Economic Analysis of Domestic Water Management: Research on HA NOI Area Viet Nam

Hoang Thi Hue
Hanoi University of Natural Resources and Environment, Viet Nam, hthue@hunre.edu.vn

Le Thu Hoa
National Economics University, HaNoi, Viet Nam

Duong Hong Son
Water Resources Institute, Viet Nam

Nguyen Thi Hong Hanh
Hanoi University of Natural Resources and Environment, Viet Nam

Pham Thi Lam
East Asia University of Technology, Viet Nam

Bui Thi Thu Trang
Hanoi University of Natural Resources and Environment, Viet Nam

Nguyen Thi Hoai Thuong
Hanoi University of Natural Resources and Environment, Viet Nam

Nguyen Duc Duong
East Asia University of Technology, Viet Nam

Abstract

Urban domestic water demand management has proven to be a very effective management method in the context of many difficulties in the urban water supply. UDW demand management has been applied, developed and achieved significant results in many countries around the world. However, UDW demand management is a relatively new concept in Vietnam. Until now, there is no available study on economic analysis of UDW demand management; Hanoi in particular do not have any comprehensive and systematic research on UDW demand management. The thesis " Economic Analysis of Domestic Water Demand Management: Research on Ha Noi Area" aims to interpret and clarify theoretical and practical issues of UDW demand management, theoretical issues of economic analysis of UDW demand management and evaluate the conditions to apply UDW demand management in Hanoi urban districts, thereby develop and propose solutions for the development of UDW demand management in Hanoi until 2025.

Keywords: *Economic, water demand management, VietNam.*

INTRODUCTION

For many countries in the world, water demand management plays an important role in the national water resources strategy. Water demand management is the use of different techniques, policies, and solutions to influence the need for water to achieve the goals of economic effect, efficiency, and sustainability. Experience of developed countries has proved that the shift from water supply management (for example finding new water sources, build dam and reservoirs, water supply stations, water treatment stations, etc.) to water demand management can significantly reduce the pressure on freshwater resources, contribute to the sustainable use of water resources and ensure the equity among water users.

With the rapid urbanization speed, Vietnam in general and Hanoi in particular are facing many challenges in urban water supply. According to the report on current state of the environment in 2016, the percentage of people provided with clean water in urban areas in Vietnam is only 82%. The current situation of water use in many urban areas, including Hanoi, shows a lot of inadequacies including the loss of water, poor awareness of people in saving water, illegally destroying the pipelines, etc. which make the water resources more and more exhausted, while the demand for clean water in urban areas is increasing in both quantity and quality. Meeting the demand for clean water to 2030 with average 150-100 liter/person/day is a great challenge for such as special city as Hanoi. Many measures of urban domestic water demand management (UDW demand management) have been initially applied in Hanoi, such as increasing water tariffs and water loss control. However, there is no study to evaluate the effectiveness of these management programs, thus, the problem needs to be addressed is to evaluate economic effect of the UDW demand management programs on the basis of comparing benefits and costs, both at present and in the future.

Theoretical basis of urban domestic water demand management and economic analysis of urban domestic water demand management

Urban domestic water management

Urban domestic water management consists of supply management and demand management. While supply management concerns about the effort of water supply units (for example, find new water sources, build dam and reservoirs, water supply stations, water treatment stations, etc) to expand water supply and meet increasing need of the consumers, demand management influences the behavior of water consumers to encourage or force them to reduce water consumption. In the context that natural resources in the world is increasingly scarce, traditional supply management has become increasingly difficult; demand management is considered as a more appropriate method for the efficient and sustainable use of water resources.

Based on the scientific basis of water demand management and specific conditions of urban area in Vietnam, the author suggests that: UDW demand management is to manage the water volume used for the needs of daily living of urban people/households; based on the selective application of policy, economic and technical measures and other supporting measures to influence the "willingness to buy" of urban people/households in order to promote the water saving, efficient, equitable and sustainable use of water resources.

