbaatar city to be approximately 1.107 million, or 273,200 HHs (UBSO 2010); 40% of Mongolian people live in the city.

Geographically, Ulaanbaatar is divided into two main areas: 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 Government’s housing program. The city areas are equipped with all urban infrastructures for water supply and wastewater disposal: hot and cold water, sewerage system (collection network and treatment), and central heating system and internet connection. In 2009, the city centre was occupied by 105,986 HHs, or 37.8% of the total UB population (UBSO 2010), a decrease of 40.1% in 2007 (UBSO 2007b). However, while most HHs live in apartments, only 0.7% of apartment area HHs reside in a modern individual house, and 0.3% of the population is homeless.

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 consist of rows of streets with wooden fences surrounding plots of different sizes, between 450 and 2,000 m² depending on location. People live in self-built, primarily one-storey detached (wooden and brick) houses or Gers (Please tell us whether you think your household would use more or less water if the price of water were to change?). In 2009, 55.16% of Ger areas’ HHs lived in one-storey detached houses, 43.07% in Gers, and only 1.29% in modern individual houses (connected to some infrastructure); 0.47% of the areas’ population was homeless (UBSO 2009a).

Geographically, the Ger areas account for 70% of Ulaanbaatar’s residential area (Margaret & Onon 2003) while in 2009 these areas were occupied by 167,196 HHs, or 62.2% of the total UB population, an increase from 49.4% in 2000 (UBSO 2010). Official data show that the registered population of the total Ger area grew by 96% between 2000 and 2009 mainly because of rural migrating HHs and newly married couples who can settle easily and cheaply in Ger areas; moreover, land privatization also impacted Ger area growth. A program of land privatization (700 m² per HH began in 2002, through the provision of private entitlements over the land plot settlers have identified as their own, and this has contributed to the formalization of residences in the Ger areas.

Water infrastructure and usage

The water distribution network is more than 50 years old, and the existing system of wells and boreholes is stretched beyond its limits. Charges attached to water sources, and water collection and its distribution, are the responsibility of the Water Supply and Sewerage Company (USAG). USAG supplies water to its consumers and to Housing and Service Authority of Ulaanbaatar (OSNAUG), which supplies water to most of the apartment residential users, via Heat and Water Distribution Centres (CTPs) (61).

In contrast to the city centre, Ger areas generally do not have basic infrastructure – while the majority of HHs 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 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 350 m.

USUG also provides water to the Ger areas through kiosks (547) with 53.4% piped or supplied by tanker trucks, and by tanker trucks to residents and businesses in June 2010. In addition, in 2009, 30% of Ulaanbaatar HHs obtained water from piped kiosks and 27.4% from un-piped kiosks and by tanker truck (USUG 2009). The tanker trucks carry 5,000 l and visit kiosks twice a day on average. Each tanker truck is required to make 10–15 trips per day. During winter the tankers have difficulty reaching many kiosks because of poor road conditions and operating hours are further reduced.

Water usage

The water demands of Ulaanbaatar’s over 1.1 million residents, more than 30,000 industries and business, 400 hectares of irrigated farms, 330,000 livestock and three power plants is in excess of 60.3 million cubic metres per annum, most of which (at least 70%) is supplied by USUG (Larson
et al. 2006; Emerton et al. 2009). However, some HHs and businesses supply their own water (by, for example, sinking their own well); the most significant examples here include the three power plants and 1,613 wells (EAUB 2010).

The average water consumption for apartment dwellers of OSNAAG consumers is between 110 litres per day (lpd) for those with a sub-meter and 340 lpd for those with universal meters and of the USUG consumers 261.5 lpd in 2009. In contrast, a Ger area HH with 4 people uses 30–40 l 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 areas dweller, being able to have showers depends on a limited numbers of public showers or having access to an apartment in the city. Water usage by Ger area residents is about one-twelfth of the basic water requirement (BWR) as stated by the World Health Organisation. According to Gleick (Gleick 1996), this minimum of 50 lpd is required for meeting the four basic human needs: drinking, human hygiene, sanitation service and preparing food. No data are available to estimate the water used by HHs that obtain water from their own shallow wells or from the river, although many unofficial private water kiosks have commenced operation during the past few years serving Ger area residents and charging almost twice the normal rate for water (USUG 2010).

