

## **Household Level Water Recycling for Non-Potable Reuse: A Study on Mujgunni Residential Area of Khulna City, Bangladesh**

**Md. Salauddin\***

### **Abstract**

The paper examined the possibility and of reusing household's grey water for non-potable uses as a means for reducing fresh water demand. The study was done in one of the planned residential areas of Khulna city where water demand and consumption is higher than other haphazardly grown areas. The study used two databases and other secondary materials, collected from relevant organizations. In addition personal communication has been made with concerned personnel. The study found that the residence of the study area get 46% supply water compared with only 20% in the whole city. Availability of water increased water consumption up to 300 litres per day per household. A significant amount of water (90%) is used for bathing, washing and cooking. Both the shower and kitchen water goes straight to drainage system to be more polluted with other toxic wastes. On the other hand, supply system is entirely based on ground water and absence of demand management techniques, over-extraction of ground water has been observed. Khulna city and surroundings have been facing salinity and arsenic contaminations in ground water, making it too vulnerable to provide fresh water to its 1.5 million citizens in coming years. Water treatment still remains uncovered in Bangladesh and authorities repeatedly had gone for capital intensive ground water extraction. Keeping in mind the ease, affordability and available technology, dual-reticulated recycling method is thus advised where the grey water will go again for toilet flushing and gardening after minimal treatment. It was assumed that the system will bring the half of the household waste water into use which will eventually reduce demand for fresh water.

### **Introduction**

Urban services including water supply are in acute shortage. Due to its geographical location, both the surface and ground water in major parts of the city is saline. Moreover, construction of Ganges Barrage in Indian side reduces water flow in main river systems and increase salinity (Ahsan, 2012). Barrages controls by India to all of the tributaries to the Ganges divert roughly 60% of river flow (Pender, 2008). By the 5<sup>th</sup> largest dam in the world, average monthly flow by to Bangladesh was reduced by 86% (ibid). Salinity problem becomes wide spread in the dry season. Khulna city do not have any surface water sources due to mismanagement and lack of perceptive planning and regulation. Thus ground water remains the main water source for the city. Only about 6% city residence use surface water (e.g. ponds, canals) for non-potable uses. Overexploitation of ground water led to arsenic contamination which becomes viral. Almost all of the KCC area is moderately arsenic affected (KDA, 2001). The gross population density of Khulna city is 67,994 per sq. km and a large number of people are involved in informal activities (KCC, 2013). The city also characterised by lower level of revenue earnings, resulting

---

\* Assistant Professor, Urban and Rural Planning Discipline, Khulna University, Khulna, Bangladesh, Email: ahmedsajal@gmail.com

poor municipal resource base. Revenue earnings through holding tax were only 22% (KDA, 2001). Daily water uses by households in Khulna city were found as high as 192 liter in the city core whereas it is much lower in urban fringe and municipality area, 112 liter (Alam et al, 2009). A significant amount of the water is used for single purpose-bathing took near the 50 percent of total use in city areas. On an average, a household spent near about 80 liter for bathing (Alam et.al, 2009). This huge volume of water goes straight to drainage system to be more polluted with other toxic wastes, fails to draw attention of the concerned authority.

The paper searched for alternative mechanisms to reduce dependency on ground water. Household water demand, consumption pattern and wastewater generation has been explored. The study also seek to explore possible vulnerabilities of future ground water reserve and advocated for a household based recycling system to make efficient use of water. Recommends were made to make the system affordable at household level, for concerned authority while approving building construction and for public awareness on sustainable water use.

### **A Review on Water Crisis, Consumption, Supply and Demand Management**

A large proportion of population concentrates in small and large urban centers of low- and middle-income countries of them most at risk due to the effects of climate change – as lives, assets, environmental quality and future prosperity are threatened by the increasing risk of storms, flooding, landslides, heat waves and drought and by overloading water, drainage and energy supply systems. Cities are believed to be the first to be affected due to climate change. Overexploitation of resources and abandonment of natural system has made the cities, according to Kalr and Trenberth (2003) a ‘concrete jungle’ which effects on effects on heat retention, runoff, and pollution, resulting in urban heat islands.