 Solutions of UDW demand management

Group of economic solutions :

1. Subsidies for installation of water-saving devices in the households

2. Water tariff and water tariff calculation framework

Group of solutions for education and awareness raising:

1. Include water-saving education in schools

2. Propaganda and social mobilization campaign on water saving and efficient use of clean water

3. Promote the benefits of water saving and efficient use of water

4. Popularize the guidelines on water saving and efficient use of water

Group of technical solutions:

1. Solutions to reduce water leakage and loss

2. Use water saving devices in the households

3. Install water meter for the households

4. Water reuse/Water recirculation

Group of institutional solutions:

1.Abolish the regime of fixed total price per month for any volume of used water

2.Restriction on water use in the specific season or rush hours

Economic analysis of urban domestic water demand management

Economic analysis of urban domestic water demand management is defined as the identification, evaluation and comparison of the costs and economic benefits from implementing UDW demand management options, thereby proves the effectiveness of the options, provide information for the decision-making process of state management agencies and water supply units.

For the process of cost-benefit analysis, many authors provide the different number of step in the process. However, their processes are different only when major analytical steps are divided into detailed steps. Thus, cost-benefit analysis always follows a process with the key steps, including: (1) Select the option(s), (2) Determine and evaluate cost-benefit of the option(s) in a certain period of time, (3) Place monetary value and evaluate the costs and benefits, (4) Evaluate the economic effect of the options, (5) Propose the best option and recommend.

Based on general cost-benefit analysis process, the thesis develops the economic analysis process for UDW demand management.

APPROACH FRAMEWORK AND METHODOLOGY

Research framework of the thesis

The thesis aims to synthesize and systematize the scientific basis of UDW demand management, develop UDW demand management model and a process of economic analysis, apply the research on UDW demand management in Hanoi to evaluate the effectiveness of UDW demand management. To achieve the research objectives mentioned above, the author proposes research framework with 3 main parts as illustrated in Figure 3.1, which is explained as follows:

(1) The first part: Scientific basis of UDW demand management and economic analysis of UDW demand management

(2) The second part: Economic analysis of UDW demand management in Hanoi

(3) The third part: Proposed direction and solutions to implement UDW demand management in Hanoi.

Methodology

Method of collecting and synthesizing secondary data

To carry out the analysis and evaluation in the thesis, a number of secondary data were collected including: Documents from local and international publications; Statistical yearbook of Hanoi city; the data related to production status and urban water management activities of HAWACO Hanoi Water Company; Master plan for socio-economic development of Hanoi city to 2020 orientation to 2030, etc.

Method of obtaining expert opinions

To add the source of information and reliability of the results of the thesis, the author met with experts in the field of water supply management, including HAWACO water plant staff, Experience in the field of economic management, water resources management.

Methods of sociological investigation

In the thesis, the author established 02 questionnaires: 01 questionnaires for the households using tap water; 01 questionnaire for managers of water supply units in Hanoi. The author delivered 30 survey sheets to the managers and 400 survey sheets to the households in 3 districts of Dong Da, Hai Ba Trung, Hoan Kiem. The number of valid survey sheet collected from the households is 308.

Market price method

In the thesis, the market price method is used to evaluate the benefits of saving wastewater treatment costs and saving electricity costs for wastewater treatment. The formula is determined by:

Bi = $|Qi - Q\text{o}|$ P

Where:

Bi: value of benefit number i when UDW demand management is applied (million VND);

Pw: treatment cost for 1m3 of wastewater (VND / m3);

Pwđ: electricity cost to treat 1m3 of domestic wastewater (VND / m3);

Qi: Volume of wastewater treated according to UDW demand management option Ca (million m3);

Qo: amount of wastewater treated according to BAU (million m3).

Based on the data from Yen So wastewater treatment plant, the cost of processing 1 m3 of wastewater (excluding electricity cost) is 2,070.64 VND/m3, the electricity cost to treat 1m3 of wastewater is 800 VND/m3.

Value transferring method

The thesis uses BTM method to estimate the benefits of water saving education and the costs of investing in water saving education. Education programs in the city include the development of a water-saving curriculum which is included in textbooks, workbooks and related experiments for the students at all levels.

The benefits of water saving education: converting these benefits as defined by Bill de Blasio in the study of New York City, USA, 2010.

The costs of investing in water saving education: Conversion of these cost as defined

by Beacon Pathway in the study of Tauranga, New Zealand, 2010.