**Water scarcity**

The rapidly expanding population is placing a great strain upon the city's water resources. Indeed, the city often faces water supply shortages during springtime (late April and May) when groundwater levels drop (Larson et al. 2006) and the snow covering the Khentii Mountain range has not yet melted. Moreover, groundwater tables in Ulaanbaatar have shown a marked decline over the past 50 years. Water is being extracted faster than the rate of recharge as the city grows, water demand increases and global climate changes. Seasonal water shortages are becoming more common (Emerton et al. 2009), and various studies warned that in the next 10 years the city will be facing a critical water shortage.

According to several forecasts, including the Urban Development Master Plan of Ulaanbaatar (UDMP) to 2025, the Ulaanbaatar Water and Sewerage Master Plan (UBWSMP) to 2020, and the study's Nemer B. et al. (2008) Ulaanbaatar will face what is formally defined as water scarcity by 2015 if population and water usage continue to grow at levels observed in 2005. This enables national and international organizations concerned with water provision and management to monitor both the resources available and the socioeconomic factors which affect access and use of those resources.

In summary, water scarcity is a significant economic and managerial problem in Ulaanbaatar. Water supplies are limited, subject to significant seasonal variation, and likely to fall in response to climate change. Water consumption is increasing because of rapid population growth and the government initiated 40,000 (period between 2005 and 2009) and 100,000 (2010 and 2015) housing units programs. Moreover, there is no control over industrial water consumption, very low (and sometimes no) water prices and no other water demand management strategies.

The research described in this paper seeks to provide information that will help those charged with managing this problem, by exploring householder attitudes towards and stated responses to different demand side policies.

**METHODOLOGY**

The water scarcity issue facing Ulaanbaatar raises the following research question: can better water demand management strategies postpone the time at which water becomes ‘scarce’ in Ulaanbaatar, Mongolia? The research question involves the following sub questions.

- How sensitive is water demand to different demand management strategies?
What are the impacts of pricing and non-pricing policies, which can reduce residential water usage or change end users’ behaviour?

In theory, residential water demand functions can be estimated using HH level data; the preferred approach is to do so with time series data with a cross section of consumer groups and/or with both times series and cross sectional data by estimating different analysing techniques such as OLS and GLS. (Schefter & David 1985; Young 1996; Saleth & Dinar 2000). However, the study area does not have enough historical or cross sectional data to estimate water demand using this ‘preferred’ approach. Therefore, this study only has limited data (from 1997 to 2010) on residential water usage by aggregate per capita use, population, water prices and HH income. But during that period, there were only four different water prices with several changes, so one cannot use ‘standard’ techniques to estimate demand. Therefore, the study will use a contingent behaviour approach to determine the likely consumer reaction to changes in water prices and other demand management policies.

The author believes that the contingent behaviour approach has not yet been used to access the potential effectiveness of different water demand management strategies, although the approach is commonly used to assess quality or price changes at recreational sites. For example, several studies have applied contingent behaviour analysis to analyse the potential economic effects of changes to (a) water quantity (levels) in lakes and rivers for recreation demand (Mitchell & Carson 1989; Cameron et al. 1999; Loomis 2002; Eiswerth et al. 2008) and (b) recreation benefits associated with restoring free flowing rivers (Loomis 2002). Moreover, the method has been used to estimate the influence of recreational pursuits on the demand for water quality (Grijalva et al. 2002). Cheesman et al., HH water demand of some municipalities of Vietnam and price elasticity estimated by stated preference by contingent behaviour method (CBM), which develops behavioural context of actual activities of HH water usage from both municipal and non municipal water sources (Cheesman & Bennett 2008).

Although both contingent behaviour and contingent valuation methods could theoretically be used to estimate demand, contingent behaviour survey questions tend to be less subject to response bias than are contingent valuation questions in. As such we choose to focus on the CBM.

Researchers involved in this study firstly developed a questionnaire designed to answer our key research questions, then collected data from a sample of householders in Ulaanbaatar, which was subsequently analysed. Further details are given in the sub-sections below.

Development of the questionnaires

The HH questionnaire consisted of seven sections. Section 1 and 7 covered demographic information such as the size of the HH, age distribution, the highest educational attainment, employment and HH income. Section 2 focused on obtaining information that would allow researchers to estimate HH water use (such as the number and variety of water-using appliances and the frequency of their use).

