The sustainability of urban water supply in low income countries: a livelihoods model
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ABSTRACT
Urban water supply can be managed by public institutions, private companies, communities, or by combinations thereof. Controversy continues over which system can most effectively improve livelihoods. Responding to this discussion, an extended model of sustainable livelihoods analysis is proposed that takes on a holistic approach: it includes issues of economic viability as well as the consequences for the vulnerability of poor people and the sustainability of water-related ecosystems. This model can be used to analyse the impact of water provision on livelihoods and to leverage policies to create a more sustainable water provision. It is applied to the city of Semarang in Indonesia that, as many coastal cities in low income countries, suffers from vicious cycles of poverty and problematic water supply.

INTRODUCTION
The world’s urban population has grown exponentially in recent decades and will continue to do so in the foreseeable future. Especially in developing countries, the rapid growth of cities has created numerous environmental problems (Van Naerssen & Barten 2002; UN-Habitat 2007). One major challenge concerns the sustainable provision of clean water to urban inhabitants. Access to water is unequally distributed and, particularly for the urban poor, it is difficult to obtain sufficient and clean water (Gatrell & Elliott 2003).

Over the last decades, water supply systems were often managed by public bodies, whose efficiency and effectiveness have been debated ever since their establishment. Since the 1980s, the management of water supply has received worldwide attention by influential actors such as the World Bank. The decreasing financial capacity of governments has led to a search for new ways to provide clean water to growing populations. Especially in urban areas, private sector participation became a panacea propagated by many donor agencies. Even so, the commoditisation of water and the privatisation of its supply have attracted criticism from members of civil society, many of whom argue that the solution lies not in the private sector but in improving public and/or community-based water supply systems (Shiva 2002; Pigeon et al. 2012). In any case, controversies persist over the effectiveness and consequences of public, private, or community-based systems – alone or combined – in managing urban water supplies (Gilbert 2007). Part of the discussion focuses on the impact on the urban poor, using indicators such as access (Connors 2005; Kyessi 2005), coverage (Pirez 2002; Budds & McGranahan 2003) and price (Pirez 2002). Another part of the discussion focuses on the providers’ organisational performance and the vested interests involved, for example to generate private profits or protection of public jobs (Budds & McGranahan 2003; Marques 2008). Ideology also enters the fray, for example whether water is a fundamental human right or a commodity in the marketplace (Derman et al. 2005).

This discussion on the governance of water supply is very often limited to direct economic effects. There is need for a more encompassing model that links different modes of water supply to the impact on livelihoods of (poor) households and includes the aspect of sustainability of water supply and water use. This article proposes and applies an analytical model to point at the different relevant and
intertwined systems that affect the sustainability of people’s livelihoods. In addition, it is hoped that the model will serve as a tool to leverage policy.

The next section gives a short overview of the debate on the governance of water supply, dealing with the pro’s and con’s of public, private, and community-based water delivery systems. It also reviews the concept of sustainable livelihoods and the approach of sustainable livelihoods analysis (SLA). We then proceed with a section comprising a detailed explanation of our model that relates urban water supply to sustainable livelihoods. Thereafter, the applicability of the analytical model is illustrated by the case of Semarang, a coastal city on Java, Indonesia. In the final section, we will give our conclusions and reflections on the relevance for policy leverage.

**MODES OF URBAN WATER SUPPLY: THE NEED FOR A MORE COMPREHENSIVE APPROACH**

The management of water supply services is a complex task that has to meet a number of different – and often contradictory – social, economic and environmental goals (Cashman 2006). Water services cater to social objectives: access to a certain minimum amount of water is generally perceived to be a merit good; that is, its consumption has a benefit to society beyond that which accrues to the individuals consuming it (World Bank 1993). Nevertheless, many developing countries have struggled with their water supply. The 1970s witnessed the widespread demise of state-led economic growth, with budget constraints and internal management problems inviting new approaches to provide quality services at acceptable costs. Since the 1980s, the World Bank and donor agencies’ support of privatisation has led to demand-responsive approaches and the principles of cost effectiveness and ‘the consumer pays’, in fact replacing previous more health-based views of the water and sanitation sector (Nicol 2000). The World Bank’s critics, however, doubt the efficacy of the sector’s privatisation. According to Hall & Lobina (2007), major innovations are more likely to come from community-based systems and public authorities than from private companies.