The formula (3.3)is:

$$V\text{đ} = V\text{đc} \times \frac{GDPppp - \text{đ}}{GDPppp - \text{đc}}$$

Where:

$V_{đ}$: The value is converted to the target area – Hanoi (VND/m^3);

$V_{đc}$: Value of benefit/cost of control area ($ Mỹ/m^3 hoặc $ New Zealand/ m^3).

$GDP_{PPP\text{-}đc}$: GDP per capita in purchasing power equal to control area

$GDP_{PPP\text{-}đ}$: GDP per capita in purchasing power equal to target area – Hanoi

Contingent valuation method (CVM)

In the thesis, to estimate the willingness to pay (WTP) of urban residents and to build the UDW demand curve for Hanoi, the thesis was conducted in 5 steps of CVM:

Step 1: Set up questionnaire

Step 2: Conduct the interviews with the specific sample size

Step 3: Analyze the results of the interview and calculate the average WTP

Step 4: Calculate total WTP

Step 5: Evaluate the factors affecting WTP

The thesis carried out WTP regression by the following variables: age (Age), gender (Gen), education (Edu), income (Inc), volume of used water per capita in the household (X).

- The regression equation is:

WTP = C+β1 Age + β2 Gen + β3 Edu + β4 Inc + β5X

To build the demand function and draw the water demand curve for urban areas in Hanoi, the thesis uses the software Eview 8.1.

Method of forecasting urban domestic water demand

Water demand forecast is used to estimate the demand for UDW in relation to the selected options, thereby determine the amount of water saved when UDW demand management is implemented compared to non-UDW demand management.

The thesis selects the method of combining expert judgment and trend analysis. Trend analysis is based on an extrapolation of historical trends, or population growth figures multiplied by the average volume of used water per capita.

Non-UDW demand management option (baseline scenario - BAU): From 2010 to 2013, the water demand was determined by using the actual data of water supply from Hanoi Water Company, the water demand per capita increased by 0.7%/year. From 2013 to 2025, the water demand per capita is extrapolated to increase at the same rate of 0.7%/year.

UDW demand management option: From 2013 to 2015, the water demand was determined by using the actual data of water supply from Hanoi Water Company (as the solution of raising water tariff was applied, water demand per capita has increased less than the years when UDW demand management was not applied). The average water demand per capita was 0.35%/year. From 2010 to 2013, the amount of water used for daily living was recalculated based on the assumption that water consumption per capita increased by 0.35%/year. In the period from 2016 to 2025, extrapolation with the

assumption that water consumption will continue to increase at a rate of 0.35% per year from 2013 to 2015.

Method of cost-benefit analysis

Based on the documents and experience in analyzing economic effect of the economists, and specifically based on the cost-benefit analysis process, the thesis develops the process of cost-benefit analysis for UDW demand management option. To assess the effectiveness of UDW demand management in Vietnam in general and Hanoi in particular, the economic analysis process proposed by the thesis consists of six basic steps:

(1) Identify problems and develop the option

- UDW demand management option (QLCa): Hanoi implements three groups of solutions, which are: (1) Water loss management, (2) Water tariff increase, and (3) Education to raise awareness about water saving and efficient use of water.

- Non-UDW demand management option or "baseline scenario" (BAU), is a hypothetical analysis about the impacts occurring if Hanoi does not choose to implement UDW demand management.

(2) Determining cost-benefit of QLCa option

In Hanoi urban area, based on a survey of current status and expert consultation, the thesis lists 10 potential benefits and 3 costs arising from the implementation of UDW demand management from a management perspective.

(3) Evaluate (estimate) the values of the costs - benefits

The main methods used to estimate the values of costs and benefits in the thesis are: estimated market price; BTM; CVM to build domestic water demand curve; correlation function.

(4) Analyze the effectiveness of QLCa option

In the 3 indicators of economic effectiveness, the thesis selects NPV (net present value) to perform the calculation and evaluation. The formula is:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

Where: r: discount rate; n: estimated number of years of project/program existence; t: corresponding time, 1, 2, ..., n; Bt: benefit at year t; Ct: cost at year t.

(5) Sensitivity analysis by factors affecting cost-benefit

The thesis conducts a sensitivity analysis with the changes of the factors including water tariff, cost of water loss management and cost of education to raise awareness about water saving, discount rate, and electricity costs.