To be more specific, the researchers recognized that few respondents would be able to provide precise information about the water used by their HH each month (particularly those living in apartments without water meters). Because of this they designed a series of questions eliciting information about the extent to which various water-using appliances were used, as illustrated below (copies of the questionnaires available from the author on request):

- This information was combined with information about the average water used by a range of different appliances compiled from the Melbourne Household Water Use Calculator (Melbourne City Council, 2003) to generate an estimate of total HH water consumption. For example, if the respondent indicated that their washing machine was a front-loader and that they did approximately 2 loads of washing each week, then the researchers were able to conclude that the HH used approximately 200 l per week of water for washing (5 × 100 l). This information was combined with other information
about the number of people living in the house and the type of toilet for example (which allowed researchers to generate an estimate of the amount of water used for the toilet per annum), to generate an estimate of the total water used per HH per week inside the home.

Section 3 contained a series of questions to determine respondents’ willingness to accept water demand management such as pricing and non-pricing policies to reduce their water usage. Finally, Section 4 contained a series of questions related to the CBM. To be more specific, the survey offered respondents a series of ‘Hypothetical Scenarios’ (see Table 1), describing prospective changes in water prices relative to the current conditions. Respondents were asked to tell us how their water usage was likely to change in response to each scenario using a 5 point Likert scale. Similar questions were used for estimating income elasticity of water demand of respondents.

**Conduct of the study**

The study is based on a survey of 664 HHs, 0.24% of the total HHs, and was conducted in Ulaanbaatar from 26 April to 10 May 2010. The survey covered 26 randomly selected Khoroo (Khoroo – the smallest administration unit (132) of Ulaanbaatar city), the smallest administration unit of Ulaanbaatar, in central six districts with governmental and administrative support from the Mayor’s office of Ulaanbaatar. More details of the sample method and copies of questionnaires are available on request.

**RESULTS**

**Respondent characteristics**

A total of 60.5% (402 HHs with 1715) of respondents from apartment areas live in their own house/flat (90.52%) and only 7.74% of the HHs lived in a rented house/flat. Moreover, 93.7%
of respondents lived in apartments. In contrast, overall 47.2% of the HHs lived in old constructed
apartment areas of between 30 and 49 years. The approximate average age of the houses/flats
was 23.17 years (mean) and the mean property size of the houses/flats was 40.7 m². Of the
39.5% total respondents from Ger areas, 87.33% lived in their own land-plot and the rest in
rented plots, 55.58% lived in detached, single storey wooden and brick houses, and the house
size was calculated by statistical mean to approximately 48.15 m². Finally, 43.2% of HHs settled
in these areas less than 10 years ago, so a large percentage of migrated HHs are involved in this
study.

The mean family size was 4.45 and 61.7% of respondent HHs’ members were highly educated.
Respondents also had a higher unemployment rate (22.96%) than the national average and the
HHs monthly income was 432,511.56 MNT, which is Mongolian currency (1Aus$=1,250 MNT in
2009).

Household water use

The study found that the average daily water use of Ger area residents was 8.8 lpd, and this did not
differ significantly across HHs of different size. Similarly, water sources (e.g. piped kiosk), education
levels, property size or employment did not appear to influence water use. In addition to water used
within the home, Ger residents use public shower-blocks (since piped water was not available in their
homes). When this additional water use was taken in to account, real water usage was between 39.58
and 68.68 lpd. As such, water for showering accounted for between 77.56 and 87.07% of total water
use. The rest of the water (12.95–22.44%) was used for cooking, preparing food and cleaning house.
The Ger area residents’ water usage did not differ by season, because their usage was so minimal that
it was under BHR.

Apartment area HHs’ minimum daily water usage was between 450 (in winter) and 543 l (in
summer) and a maximum of between 621.5 and 714.4 l for apartments with leaking toilets, taps or
additional showers. As would be expected, indoor water use (298.43 and 1,332.67) increased as
HH size increased (1–10) but per person water consumption decreased, because water appliances’
frequencies of use among both small and large families was almost the same. Apartment water usage was
similar to the results shown in the 2009 report of OSNAAG: in the warm season between 120–281 lpd
and in the cold season between 127 and 291 lpd (OSNAAG 2009) and in the Ulaanbaatar Statistical

The residential water usage component is made up, in the warm season, as follows: 39% shower,
38% toilet, 11% bathing, 7% washing dishes, 3% washing clothes and other; and in the cold
season: 45% toilet, 50 shower, 10% bathing, 8% washing dishes, 4% washing machine and other. It
was explicitly different by season; moreover, water for showering and bathing depended on the
season as is the case in developed countries.