Given the multiple actors and goals involved in water supply, an approach that solely focuses on the performance of public utilities and/or private business is not sufficient. First, it presupposes that providers should be financially self-reliant and business should always be profitable, which contradicts a view of clean water as a merit good. Second, the dominant set of criteria used to evaluate the governance of water supply (efficiency and productivity) is not complete. Water providers’ networks can have important social implications. Third, besides possible social objectives, any delivery of urban water involves environmental issues. For example, due to its relatively low cost and generally high quality, groundwater has often been the preferred source for reliable public water, especially in urban areas (Burke & Moench 2000; Foster 2001). Groundwater, however, can be a depletable resource and both people’s vulnerability and sustainability are at stake. We will come back to this in our case study on the city of Semarang.

**LIVELIHOODS AND SUSTAINABLE LIVELIHOODS ANALYSIS**

Around the turn of the century – and in light of the fact that the world’s poor still lacked access to safe drinking water – scholars began to focus on the consequences of water provision for people’s livelihoods (Nicol 2000; Duran et al. 2004). In general, the breadth of the livelihoods approach offers potential to integrate the health-based and demand-responsive approaches.

The livelihood approach considers people as actors in development and focuses on the strategies of households to survive and to improve their livelihoods (De Haan & Zoomers 2005; Rigg 2007). In SLA the concept is related to contextual factors (structures and processes) that make household livelihoods sustainable or vulnerable. In this way it is a useful tool for policy analysis and policymaking (Department of International Development DFID 1999; Pasteur 2001). SLA was originally a method to analyse rural poverty in developing countries (Chambers & Conway 1992; Carney et al. 1999). Over time it came to be used in urban areas as well (Moser 1998; Meikle et al. 2001; Farrington et al. 2002).

Following Chambers & Conway (1992) a livelihood can be conceived as comprising assets (physical, social, human,
natural and financial resources), capabilities (the ability of people to do something with their resources) and activities (the need to make a living). SLA focuses on the sustainability of livelihoods and whether households are able to maintain or enhance their capabilities and assets, to provide livelihood opportunities for the next generation and, as a surplus value, to benefit other livelihoods at the local and global levels in both the short and long term.

Its analytical framework also focuses on external and internal factors that make households vulnerable. Shocks, trends, and seasonality are components of change in the external environment that can threaten livelihoods (Chambers & Conway 1992; Moser 1998). Shocks (e.g. floods, earthquakes, eruptions of volcanoes) are typically sudden, unpredictable, and traumatic; trends (e.g. climate change, changes in biodiversity) point at specific international, national, regional or local long-term developments to which households have to adapt; seasonality includes all environmental changes that follow seasonal dynamics.

The internal side of vulnerability is closely linked to asset ownership (Chambers 1992; Moser 1998). Since every household commands qualitatively different assets, identical external changes can differentially impact households. For example, a household may take years to recover from a flood, while for a neighbouring family it may be a mere disturbance to daily life (Dietz et al. 2004). Poor households are usually but not necessarily the most vulnerable. For example, waterborne disease caused by poor water quality can attack everyone in the community, rich and poor alike (Cairncross 1990).

According to Farrington et al. (2002), livelihood strategies include coping strategies to respond to shocks in the short term and adaptive strategies to improve circumstances in the long term. Successful strategies allow building asset bases as buffers against shocks, negative trends and seasonality, and vice versa, ineffective strategies deplete asset bases and increase household vulnerability.

In the original sustainable livelihoods framework (see Carney et al. 1999) for the details of the original framework), the context that impacts on livelihoods and their strategies is characterised by specific policies, institutions and processes (PIPs) also including legislation (Farrington et al. 2002). PIPs impact on the assets of people. For example, educational and health legislation and programmes aim to increase human resources and micro-credit programmes will strengthen the financial assets of people and households. PIPs thus determine access to various types of assets and enhance capabilities of people to pursue their livelihood strategies. They act as conduits to make assets available, or as barriers to such access.

**CONNECTING WATER PROVISION TO SUSTAINABLE LIVELIHOODS**

As said, up to now SLA in water provision has mainly been used in the context of rural households (Nicol 2000; Soussan et al. 2004). To facilitate its application to urban areas, we suggest some modifications to the original sustainable livelihoods framework. In our model we underscore the role of actors in water provision whether state-owned, private and/or community-based, (‘providers’), and actors in water governance at several levels, international, national, regional and local (‘regulators’). In this way, we make use of a subsector analysis that examines the interaction between providers, regulators and end users (households and their livelihoods).

