First SWITCH Scientific Meeting
University of Birmingham, UK
9-10 Jan 2006

Financing and Cost Recovery of Innovations in the Urban Water Cycle in Terms of Different Institutional and Technological Options

Xiao Liang* and Meine Pieter van Dijk

Department of Management and Institutions
UNESCO-IHE Institute for Water Education
Delft, The Netherlands

Abstract
SWITCH project aims at seeking a paradigm shift in urban water management. A multidisciplinary learning alliance from the technological to economic research groups is established. The present work focuses on the economic aspect of the SWITCH programme. For achieving effectiveness, efficiency and sustainability on water management, the present research is intended to propose innovative and integrated financing approaches and cost recovery plans in terms of different technological and institutional options. The analytical framework includes four important points. Firstly, the economic efficiency and effectiveness of the existing water management models employed by demo cities will be analyzed. This could be assessed by the relevant indicators (e.g. UFW, operational efficiency). Secondly, an economic model is applied to estimate the different technological and institutional options and then make a comparison between them. Cost Benefit Analysis is the crucial instrument to determine the optimal technological and institutional options. Thirdly, based on the research of the second point, innovative financing plans and new forms of cost recovery (e.g. optimal pricing system) could be developed. Fourthly, for sustainable and efficient financing and cost recovery, the environmental externalities and risks will be evaluated and analyzed.

Keywords: economic, financing, cost recovery, urban water management, Institution, technology

1 Introduction

Currently freshwater withdrawals grow dramatically, resulting in water stress in many countries (Seckler *et al.*, 1998). The deteriorating environment accelerates the tendency of gradual shortages of fresh water. While freshwater supplies are clearly limited, for most people water scarcity is caused by the competition for water uses and by political, technological and economic barriers that limit access

* Corresponding Author: x.liang@unesco-ihe.org

to water (Falkenmark and Lundqvist, 1998). Additionally climate variability, urbanization, population growth, urban sprawl, and rural-urban migration expand the pressure on urban water supply and services. There is a big challenge for many countries to reach sustainable, healthy and effective urban water system. Therefore the SWITCH (Sustainable Water Improves Tomorrow's Cities' Health) programme supported by the EU is seeking a paradigm shift in urban water management to increase sustainability of water treatment, to reduce risk, to improve governance of water and to translate the scientific innovation into management effectively. The programme proposes to generate new efficiencies from integration of actions across the urban water cycle.

Nine cities around the world have been chosen as demonstration cities and a learning alliance framework will be established in each demo city. Through the learning alliance platform, the barriers to information sharing are broken down and the process of innovation is speeded up. A real improvement in eco-efficiency requires a fundamental change in culture, structure (institutions) and technology (Strigl, 2003). So the strategy of SWITCH is the development, application and demonstration of a range of tested scientific, technical and socio-economic solutions that contribute to the achievement of sustainable and effective urban water management schemes. It implies there are multi-disciplinary participations in the SWITCH programme, i.e., the integration of the technological means, socioeconomic aspects, environmental concerns, and health considerations. The current research is one part of SWITCH, emphasizing financial and economic analysis of urban water management activities in demo cities.

Three demo cities are selected currently from developing and developed areas: Beijing (Asia), Accra (Africa) and Hamburg (Europe). The recent dominant paradigms on urban water management and waste water treatment are principally developed in rich countries. The developing countries always import the urban water management and sanitation models at each stage from the developed world (McGranahan *et al.*, 2001). However, the urban water treatment models from the industrialized countries may not lead to sustainable and effective solutions for the developing countries. For example, the technology model of centralized piped sewerage is too costly for the societies in poor cities to operate without external assistance. (Abeysuriya *et al.*, 2005). Therefore, the research work on the demo cities in both developed and developing countries could help to develop more appropriate solutions. The comparative analysis between these three demo cities would be employed in the present work. Each demo city has its own characteristic geography, climate, politics, institution, and economic development. The comparative analysis helps to identify the general problems faced by all cities and to find the innovative economic plan and method for each city. Besides the unique technological and economic solutions for each demo city, the general applicable model may be built up through the comparison.

2 Different technological and institutional options

Different research groups involved in SWITCH programme could lead to different institutional and technological proposals. According to the practice of demo cities, these different options will be chosen and developed further. Concerning the institutional changes in water sector, the main recent tendency is private sector involvement, decentralization, and globalization. About the technological improvement, Schutze *et al.* (1999) indicated that for the urban wastewater system the new concept of "integrated control" is replacing the conventional management which aims at optimum performance of the individual components. Since financial and economic analysis is based on different technological and institutional options, the current research work should link with other research groups. Technological options influence the cost supposed for paradigm shift, and institutional options determine the financing source and the means of recovering cost. Hence it is significant to learn the technological and institutional options before performing the economic analysis.