Price elasticity of water demand

Information collected in the CB part of the questionnaire was used to estimate the price elasticity of
water demand, \( \epsilon_p = \%\Delta Q_w / \%\Delta P_w \).

\( (Q_w = \text{water demand;} \ P_w = \text{price of water}) \), for each ‘hypothetical’ scenario presented – See Figure 1.

Each price choice was designated at 10, 50 and 100% increases and 10%, 50% decreases, while
their preference for changes of water demand were designated by less than 50 and 10% of water
usage, more than 10 and 100% of water usage, and no change. The results of price elasticities on
water demand by apartment respondents were in the range \(-0.1026\) to \(-0.2064\), and by Ger areas
respondents in the range \(-0.1414\) to \(-0.2743\).
In all cases, water demand was found to be price inelastic: in a range of \( -0.1514 \) and \( -0.2236 \) (averaged across all respondents).

**Respondent attitudes to price and non-price policies**

Respondents were asked to indicate whether they thought that a range of different price and non-price policies would enable them to reduce water consumption on a 5 point Likert Scale: strongly agree (5) to strongly disagree (1).

Further, respondents were asked to rank the importance they ascribed to subsidizing, socio-political and supply side policies on a 5 point scale from: 1 – very important to 5 being the highest level of importance. Figure 2 shows respondents’ attitudes by the importance mean (vertical axis) of respondents on each pricing, non pricing policy/ies (horizontal axis). Apartment respondents (0) and Ger area respondents (1) were used to test the calculation, test variables, 5 pricing policies, 12 non-pricing policies and supply side policies, and the group variables.

The attitudes of residential users to water demand and supply side policies were compared using independent \( t \)-tests, confirming that which is obvious visually, namely that both groups prefer or
are willing to accept more pricing policies (more than mean 3.5) but not a change in prices, socio-political policy (more than mean 3), supply side policies (more than mean 2.5), and subsidizing policies (more than mean 2.5) with significant mean differences between the two groups.

The significance of the difference between the 5 pricing and 12 non-pricing policies means were tested using the t-test for independent groups. The result identified that t test values, t of average pricing policies is −0.474, with 0.6175 mean differences, and t of average non-pricing is 9.135 with 0.8197 mean differences, are statistically significant.

In all, 70.6% of respondents wanted to have information on the water bill, indicating that billing reform could do much to improve the current state of affairs. Additionally, the effectiveness of public education programs would be enhanced if householders had accurate information about water usage (which would, incidentally, require more individual water meters).

It seems that apartment respondents have a slight preference for supply side policies compared to Ger respondents (0.008). Both groups are inclined to support safety and efficient water delivery systems, protecting the Tuul River and sewerage system connection to Ger areas HHs, but neither group is willing to accept the policies ‘Constructing dam’ and ‘Reusing water’.

**CONCLUSION**

The case of Ulaanbaatar is a typical example of where demand orientated water policies is needed. This is clear due to growing water scarcity in the Ulaanbaatar area and the difficulty in finding new water resources, especially water resources that totally depend on groundwater.

The results indicate that residential water demand is inelastic. These results are comparable with those found in the literature, most of all for developing countries.

The findings of this study support others that recommend demand management policies rather than supply side policies to influence residential users’ water use behaviours/habits. However, these results show that pricing policies alone may not suffice in managing residential water demand – primarily because water demand is so price inelastic.

Concerning the subsidizing policies, installing water sub metering, water efficient appliances, toilets and showerheads, installing water efficient equipment to business users and running public awareness campaigns would help in developing water demand management in the city. This all costs money – but the fact that respondents were generally supportive of pricing policies indicates that it may be possible for water planners to (a) use pricing policies to collect revenue; and then (b) use the revenues to fund policies that are capable of reducing water demand and/or improving water infrastructures (e.g. water recycling).

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