World Urban population are increasing rapidly with a 3% annually since 1950 and is expected to be doubled by 2050 (WHO, 2013). Vorosmarty et.al (2000) studied on the global water availability and challenges in the age of high population densities in urban areas. They concluded that much of the world will face substantial challenges to water infrastructure and associated water services. It is thus assumed that cities will have to adopt hi-tech options to meet up extra demand. Much of the world urban population will live in developing countries, mainly due to high rural to urban migration rate. Between 1995 and 2005, the urban population of developing countries grew by an average of 1.2 million people per week, or around 165 000 people every day and By the middle of the 21st century, it is estimated that the urban population of these counties will more than double, increasing from 2.5 billion in 2009 to almost 5.2 billion in 2050 (WHO, 2013).

The challenge is not the availability of water but providing safe water. Over 25 million people in Bangladesh do not have access to an improved water sources (WaterAid-UK, 2013). Water sector lacks insightful ideas and mostly governed through capital investment. Al-Jayyousi (2003b) argued that most of the water project in developing countries are supported from external sources and failed to sustain after withdrawal of aid. Thus water management under current and coming stresses need to be more innovative.

There are a number of social and economic model of household water consumption. A social model developed by Gregory and Di Leo (2003) emphasized environmental behavior where awareness (i.e., issues, knowledge and opportunities) affects unreasoned (habits and reflexes), and reasoned (i.e., involvement, attitudes, intentions, perceived self-efficacy) influence. Furthermore, behavior is also affected by situational influences (e.g., socioeconomic, household and physical environmental variables). This model has been tested with residents of Shoalhaven, Australia. They have found that environmental awareness, personal involvement, habits and demographic characteristics (e.g. income, age, education and household size) have some predictive ability for household water consumption.

Water consumption also said to be influenced by hours of living in home, age related diseases (Green, 2003 and Russac et al., 1991 in Memon and Butler, 2006;). Affluence also is a key factor in influencing water consumption. It was found that water use in urban residence and high quality houses in developing countries are more than double of the suburb and rural areas (Stephenson, 2003 in Memon and Butler, 2006). Water uses thus have a strong positive correlation with affluence and geography. However, there are still some factors that believed to have influence of water use and yet to be exposed. Less discussed but potentials factors would be number of children in a household and weather in a particular location. Countries in tropical and subtropical areas can have high demand of water for frequent washing purposes.

A most recent study on peri-urban water security in Khulna was done with a focus on identifying the climate vulnerability of water sources and adapting techniques of local people (Kumar et al., 2011). This research took into account the institutional arrangement of water supply and going to provide a community level coping mechanism. However, no indication of demand management or water recycling was given to the scoping report. Earlier, in 2010 Asian Development Bank has conducted a city wide study on water supply with a view to finance in the water supply sector through KWASA. Water demand management and repairing water leakages were recommended along with core economic solution like construction of reservoirs and ground water management (ADB, 2011b). Eventually, KWASA has taken a project which proposed a surface water system which will distribute water through a system of storage reservoirs and overhead tanks. Authorities are still interested in large physical investments rather than soft policies of supply and demand management. Vairavamoorthy and Mansoor (2006) argued that water supplies in most developing countries are supply driven where shortage of supply embraces capital investment. These kinds of practices, as UN-HABITAT (1999), quoted in Vairavamoorthy and Mansoor, 2006:) concluded create impediments on taking innovative approach for demand management. A number of demand management approaches have been prescribed by Vairavamoorthy and Mansoor (2006) like water pricing, subsidies, wastewater reuse, water metering etc. Soft side demand management approaches e.g. institutional capacity building, public awareness has also been proposed (ibid).

Several studies have found that organization led demand management approaches were not successful. As for example, water pricing is considered to have influence on consumption but the belief has more recently been dispelled by the research from Worthington and Hoffman (2008); Barrett, (2004). They demonstrated that in most cases

residential water demand is largely price inelastic because of its low relative cost when compared to other life essentials (Worthington and Hoffman 2008; Barrett, 2004 cited in Wills et al. 2011b). Darby (2010) studied efficiency and applicability of smart metering for reduction in demand and costs but got little evidence in demand reduction. However, she concluded by saying that metering could influence demand reduction if a strong strategic intention from the authority and social support was ensured.