2.1 Technological options

Since urban sewage consists of nutrients, organic materials, disease-causing microorganisms, heavy metals, toxic household cleaners and storm water, it is difficult to recycle. So it leads to the requirement of more appropriate technology improvements. There are several technological methods proposed by other researched groups of SWITCH programme. Since each demo city has its owned water management problem and the special characteristics on geography and climate, the technological options for each demo city may be different. So the technological options would be determined separately and differently according to demo cities. For example, the technological options studied for Beijing city are river bank filtration, soil aquifer treatment, decentralized waste water treatment, urban agriculture and managed wetland. There are still other alternative ways to improve the sustainable water treatment. That could be proposed in future and would be studied if desirable.

2.2 Institutional options

Compared with technological influence, institutional change could affect the financing and cost recovery significantly. Building new government structures facilitates to successful management and service in water sector. Pro-poor measures may be developed principally in the new institutional models. So that implementation of proper institutional options in demo cities is the key for financing resource and cost recovery in urban water management. Since the water sector is liberalized gradually, different governance structures concerning water management occur. It is changing from only municipal department involved in water sector to incorporated company, public private partnership, community management and even NGOs joining into urban water management.

3 Research objective

In some countries, problems of water supply and sanitation are usually not the lack of water or the lack of demand for water, but rather a series of non-technical factors to distribute the water to the users and to develop financial viable sustainable waste water treatment plants. Few countries have realistic policies, operational strategies, cost recovery plans and sustainable financing for increasing service coverage, particularly for the poor. The water management and service sectors of developing countries are facing the dilemma of lacking enough capital for investment and low cost recovery. In developing countries, water management and sanitation services are largely provided by public sector and the government is the principal provider of infrastructure. However, public services providers have often failed to provide consumers with adequate services and most of the poor are lack access to the drinking water. Faced with the pressure to reduce the public sector debt and improve public facilities at the same time, governments have looked to private finance (Grimsey and Lewis, 2002).

The objective of the current research work is developing sustainable, efficient and effective financing and cost recovery plans for each demo city. It can be specified as : determining which sources of financing in terms of demo cities, especially of infrastructure finance; identifying partnerships developed to finance; finding out innovative financial plan; checking the cost recovery system; and building up new forms of cost recovery.

4 Alternatives for the financial and economic analysis

4.1 Economic analysis of situation

Problems in developing countries are low cost recovery, overstaffing, high water charges and poor governance. More effective provision of services in settlements with lower risk and improved financial sustainability in aspect of financing and cost recovery are the objectives of the present research. Identifying the current practice of each demo city is the crucial step to create new and imaginative approaches in further economic analysis. It is the precondition for the current research that doing economic analysis on the existing situation.

The efficiency and effectiveness of the existing economic model will be assessed by the relevant indicators: balance sheet, profit and loss account, indicators of efficiency (such as Unaccounted For Water, operational efficiency, employee per connections). These factors reflect the practical situation on the water managements and services in demo cities. For better learning and making consequent cost benefit analysis, an analysis of the recovery of costs on the existing situation would be applied.

4.2 Options comparison and cost benefit analysis

Some of the proposed institutional options have been currently implemented in the demo city, whilst some may be used in the future. It must be determined if the technical improvements based on the original technology and infrastructure can be carried out. So the different technological and institutional options would be compared via the economic and financial evaluation.

The feasible and optimal options could be determined through cost benefit analysis which is the crucial instrument in the research. Base on the existing development model, the technological and institutional options would lead to new activities or projects. Cost benefit techniques are employed to determine whether the capacity of existing projects should be extended and, if so, by how much, that means cost benefit analysis implies estimating the optimal new capacity, or the optimal use of the existing capacity (Mishan, 1988). With the help of economics, one could choose the optimal solutions related to different institutional and technological options (Braden and Van Ierland, 1999). The technological and institutional options will be compared according to the results of cost benefit analysis and the local practice including political and cultural aspects. The results of comparison assist to create an innovative financing and cost recovery plans.

4.3 Financing and cost recovery

Because of the lack of institutional and administrative management capacity and the lack of adequate financial flows into the water sector, the financial challenge is particularly acute. The strategies for cost recovery in developing countries are typically short sighted as they usually address only part of the issue of sustainability, such as focusing only on operation and maintenance costs. The project plans fall usually short of systematic risk and sensitivity analysis before the projects are carried out for water supplies and services. Consequently it results in the failure to deliver effective and sustainable water supply and sanitation services. In order to solve the problem, innovative financing and optimal cost recovery plans should be developed. It is the essential part in the present research.

The chosen technological and institutional options would have significant influence on the financing settlement and cost recovery forms. Additionally the changed financing instruments and operation methods may impact on the cost recovery of urban water management. A great number of studies propose various economic models for improving effectiveness, efficiency and sustainability on financing and cost recovery (Renzetti and Kushner, 2000, Rogers *et al.*, 2002, Singh *et al.*, 2005, Almagro, 2005).