As a second modification we propose that next to the vulnerability context of shocks, trends and seasonality, the sustainability context will be made more transparent. We distinguish three aspects of the sustainability context. Ecological integrity is about preserving water and the hydrological processes on which all life depends. Economic efficiency means that the urban water supply system does not waste its resources. Social equity refers to the more explicitly normative principle that households or providers should organise their livelihoods while not disrupting options for others to organise theirs.

**Figure 1** shows our model of urban water supply for sustainable livelihoods. Below we briefly describe the model’s different dimensions, as represented by boxes, starting with the actors.

**Actors in water provision**

As stated earlier, we distinguish regulators, providers and water users as the three groups of actors in urban water provision. Municipal, regional and national policy-makers...
create laws and regulations governing the water supply. Providers vary from small private water peddlers to large state-owned or multinational companies. End users include industries and households but since we focus on water supply to meet basic human needs we will leave the former out of our model. The model thus contains three boxes of ‘agency’: the policy actors (Regulator Box), the providers in the water supply sub sector (Water Supply Box), and the household (Household Box).

In reality there may be overlap between these actors. An example is self-provision, where a household owns a water source such as a deep or shallow well. In this case there is at least an overlap between the Water Supply Box and the Household Box. Another possible overlap exists between the Regulator Box and the Water Supply Box, which happens when a public regulator fully controls provisions. This overlap may undermine the social goal of access and universal service – especially for the poor – since there might be too much stress on the financial aspect of generating profits for the regulator’s own purposes.

Because water has many spatial and environmental characteristics, we have to further differentiate the regulators within a multi-level governance setting. We thus have international, national, regional, and local-level regulators, ranging from international bodies such as the World Bank or the United Nations to national governments, business entities and associations, down to local communities. This group of actors is visualised in the Regulator Box, which must be adapted to individual cases.

There are three major categories of providers in the sub sector analysis: public companies, private companies and community-based systems. Of course many combinations are possible (Hoedeman 2006). Providers’ own policies and their institutional sustainability belong to the Water Supply Box. Policies include those for pricing, technology, infrastructure, etc., while institutional sustainability refers to the provider’s capacity to sustain its existence in the urban water supply business.

Adopted from the original SLA, the Household Box contains four elements: assets, strategies, outcomes and

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**Figure 1** | Model of urban water supply for sustainable livelihoods.

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resilience, which actually also apply to the boxes of Water Supply and Regulators. However, since the focus of the model is on water supply for daily human needs, they are figured out in the model only for households. In general, a household is resilient when it is able to cope with and recover from adverse external changes and has assets and strategies at its disposal to sustain its livelihood as an outcome.

Differentiating these groups of actors allows us to specify the roles they play. First, the regulator plays the role of watchdog (Johnson & Handmer 2002; Marques 2008) meaning providers are accountable to elected public authorities (Hall & Lobina 2006). Second, by making water supply providers autonomous and not a part of the government apparatus, ‘comparative’ or ‘yardstick’ competition is induced, possibly leading to more efficient delivery. Third, by considering users as a separate entity, we are able to examine social control mechanisms that counterbalance the power of the other actors, e.g. social networks of communities counterbalancing market or state actors.

The contexts of sustainability and vulnerability

Urban water delivery in developing countries is often characterised by heavy reliance on groundwater, high rates of unaccounted-for water, and low coverage. Heavy reliance on groundwater can threaten ecological integrity, while a high rate of unaccounted-for water implies economic inefficiency. Low coverage can harm social equity, especially a disadvantage for the poor, as those who are not covered are usually poor.

As in the original sustainable livelihoods framework, the vulnerability context includes shocks, trends and seasonality. These are worked out in the model’s Vulnerability Context Box. But different from the original framework we introduce three aspects of sustainability – ecological integrity, economic efficiency and social equity – that constitute the model’s Sustainability Box.

Within this model, the assessment tries to find a balance in terms of vulnerability and sustainability. Providers’ activities can support households to cope with negative changes, to create a virtuous cycle of outcomes, and to allow households to build and increase their assets and capacities. Below are the major criteria, including explicitly normative ones, to assess the providers’ performance. They must:

1. Be able to safeguard the resilience of households in case of negative external and internal changes;
2. Reduce vulnerability through policies that grant access especially to the poor, and maintain reliability of supply regardless of season;
3. Preserve the sustainability of water resources;
4. Maintain the continuity of the water supply system, ideally through the implementation of a full cost recovery principle that contributes to institutional sustainability.