The potentials of decentralized water recycling were not understood in Bangladesh though it is very much common in Australia and USA and developing countries like Malaysia. UK still has the low rate of implementation but from 2016 all buildings are to be constructed according to the highest level of the code, the internal per person daily water use has to be less than 80 liters suggested in Codes for Sustainable Homes (Environmental Agency, 2011). Majority of consumers (63%) do not pay water bill by volume which also a reason for low level of grey water recycling in UK. However, in recent years, a number of studies have been done on application of household greywater reuse in UK and Ireland e.g. in Ireland (Li et. al, 2010) and Birmingham eastside (Maunsell, 2004). Study carried out at southern France, among 400 municipalities found it that the choice of a water-pricing structure is a complex exercise, involving trade-offs between cost recovery, equity, and environmental efficiency (Rinaudo et. al, 2012; p 2067). In their study (Short, et. al, 2012; p 1954) on water system in Australia, 60% responded opposed to price increase as a tool for demand management. Around 80% responded that they had installed water saving devices. About 61 percent were in favour of authorities responses in installing water saving equipment. The study also stressed on community awareness regarding efficient water uses.

### **Methodology**

Data were retrieved from two databases (Khanam, 2010 and KDA, 2012) containing household socio-economic as well as water related information of the case study area and whole Khulna city to get data about water supply, use and wastage etc. Khanam (2010) Studied on water supply status of Mujgunni residential area and KDA (2012) conducted socio-economic household survey under the and sample survey under Detail Area Planning (DAP) for Khulna Metropolitan area. Urban and Rural Planning Department of Khulna University was a reliable sources of data in forms of dissertation, project reports on water supply system of Khulna city. KWASA had been preparing water supply master plan which was another source for current planning proposals.

### **Findings and Analysis**

#### **Design Recommendation**

Based on the findings, this study proposes a dual piped water supply system where wastewater will be stored in the basement and later the water taken to the rooftop water tank for supplying water to toilet flush and other non-potable use (e.g. car wash, gardening, outside cleaning).

In the existing plumbing system, Shower and kitchen waste water are carried through pipe only to discharge in the drainage system. With some addition piping arrangements, these large volumes of water can be stored for non-potable uses. Building structure in the

study area is suitable for the recommended design. Almost all the buildings in the study area are at least two-storied (91.5%). Toilet, shower and kitchen will have different piping system to collect the waste water.

A new basement storage tank will be constructed where waste water from these two sources will mount up. This storage tank will have two separate chambers to allow suspended solids in the waste water settle down and enter the next chamber. Then the waste water will flow across another small rectangular shaped chamber filled by small brick/small rock particles and sand. This chamber will work as filter bed which will rectify the water holding finer suspended solid and germs. This system can effectively reduce germs and solid from the waste water as the system will run continuously round the clock. The rectified water will then store up in a small tank from where water will be transported to rooftop water tank.

The rooftop water tank will have a separate chamber allows two types of water flow in two separate piping system. An additional outlet will be taken to the basement from the recycled water tank for washing and gardening purposes. Layout of the basement or underground recycled water reservoir and the connection system is highly case specific, will depend on quantity of wastewater, plot size and building materials.

A Wide variety of options, however, are available to make the system more pathogen free. Water Aid-Bangladesh, with the technical help from Centre for Science and Environment (CSE), India has implemented a number of community based projects in Tangail and Khulna. Though CSE has implemented the techniques successfully in different institutions and community, the total system can be squeezed into the basement of a building (<http://www.cseindia.org/node/3798> and Salauddin et al., 2012).

Nevertheless, the proposed recycling mechanism could face a number of challenges. Cities of Bangladesh are densely population and land is scarce. From the technological point of view, recycled waste water can be beyond of non-mechanised treatment after several reuse. The necessity of regular maintenance can be act as a disincentive for the households. But the continuous research and successful application of this kind of recycling system in different parts of the world brings hope to cope with the most scares resources.