(6) Select the appropriate option to apply

The selected option is the one with the largest positive NPV.

ECONOMIC ANALYSIS OF URBAN DOMESTIC WATER DEMAND MANAGEMENT AND PROPOSED SOLUTIONS FOR URBAN DOMESTIC WATER DEMAND MANAGEMENT IN HANOI VIETNAM

Introduction about Hanoi

Hanoi is the capital of Vietnam, the second largest city of the country, located in the center of the Northern Delta with many advantages and opportunities for socio-economic development. However, satisfying the demand of clean water for the people in Ha

Noi is a great challenge for many reasons: the urbanization process and the challenge of increasing urban population in Hanoi lead to increasing water demand; the demand of water quality is higher and higher while the quality of water supply decreases; clean high rate of water leakage and loss in Hanoi.

Current status of domestic water production and supply in Hanoi

The results show that the city has 12 main water plants managed and operated by Hanoi Water Company. However, the exploitation of underground water is so difficult that 90% of the factories cannot. maintain the capacity. The average output of the plants is 1,462,000 m3/month. Among the water consumption groups, the household is the largest group, accounting for 55.04% of total commercial water production.

From the statistics on urban water supply from Hanoi Water Company, data about the consumers, the number of people accesses to clean water in Hanoi, the study calculated the average water supply per capita supplied to people in urban districts of Hanoi, as shown in Table 4.3.

Thus, the average water use rate per capita is 130 liters/person/day (equivalent to 3.93 m3/person/month). The results of survey conducted with staff of the company show that the water supplied to the market now meets 80% of the demand, of which the percentage of people accessing water in the inner city is about 95.75%, in suburban area is 14%. However, in fact, many areas lack water, especially in the summer in the dormitories, old streets with high population density.

Current status of UDW demand management in Hanoi

The results of secondary data analysis show that Hanoi start using UDW demand management:

- The implementation system is People's Committee of the city, relevant departments such as Department of Finance, Department of Construction, Department of Agriculture and Rural Development through Hanoi Water Company to influence the households, domestic water consumers.

- Two UDW demand management solutions are water loss prevention and water tariff increase;

- A number of important legal documents of the central government and Hanoi city contain the regulations on saving and efficient use of urban water.

Assessment on urban domestic water demand in Hanoi

Current status of using domestic water of Hanoi people

According to the survey results, the average number of households using water from 10 m3/month to 15 m3/month accounts for the highest rate of 46.15%. As described by statistical results, the average usage of 308 households is 15.03 m3/month (equivalent to 3.8 m3/person/month). The thesis performed a descriptive statistic of the rate of average water use for non-essential purposes which results in 5.24%. Thus, the water demand for non-essential purposes is estimated at 0.78 m3/household/month.

Willingness to pay of Hanoi people

Statistical results describe WTP of the surveyed households in 3 urban districts of Hanoi.

Shows that the average WTP of the households for 1m3 of water is WTPTB = 9,534.88 VND/m3, with the observation of 258, the standard deviation of 1,242.96.

 Assess the factors affecting willingness to pay

Eview 8.1 is used to analyze the factors influencing WTP, in which independent variables include age, gender, education level, income and volume of used water. The results of multivariate regression are shown in Table 3.9:

Thus, regression is:

WTP = -3.508258 + 0.045654Age - 0.414596Gen + 0.553649Edu + 1.857481Inc - 0.160386 X

R - Square = 0.623423 means that the independent variables in the models (the age, gender, educational level, income, and volume of used water) can explain about 62.34% of WTP variation in Y (price for which the consumers are willing to pay). The remaining 37.66% is for contingent factors and other factors not included in the model. Among independent variables, income and volume of used water are strongly correlated with WTP variable.

 Current domestic water demand curve in Hanoi

The study conducts descriptive statistic of average volume of water used by the households, the average number of family member, thereby estimates the average volume of water per capita. Combination of this data and current population of Hanoi (year 2016) will create a basis for the calculation of total volume of used water in Hanoi corresponding with each price level. The results are shown in table 4.10

From the figure in table water demand function is established and shows the relationship between the price of WTP (Y) and the total volume of used water (X). The demand function is:

Y = -1080,88 X + 12.584,19

Linear function (3.1) with:

a = -1080,88 < 0. Thus, the volume of used water decreases when the prices increase, this is perfectly consistent with the theory and practice; b = 12.584,19 represents for the remaining factors not included in the model.