The model can also be employed to point to specific measures to leverage performance, for example regulating tariff structures to balance the interests of the supply system’s institutional sustainability with universal access, or regulating groundwater extraction to maintain its sustainability.

APPLYING THE MODEL TO THE CITY OF SEMARANG

Semarang is the capital of Indonesia’s Central Java Province and has a population of some 1.4 million. It lies on the coast and suffers from ecological deterioration due to seawater intrusion and land subsidence aggravated by excessive groundwater extraction. The location of our study, Tanjung Mas Sub-district, includes some 30,000 inhabitants and 6,000 households, of whom many are poor. In this sub-district we find the most varied urban water provisions of the city. It is also the area with the most serious problems of groundwater exploitation, seawater intrusion, tidal floods and land subsidence. The water table drop is currently more than 20 m below sea level, which makes it a very critical area for groundwater exploitation.

There are five kinds of water supply in Tanjung Mas. The water is provided by: (1) A company owned by the local government, Perusahaan Daerah Air Minum or PDAM. The water is treated and piped to households; (2) Privately owned and commercially exploited deep well providers; (3) People who own shallow or deep wells (self-provision); (4) Bottled water retailers; and (5) Water kiosks that refill bottles.

Figure 2 displays the relations between the providers, the source of water, its treatment, distribution, and end
users. It shows that only PDAM and self-provision shallow wells use surface water as their source. Commercial deep wells and refilled-bottled water kiosks use vulnerable groundwater as their source. Water kiosks, selling refilled-bottled water, sometimes rely on mountain springs in the higher area of Semarang, but also make use of deep wells and thus groundwater. While the 24 Semarang bottled water companies also use groundwater, it is not necessarily from the Semarang area.

From the point of view of sustainability and health, the public service of the PDAM is the best option since it uses treated surface water that can be used for drinking. Bottled water and refilled-bottled water from mountain springs are also ecologically fairly sustainable with regard to the Semarang coastal area. However, the quality of the refilled-bottled water is sometimes questionable (Hadipuro & Indriyanti 2009). The commercial deep well providers use raw (untreated) groundwater and it is questionable if it is drinkable. These providers have to obtain their water from 80 to 100 m down and it is increasingly salty. Self-provision from shallow wells usually produces salty, yellowish and turbid water that is normally not used for drinking but for cleaning, washing or gardening.

Merely to illustrate how the model can be applied, we focus specifically on three providers: the PDAM, the deep well providers and self-provision through shallow wells. We will assess the impact of these three on people’s livelihoods as well as their sustainability at the macro level: ecological integrity, economic efficiency and social equity.

Public provision

The public provider, PDAM, is owned by the local government. To get connected, a household pays an initial fee of Rp. 700,000 (USD 77 in 2010). PDAM uses a block tariff and cross subsidy mechanism to ensure economic efficiency and, to a certain extent, social equity. Most of the raw water is surface water. The quality of the water is regulated by the Ministry of Health, which can be considered as an indicator that the water is safe for health. The major problem of PDAM is that the expansion of the service lags far behind urban growth. Coverage in 2010 only reached about 50% of the population of Semarang City. A household survey held shows that poor people and those who lived in illegal or rented houses in the area covered by PDAM could not connect to PDAM due to the expensive connection fee and the PDAM policy of covering only legal settlements. In other words, these restrictions impact those that do not have sufficient financial assets or ‘appropriate’ physical assets.
Self-provision with shallow wells

Due to seawater intrusion and flooding, only households living further inland can still use their own shallow wells to provide water for bathing, washing, and watering their yards. Although shallow wells are privately owned, in practice they tend to be used publicly. Most landowners do not object to their neighbours using water from their shallow wells, thus these wells are natural assets for a broader range of people and they reduce for them, to some extent at least, the financial burdens of water supply. But they do not solve the problem of supply for drinking water.

Deep wells as an alternative

As many poor people cannot afford the PDAM connection fee, and bottled water is expensive too, they turn to small-scale water supply providers. Found in almost every part of Tanjung Mas, they use groundwater from deep wells and pipe it to their subscribers. Some use water meters to charge for the service; others charge based on time. Every 10-15 minutes or every cubic metre costs Rp. 3,000 (0.33 US Dollars). The uniform tariff bears most heavily on the poor. Actually, this alternative to the PDAM is for most poor people five times more expensive than the public service. Moreover, there is no government control or charge for the extracted water and the excessive use of groundwater leads to further seawater intrusion, which makes it increasingly difficult to access fresh water. Deeper groundwater extraction also causes further land subsidence, which in turn means increasing vulnerability in the case of tidal flooding.