### **Implementation Mechanism**

The proposed system will require several focused institutional responses as well as collaboration from consumers. The whole process should have to be managed by KWASA, with continuous consultation with KCC and KDA in plan making and implementation. Implementation mechanisms that might be in action are discussed below:

### **Institutional Arrangements in Plan Making and Implementation**

Current segregation in plan making and isolated implementation should be synchronized by responsibility sharing within the common goal of city development. Organizations will share their aspiration in plan making. While providing water connection, KWASA will seek building approval letter from KDA and vice versa. KCC, as a local government will work closely with community people to make the system acceptable. KCC, KWASA and KDA should endeavour towards capacity building, an

essential step for better implementation of Plans. Currently the organizations are running with manual record keeping which is a major impediment in collaboration. It also restricts civil society and people from information and decrease the transparency of service providing organizations. A central record keeping system is necessary taking into consideration the three important areas of management such as transactional activities, operational activities and management control.

#### **Municipal Tax Discount**

Properties are charge annually by KCC in the name of holding tax. While approving new building plans, KDA will consult with the applicant to include a recycling system by offering tax rebate for a certain period of time, depending on the building type and capital involvement. However, KDA is now not in a position to impose the system because the rate of application for building plans approvals are quite low. Further strict regulation might have negative impact on plan approval process. Adopting of recycling system would be a 'carrot approach' in the first instances and gradually moved to 'stick and carrot' approach. The plan approval committee in KDA would consist of member form KCC and KWASA. The amount of tax rebate against each application would be recorded. The short term losses of KCC from tax rebate can be compensated from water charges.

#### **Restructuring Housing Loan**

Bangladesh House Building Finance Corporation (BHBFC) and scheduled banks are giving loans to individuals for constructing houses. Before sanctioning loans, financial institutions seek building construction approval letter from concerned authority. Thus, KDA can amend their building regulations and work closely with the applicants to install the recycling system for speeding up the loan approval process. Organization agreement between KDA, KWASA and financial institution are required. Interest rates for the loan can be lowered for those plans having recycling system. High recommendations can be made available to the financial institutions for those building plans. To monitor the process, total loan amount can be distributed at different stage of the building constructions.

#### **Financial and Logistic Supports from KWASA**

KWASA proposed a new connection charge applicable to all buildings. It is assumable that houses without any recycling system would consume more fresh water. KWASA thus, can propose a different connection charge and monthly water tariff higher than the houses will have install recycling system. Moreover, connection charges can be divided into affordable instalments over a certain period of time. To help consumers and make them familiar with the system, KWASA will have a logistic division for water recycling. It would help the building owners design their building with efficient recycling system. In addition, KWASA will work with the already constructed buildings owners in installing recycling system. Once installed, maintenance of the system will be done by the owner of the house and costs will be shared by the tenants with the monthly water charges.

### **Awareness Campaign and Community Involvement**

Community involvement and awareness campaign is crucial in mainstreaming water recycling. Professionals e.g. Architects, Planners, Engineers need to be motivated. Prejudice and conservativeness towards wastewater reuse needs to be eliminated through proper consultation with consumers and community people. Awareness regarding water crisis and citizen's responsibilities towards water use behaviour should be highlighted and publicized through appropriate media (e.g. workshops, trainings and guiding documents).

### **Conclusion**

The study aimed to identify alternative solution to reduce over-extraction of ground water and wastage of water in a city where water is scarce and most of its residence did not have sufficient safe water. Consideration of demographic attributes along with existing qualitative and quantitative assessment of water supply services illustrates that the surface and ground water resources are in vulnerable position by overutilization, exploitation and ignorance. Piped water network was inadequate. Water supply authority assumed that their proposed extension of pipeline and surface water sources would increase the supply after the plan period. However, without efficient demand management, the situation might get worse. Increasing urban population will struggle to have safe water. With limited resources and unseen negative environmental externalities, rethinking in providing water services is urgently important. The study proposed a household level water recycling system as a tool for demand management. The system would enable households to retain the wastewater for reuse. Recycled water will be used for non-potable uses where fresh water was being used. Some implementation mechanisms have been proposed in context of Khulna city. It was believed that the system would help building awareness among people in prevailing adverse economic and environmental situation as well as help building consensus in securing resources for sustainable development.