4.3.1 Innovative financing plan

There are two alternative meanings of explaining the “innovative finance”. Generally the “innovative financing” is interpreted to be the particular means and a plan of finance. However, another explanation is the financing for certain projects which are innovative. This “innovative financing” is reflective of and consistent with contemporary target such as sustainability and efficiency, and is responsive to the issue within a service area, and is affordable by those within the service area who are the project's beneficiaries (Houston, 1995). So this innovative financing plan is uniquely designed to meet the need and capability of the project. Table 1 (Van Dijk, 2006) shows the usual financing options for infrastructure. The tools of finance should be as flexible as the project to be financed and just as projects are uniquely designed, so too must be the financing (Houston, 1995).The goal of SWITCH is to reach a paradigm shift in urban water management. Thus the present research would propose a novel financing plan uniquely for the paradigm shift in demo city.

Table 1 Instruments for infrastructure finance

From more traditional finance	To more alternative finance
Loans or bonds Municipal Infrastructure Development Funds, for example ● Investment/capital funds ● Trust fund ● Endowment fund BOT (Build Operate Transfer) Subsidized entry fees Higher levels of government financed out of general or specific tax revenues State Level Finance Institutions	Microcredit to finance water connections Rotating savings and credit associations (ROSCAs) to link traditional savings with credit Private sector involvement Project finance Design, Finance, Build and Operate (DFBO) and ROT (Rehabilitation Operate Transfer) Hedging (futures/options) to cover risks Pooled Finance Development Fund

4.3.2 Cost recovery

Cost identification and cost evaluation are very important to the cost recovery analysis. The full cost of a water project consists of the capital cost, operation and maintenance (O&M) cost, opportunity cost, economic externalities and environmental externalities, but the calculation of all the cost components for complying with the full cost recovery principal is always difficult (Tsagarakis, 2005).

Pricing is the vital issue for the recovery of full cost. In theory, a water pricing system where charges are equal to the marginal costs of providing the water services will allocate resources more efficiently. Dinar and Subramanian (1997) argued that a proper pricing mechanism could improve water allocation and conservation. But in practice, deviations from the pricing principle of marginal cost are common (Seppala and Katko, 2003). Renzetti (1999) estimates the welfare gains from reforming water prices for the Greater Vancouver Water District and finds that the prices charged to residential and commercial consumers are only a third and a sixth of the estimated marginal cost for water supply and sewage treatment respectively. Kim (1995) estimates the cost of supply for a sample of 60 U.S. municipal water utilities and finds that prices exceed marginal costs for both residential and non-residential by 150 percent and 40 per cent respectively. Water pricing should reflect the full costs of supply including environmental and resource costs. Braden and Van Ierland (1999) illustrated that the effective price should involve two aspects: (1) all users pay for water which is essential preserved for healthy ecosystems, which means the present payment should be equal to the future value; (2) the water fee includes distribution and actual uses. Basically, in term of economic principle, price is determined by supply and demand. However as the water has a special economic characteristic, pricing water is more complex than general goods.

4.4 Valuing environmental externalities

The traditional economic method in treating water issue focuses mainly on the supply planning which ignores the environmental impact and only emphasizes on minimizing prices and maintaining system reliability (Baumann *et al.,* 1998). It induces the negative external influence on the environment so that it hinders sustainable development in urban water management and ecological city building. Hence valuing environmental externalities is indispensable in the present work. The externalities can be described as a difference between the benefit (cost) that accrue to society and the benefit (cost) that accrue to the project entity (Belli *et al.*, 1996). Environmental externality is one part of environmental assessment. Monetary value should be assigned to the environmental cost and benefit. But it is not easy to quantify the environmental impact. After identifying the cost (benefit) of environmental externalities caused by the projects, the monetary value would be assessed for the environmental cost.

4.5 Risk and sensitivity analysis

Water management is about changing risks, where we have a great deal of uncertainly concerning the magnitude of those risks. Uncertainty and risk are present whenever a project has more than one possible outcome. The measurement of economic costs and benefits, therefore, inevitably involves explicit or implicit probability judgments (Belli *et al.,* 1996). The risk analysis programme will reduce the probability that an event will occur and which event will have temporary or long term impacts on the water management (Green, 2003). Some of the key risk factors during the different stages of a project are likely to include cost overruns, construction delays and variation from design specifications during design and construction, inadequate revenues and foreign exchange availability, interest rate fluctuations and exchange rate depreciation, changes in regulation and losses caused by force (Hallmans and Stenberg, 1999). Sensitivity analysis assesses risks by identifying the variables that most influence the net benefits of the project and quantifying the extent of their influence. Sensitivity analysis may help to identify weak design options and classify the need for obtaining additional information on some variables (Belli *et al.,* 1996). Sensitivity analysis explores the impact of assuming difference and provides the insight of how much weight of certainty (Li, 2006).

5 Conclusion

In terms of SWITCH objective, the present work aims to develop innovative financing approaches and cost recovery plans for three demo cities. Different technological and institutional options proposed by other research groups would be the basis for financial and economic analysis. So the research would link with other research groups involved in SWITCH programme. The analytical framework includes four points: 1 existing situation analysis; 2 different technological and institutional options chosen via cost benefit analysis; 3 innovative financing and cost recovery plans development; 4 valuing environmental externalities and risk analysis.

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