Because poor people in Tanjung Mas have no choice but to use relatively expensive water from deep wells, the sustainability context will undoubtedly further deteriorate. It is a vicious circle: poor people use groundwater, causing this source to become increasingly scarce and expensive, and thus making them more vulnerable and less resilient in the long run.

The situation is further sustained because, from the point of view of ‘social assets’, small-scale providers have certain advantages. Because a provider only covers nearby households, the provider and subscribers know each other personally. There is flexibility in payments; there are no cases of termination, even when a subscriber is unable to pay the bill for some months. This would be impossible with the public service such as PDAM. To conclude, stopping the activities of small-scale providers will only increase poor people’s difficulties in accessing water.

A way out? Combining providers as household strategy

As we have seen, because of a lack of assets, both natural, physical and financial, poor people often depend on the provisions by deep wells as a livelihood strategy. From a sustainability point of view – including the resilience of households in the long run – this strategy is problematic. A sound option for the future would be to direct household strategies towards connecting to the PDAM public service for drinking water and using shallow wells only for washing, bathing and gardening. This combination has a positive impact on people’s health, on the sustainability of water supply systems and in the long run, on a household’s financial assets as well. Moreover, because shallow wells are seen as public utilities, the use of shallow wells as a water supply source will strengthen the social assets of the community. However, using PDAM water obliges people to pay the connection fee and pay for the water they consume, while if they only use water from their shallow wells, they do not need to pay at all.

Seeking a more balanced combination of the two sources would minimise the negative impact on the full range of assets: physical, natural, financial, social and human. Unfortunately this ideal situation will not be achieved until at least three problems are addressed: the threshold of the connection fee, the general problem of PDAM coverage, and the continuous deterioration of water from shallow wells. To do this, we suggest different options to improve the situation in Semarang. Regulators can address the threshold of PDAM’s connection fees by improving access to specific and labelled financial resources, such as micro-credit facilities, or adjusting the fee to the available financial assets of poorer households. PDAM’s policy of providing public hydrants or water terminals answers the problems of those who rent houses without piped water supply connections and those who live in illegal houses. Physical assets (e.g. owning a house) then become irrelevant to getting connected.
CONCLUSION

The daily delivery of water to meet basic human needs in developing countries is no easy task. It has to meet a variety of goals, social as well as (at times conflicting) economic and environmental goals. It impacts upon health issues, on interlinkages between local economic and social networks and the sustainability and ecology of urban life. This is why there is a need for a more holistic and comprehensive approach that combines this variety of goals and tasks in the assessment and governance of water supply.

We have proposed a household-centred model that integrates SLA with urban water provision, and have extended the criteria normally used to judge urban water supply. Our mission was, in other words, to connect the specific characteristics of the water supply market, sometimes embedded in social networks, to the vulnerability and sustainability of livelihood patterns and related strategies of poor households. This model stretches the assessment of the governance of water supply beyond the discussion of the economic and social performance of public, private, or community-based systems towards providers’ performance in terms of reducing household vulnerability and safeguarding the very different aspects of sustainability: ecological integrity, economic efficiency and social equity.

The model’s application to the city of Semarang shows that some modes of provisions are relatively sustainable and are in fact contributing to the long term ‘common good’ of the urban environment of Semarang but problematic access and incentives of the economic system limit the amount of households that can be connected to these modes of supply. To cut costs, many providers, rather than treat surface water, prefer to use groundwater as their source to run their business and provide their network. Relying on groundwater, as we have seen, is often not a sustainable practice, particularly in environmentally vulnerable areas such as Semarang. For both short-term financial and social reasons households might stick to modes of supply that are less sustainable but are easily accessible and socially valuable to them.

We have identified the essential problems and thresholds that could be addressed in the governance of water supply in the city of Semarang, mainly focusing on the connection fee for the public (PDAM) service, the general problem of PDAM coverage and the deterioration of water from shallow wells. We gave suggestions for issuing policies to improve providers’ performance in light of the criteria of reducing the overall vulnerability of the city and its households.

The model, as proposed, is combining different existing frameworks, but explored more specific tools and indicators to make SLA more operational and relevant for water governance. The application of the model in more case studies will generate further improvements and insights. Hopefully the model will prove to be useful to regulators trying to break the vicious cycles of unsustainable water supply in developing countries in light of both the vulnerability of poor households as well as the general adaptability to environmental changes.

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