### **References**

- ADB (Asian Development Bank), 2011b. *Adapting to climate change: strengthening the climate resilience of water sector infrastructure in Khulna Bangladesh*. [online] Available at: <http://www.adb.org/sites/default/files/pub/2011/adapting-climate-change-ban.pdf> [accessed 20 December 2012]
- ADB (Asian Development Bank), 2013. *Khulna Water Supply Project: Project Data Sheet (PDS): Details*. [Online] <http://www.adb.org/projects/42171-013/details> [Accessed 18 July, 2013]
- Ahsan, S.M.R., 2012. *Climate Change and the Urban Poor in Khulna Presentation on the Existing Situation and Outlook*. [Online] Available at: [http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Resilient\\_Cities\\_2011/Presentations/B/B2\\_Ahsan.pdf](http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Resilient_Cities_2011/Presentations/B/B2_Ahsan.pdf) [Accessed 20 July 2013]
- Alam, M. A., Tuhin, M. A. R., Hossain, M. Z. and Salauddin, M., 2009. Designing an Effective Water Supply Network for Khulna City: A GIS Based Approach. *PLAN PLUS*, 5. Khulna: Urban and Rural Planning Discipline. pp. 88-101.
- Al-Jayyousi, O.R., 2003a. Greywater reuse: towards sustainable water management. Desalination [Online] Available at: <http://www.sciencedirect.com/science/article/pii/S0011916403003400> [Accessed 28 December 2012]

- Al-Jayyousi, O., 2003b. Global and Local agendas in water management: from vision to action. In: C.M. Figuerres, C. Tortajada, and J. Rockstrom, eds. 2003. *Rethinking water management: Innovative approach to contemporary management*. London: Earthscan Publication Ltd. Ch 3
- BBS, 2010. Report of the Household Income and expenditure survey 2010. Ministry of planning. [http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/HIES-10/Cont\\_Summary\(3\).pdf](http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/HIES-10/Cont_Summary(3).pdf) [Accessed 12 July 2013]
- BBS (Bangladesh Bureau of Statistics), 2012. Population census 2011. Ministry of planning: BBS.
- Darby, S., 2010. Smart metering: what potential for householder engagement? *Building Research & Information*. [online] Available through Newcastle University library website <http://www.ncl.ac.uk/library/> [06 August 2013]
- Environmental Agency, 2011. *Greywater for domestic users: an information guide* [Online] Available at: <http://cdn.environment-agency.gov.uk/geho0511btwc-e-e.pdf> [Accessed 02 January 2013]
- Gerring, J., 2004. What Is a Case Study and What Is It Good for?. *American Political Science Review*. [online] Available at: <http://people.ucalgary.ca/~nmstuewe/CaseStudy/pdf/whatisacasestudy.pdf> [Accessed 10 August, 2013]
- GHK International, 2001. Addressing urban poverty through City development strategies A case of Khulna city, Bangladesh. Draft Final Report. United Kingdom: GHK International Ltd.
- Gleick, P. H., 1996. Basic water requirement for human activities: meeting basic needs. *Water international*. [online] Available at: [http://www.pacinst.org/reports/basic\\_water\\_needs/basic\\_water\\_needs.pdf](http://www.pacinst.org/reports/basic_water_needs/basic_water_needs.pdf) [Accessed 05 July 2013]
- Gregory, G.D. and Di Leo, M., 2003. Repeated behavior and environmental psychology: the role of personal involvement and habit formation in explaining water consumption1. *Journal of Applied Social Psychology*. 33, pp. 1261-1296.
- Green, C., 2003. *Handbook of water economics-principles and practices*. UK: John Wiley and Sons Ltd.
- IFAD (International Fund for Agricultural Development), 2013. *Water facts and figures*. [Online] Available at: <http://www.ifad.org/english/water/key.htm>. [Accessed 10 July 2013]
- Rinaudo, J.D., Neverre, N and Montginoul, M., 2012. Simulating the Impact of Pricing Policies on Residential Water Demand: A Southern France Case Study. *Water Resource Management* [Online] Available at: <http://link.springer.com/article/10.1007%2Fs11269-012-9998-z> [Accessed 25 December 2012]
- Kaika, M., 2006. The political ecology of water scarcity: the 1989-1991 Athenian droughts. In: N. Heynen, M. Kaika, and E. Swyngedouw, E., ed. 2006. *In the nature of cities: urban political ecology and the politics of urban metabolism*. UK: Routledge. Ch 10
- Karl, R.R. and Trenberth, K.E., 2003. Modern Global Climate Change. *Science magazine*. [online] Available at: <http://www.sciencemag.org/content/302/5651/1719.full> [Accessed 10 August 2013]
- KDA (Khulna Development Authority), 2001. *Master Plan, Vol-III*. Khulna: Khulna Development Authority.
- KDA (Khulna Development Authority), 2012. Socio-economic and Environmental Survey. Preparation of Detailed Area Development Plan for Khulna Master Plan Area (2001) Project. Khulna: Khulna Development Authority.
- Khanam, M., 2010. A Comparative Study on Water Utilization in Mujgunni and Banorganti Residential Area. BURP. Khulna University
- Khanam, M. and Mansur, R.A., 2011. Comparison of water utilization between planned and unplanned residential area: Khulna city perspective. In: IWFEM (Institute for Water and