Correlation coefficient R2 = 0.724982 proves that the independent variables can explain 72.49% of the dependent variable values, the error due to other factors (noise) is 27.51%.

Consider the limit of the values X, Y:

The WTP value is the basis for the construction of demand function and the nature of WTP curve is to coincide with the demand curve. Thus, the value of Ymax is the highest level of willingness to pay of Hanoi people for domestic water use. According to the survey results, Ymax value = 12.000 VND/m3, put this value into the equation 4.1, value of X = 11.63 (million m3)

Forecast of domestic water demand in Hanoi until 2025

According to data from Hanoi Water Supply Company, the average volume of water supply per capita in the city is 3.93 m3/person/month. The sociological survey shows that the average water demand per capita is 3.8

m3/person/month. It is found that the average volume per capita of water demand and water supply are not much different (3.8 m3/person/month and 3.93 m3/person/month respectively), thus, the difference may be explained by the loss of water. As a result, the forecast of urban domestic water demand in Hanoi to 2025 is based on the assumption (section 2.5.6) is reliable. Urban domestic water demand in Hanoi from 2010 to 2025 is calculated according to BAU and QLC options shown.

Based on the calculated data in the table, it is forecasted that domestic water demand will increase by 40.92 million m3 in 2025 compared to 2013 (for BAU option) and the volume of water saved by implementing UDW demand management by 2025 is 6.98 million m3. As a result, even there is no investment in expanding water supply infrastructure, the application of UDW demand management can address 17.1% of increased domestic water demand.

Economic analysis of UDW demand management option in Hanoi

Domestic water management option in Hanoi

 Option with UDW demand management (or QLCa):

• Solution of water loss management: install, check and replace/repair the broken water meters; verify water meters.

• Solution of water tariffs: Progressive water tariffs applied to the private sector (daily activities). Water tariffs are adjusted from 2013 to 2015.

• Educational solutions for efficient water use in schools: develop water-saving curriculum included in textbooks, workbook, related experiments for students at all levels. Organize water conservation seminars for teachers.

 Compared option or "baseline scenario" (BAU)

• Hanoi does not apply UDW demand management

Identify cost-benefits from UDW demand management option in Hanoi

The author conducted the survey and expert consultation to determine the cost-benefit list of suitable QLCa for Hanoi.

The calculation results of costs and benefits from implementation of QLCA option in Hanoi in the period 2010-2025 are shown in Figure 4.16.

The thesis has estimated 8 benefits and 3 costs of QLCa option in Hanoi in the period 2010-2025. The study calculated the net present value of QLCa in Hanoi which is NPV = 734,597.01 (million VND) with a discount rate of 0.05. However, values of two benefits that are not estimated: Entertainment benefits (B8) and Reduce scarcity of water resources (B9). Although these two benefits may arise in the study to a certain extent, it is difficult to assess these benefits due to lack of the necessary data.

Proposed direction and solutions to implement urban domestic water demand management in Hanoi

In order to implement effective management of the demand for irrigation water supply in Hanoi, the thesis proposed a solution based on the results of the analysis of the current status of water supply management in Hanoi. The results of net present value analysis of NPV correspond to each bridge management solution, to select the priority order of solutions, include:

• Increased water tariff: increasing water tariff with reasonable roadmap and consensus of consumers. Include increased wastewater treatment cost in the water tariff. On the water bills of the households, 0.78 m3 will be separated by applying price at level 4 in the progressive pricing framework.

• Strengthen water loss management: water use audit in the households, schools, offices; apply GIS in customer pipeline network management.

• Diversify forms of communication and education to raise community awareness on efficient water use: Integrate education programs on water saving in schools; Propaganda and social mobilization campaign on water saving; popularize the guidelines on water saving on the mass media.

References

ADB (2009) Water – vital for Vietnam's future. Asian Development Bank & Office of National Water Resources Council, Hanoi, Vietnam.