- Flood Management), 3rd International Conference on Water & Flood Management. Dhaka, Bangladesh. 8-10 January 2011.
- Kumar, U., Alam, M., Rahman, R., Mondal, S., and Huq, H., 2011. *Water Security in Peri-Urban Khulna: Adapting to Climate Change and Urbanization*. [online] Available at: <http://www.saciwaters.org/periurban/2%20idrc%20periurban%20report.pdf> [Accessed 15 June 2013]
- KWASA (Khulna Water and Sewerage Authority), 2013. *About Khulna WASA* [Online] Available at: <http://www.khulnawasa.org/about.php> [Accessed 02 January 2013]
- KWASA (Khulna Water and Sewerage Authority), 2013. Personal Communication with Md. Kamaluddin Ahmed, Superintendent Engineer on 15 June, 2015
- Li, Z., Boyle, F. and Reynolds, A., 2010. Rainwater harvesting and greywater treatment systems for domestic application in Ireland. *Desalination* [Online] Available at: <http://www.sciencedirect.com/science/article/pii/S0011916410003504> [Accessed 27 December 2012]
- Marks, J.S., Taking the public seriously: the case of potable and non potable reuse. *Desalination* [Online] Available at: <http://www.sciencedirect.com/science/article/pii/S0011916405007277> [Accessed 03 January 2012]
- Maunsell, F., 2004. Greywater recycling and rainwater harvesting feasibility study sustainable Eastside [Online] Available at: <http://www.sustainable-eastside.net/Greywater%20and%20Rainwater%20Feasibility%20Study.pdf> [Accessed 03 January 2013]
- Memon, F.A. and Butler, D., 2006. Water Consumption trends and demand forecasting techniques. In: D. Butler and F.A. Memon, eds.. *Water demand management*. UK IWA Publishing. Ch 1.
- Pender, J.S. 2008. *What Is Climate Change? And How It Will Effect Bangladesh. Briefing Paper. (Final Draft)*. [online] Available at: <http://www.kirkensnodhjelp.no/Documents/Kirkens%20N%C3%B8dhjelp/Publikasjoner/Temahefter/FINAL%20Draft%20WHAT%20IS%20CLIMATE%20CHANGE%20AND%20HOW%20IT%20MAY%20AFFECT%20BANGLADESH.pdf> [Accesses 10 August, 2013]
- Russac, D.A.V., Rushton, K.R. and Simpson, R.J., 1991. Insight into domestic demand from metering trial. *Water and Environmental journal*. 5 (3). pp 342-351.
- Salaudhin, M., 2013. Political Ecology, Stress Analysis and Capital Investment in Water Sector: A Study of Khulna City. *Journal of Bangladesh Institute of Planners*. Vol 6. Available at: [http://bip.org.bd/SharingFiles/journal\\_book/20141016154213.pdf](http://bip.org.bd/SharingFiles/journal_book/20141016154213.pdf)
- Salaudhin, M., Hasan, S., Sarkar, G., Das, D., Rahman, M., Rahman, M.N. and Fatemi, M.N., 2012. Designing a Decentralized Wastewater Treatment Unit, Ideas presented at International Training on 'Decentralized Wastewater Treatment and Reuse' conducted by Center for Science and Environment and Water Aid-Bangladesh, 3-6 March, 2012.
- Schell, C., 1992. *The Value of the Case Study as a Research Strategy* [online] Available at: <http://www.finance-mba.com/Case%20Method.pdf> [Accessed 12 August 2013]
- Short, M. D., Peirson, W. L., Peters, G. M. and Cox, R. J., 2012. Managing Adaptation of Urban Water Systems in a Changing Climate. *Water Resource Management* [Online] Available at: <http://link.springer.com/content/pdf/10.1007%2Fs11269-012-0002-8> [Accessed 02 January 2013]
- Stephenson, D., 2003. *Water resource management*. UK: A.A. Balkema Publishers
- UN (United Nations), 2002. *Report of the World Summit on Sustainable Development*. [online] Available at: [http://www.unmillenniumproject.org/documents/131302\\_wssd\\_report\\_reissued.pdf](http://www.unmillenniumproject.org/documents/131302_wssd_report_reissued.pdf) [Accessed 10 December 2012]

- UN-HABITAT, 1999. Managing water for African cities-developing a strategy for urban water demand management: background paper no 1. Expert group meeting UNEP and UN-HABITAT
- Vorosmatry, C.J., Green, P., Salisbury, J. and Lammers, R.B., 2000. Global Water Resources: Vulnerability from Climate Change and Population Growth. *Science magazine*. [online] Available at: <http://www.sciencemag.org/content/289/5477/284.short> [accessed 15 July 2013]
- Vairavamoorthy, K. and Manssor, M.A.M., 2006. Demand management in developing countries. In: D. Butler and F.A. Memon ed. *Water demand management*. London: IWA Publishing. Ch 8.
- WaterAid-Uk, 2013. *Bangladesh*. [online] Available at: [http://www.wateraid.org/uk/where-we-work/page/bangladesh?gclid=CJOR1vHS\\_7gCFeXMTaodLTcAPQ](http://www.wateraid.org/uk/where-we-work/page/bangladesh?gclid=CJOR1vHS_7gCFeXMTaodLTcAPQ) [Accessed 10 August 2013]
- WHO (World Health Organization) 2006. *Guidelines for drinking water quality*, World Health Organization, Geneva, Switzerland.
- WHO (World Health Organization), 2013. *Global Health Observatory (GHO); Urban population growth*. [online] Available at: [http://www.who.int/gho/urban\\_health/situation\\_trends/urban\\_population\\_growth\\_text/en/](http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/) [accessed 12 August, 2013]
- Willis, R.M., Stewart, R. A., Williams, P.R., Hacker, C.H., Emmonds, S.C. and Capati, G., 2011a. Residential potable and recycled water end uses in a dual reticulated supply system. *Desalination* [Online] Available at: [www.elsevier.com/locate/desal](http://www.elsevier.com/locate/desal) [Accessed 27 December 2012]
- Willis, R. M., Stewart, R. A., Panuwatwanich, K., Williams, P. R. and Hollingsworth, A. L., 2011b. Quantifying the influence of environmental and water conservation attitudes on household end use water consumption. *Journal of Environmental Management* [Online] Available at: <http://www.sciencedirect.com/science/article/pii/S0301479711000892> [Accessed 28 December 2012]
- Worthington, A.C., Hoffman, M., 2008. An empirical survey of urban water demand modeling. *Journal of Economic Surveys*. 22 (5) pp. 842-871.