Anh M. T. P., Ali M., Anh H. L. and Ha T. T. T. (2004) Urban and peri-urban agriculture in Hanoi – Opportunities and constraints for safe and sustainable food production. AVRDC – The World Vegetable Center, Technical Bulletin No. 32, AVRDC Publication 04-601, Shanhua, Taiwan, pp.66.

Anh N. H. (2010) Wastewater management and treatment in urban areas in Vietnam. In: Proceedings of the 1st WEPA International Workshop, Hanoi, Vietnam.

AWWA (2008) Manual of water supply practices, water audits and loss control programs (M36), 3rd Edn., American Water Works Association, Denver.

Dan N. V. and Dzung N. T. (2002) Groundwater pollution in Hanoi area, Vietnam. ESCAP – IWMI Seminar on Environmental and Public Health Risks Due to Contamination of Soils, Crops, Surface and Groundwater from Urban, Industrial and Natural Sources in South East Asia. Hanoi, Vietnam. December 10th – 12th 2002.

Danilenko A., Dickson E. and Jacosen M. (2010) Climate change and urban water utilities: Challenges & opportunities. Water Working Notes. Water Sector Board of the Sustainable Development Network of the World Bank Group.

Dung N. N. (2007) Integrated management of groundwater resources in Hanoi to meet the needs of urban water consumption. In: Proceedings of the 10th Scientific Workshop - The Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN), Vietnam.

GSO (2011) Result of the survey on household living standards 2008. General Statistics Office of Vietnam,

Hanoi People's Committee (2009a) Decree No. 119/2009/QĐ-UBND. Government Portal

Hanoi People's Committee (2009b) Decree No. 120/2009/QĐ-UBND. Government Portal

HSO (2010) Hanoi Statistical Yearbook 2009. Hanoi Statistical Office, Hanoi.

IMHEN (2010) Impacts of climate change on water resources and adaptation measures – Final report. Vietnam Institute of Meteorology, Hydrology and Environment, Ministry of Natural Resources and Environment (MONRE).

MoC (2009) Orientation for municipal master plan in Vietnam to 2025 and vision to 2050. Ministry of Construction, Hanoi, Vietnam. (in Vietnamese)

MONRE (2003) Vietnam environment monitor 2003 – Water. World Bank in Vietnam, Danish International Development Assistance, and Ministry of Natural Resources and

MONRE (2010) Synchronous solutions for water losses prevention. Ministry of Natural Resources and Environment, Vietnam,

Nakagawa N., Otaki M., Aramaki T. and Kawamura A. (2009) Influence of water-related appliances on projected domestic water use in Tokyo. Hydrological Research Letters, 3, 22-26.

Nguyen T. Q. and Helm D. C. (1995) Land subsidence due to ground water withdrawal in Hanoi, Vietnam. In: Proceedings of the Fifth International Symposium on Land Subsidence, IAHS (International Association of Hydrological Sciences), The Hague, Publ. No. 234.

Otaki Y., Otaki M., Aramaki T. and Sakura O. (2003) Residential water demand analysis by household activities. In: Proceedings of Efficient Use and Management of Water for Urban Supply, Tenerife, Canary Islands, Spain, CD-ROM.

Otaki Y., Otaki M., Bao P. N., Nga T. T. V. and Aramaki T. (2013) Micro-component survey of residential water consumption in Hanoi. Water Science & Technology: Water Supply, 13(2), 469-478.

Schuttenbelt P., Anh N. V. and Withney B. (2009) Sustainable urban development forum 2009- Challenges in the wastewater and waste sector in Vietnam, background paper. InWEnt – Capacity Building International, Germany. Regional Office in Vietnam.

VIWASE (2010) Master plan on urban water supply for Hanoi City to 2030 and vision to 2050 - First report. Vietnam Water, Sanitation and Environment Company. (in Vietnamese)

VWSA (2009) Benchmarking of urban water supply in vietnam (2004-2007). Vietnam Water Supply and Sewerage Association.

Winkel L. H. E., Trang P. T. K., Lan V. M., Stengel C., Amini M., Ha N. T., Viet P. H. and Berg M. (2011) Arsenic pollution of groundwater in Vietnam exacerbated by deep aquifer exploitation for more than a century. PNAS, 108(4), 1246-1251.

Env