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Analysis

Water flows, energy demand, and market analysis of the informal water sector in Kisumu, Kenya

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ABSTRACT

In rapidly growing urban areas of developing countries, infrastructure has not been able to cope with population growth. Informal water businesses fulfill unmet water supply needs, yet little is understood about this sector. This paper presents data gathered from quantitative interviews with informal water business operators (n = 260) in Kisumu, Kenya, collected during the dry season. Sales volume, location, resource use, and cost were analyzed by using material flow accounting and spatial analysis tools. Estimates show that over 76% of the city's water is consumed by less than 10% of the population who have water piped into their dwellings. The remainder of the population relies on a combination of water sources, including water purchased directly from kiosks (1.5 million m^3 per day) and delivered by hand-drawn water-carts (0.75 million m^3 per day). Energy audits were performed to compare energy use among various water sources in the city. Water delivery by truck is the highest per cubic meter energy demand (35 MJ/m^3), while the city's tap water has the highest energy use overall (21,000 MJ/day). We group kiosks by neighborhood and compare sales volume and cost with neighborhood-level population data. Contrary to popular belief, we do not find evidence of price gouging; the lowest prices are charged in the highest-demand low-income area. We also see that the informal sector is sensitive to demand, as the number of private boreholes that serve as community water collection points are much larger where demand is greatest.

1. Introduction

Access to safe water is increasingly recognized as a basic human right (Meier et al., 2012), especially in light of the high disease risks associated with unsafe water and sanitation access (Pruss et al., 2002). Yet, access to safe water sources remains a significant problem in many rapidly-growing cities in developing countries, as infrastructure is often unable to cope with unprecedented urban population growth (WHO and UNICEF, 2012). Although access to improved water sources has increased in Asia to meet the Millennium Development Goals, this is not the case in sub-Saharan Africa, where only 61% of the population has improved water access (WHO and UNICEF, 2012). The problem is especially acute in rapidly urbanizing regions, where the rate of urban expansion exceeds those of economic growth and infrastructure development (Gulyani et al., 2005). As a result, many people turn to informal water services, such as small-scale water vendors and bottled water delivery, for their drinking water (Sima and Elimelech, 2011). Studies show that more than 25% of the population in Latin American cities and 50% of the population in African cities depend on the informal water sector (Solo, 1999a). In Kenya, only 14% of urban households have private connections (Kenya Open Data Project, 2012). Interruption of services as a result of unreliable electricity, over-utilized systems, and leaks undermine services for even those with private connections (Gulyani et al., 2005). Furthermore, negative or low pressure which results from intermittent piped water supplies contributes to recontamination of treated water (Geldreich, 1996; Kumpel and Nelson, 2011). Research has shown that the small-scale private sector has been estimated to account for 85% of all private-sector investment in water security (Kariuki and Schwartz, 2005).

Regardless of distribution mode or treatment technology, the supply of high-quality drinking water can carry a high environmental burden. Treatment via conventional means has been shown to produce 300 g of CO_2 equivalent per cubic meter of water treated (Vince et al., 2008a). Even more alarming, especially in cities with aging piped distribution systems, are the high energy and monetary costs associated with pumping water (Colombo and Karney, 2002; Filion et al., 2004; Hertsin et al., 2011; Vince et al., 2008b). Life cycle impacts for municipal water treatment and distribution (Lundin and Morrison, 2002; Mohapatra, 2002; Stokes and Horvath, 2005) and for water bottle distribution

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(Larson and Larson, 2006) have been investigated previously, but little is known about the impact of *informal* water supply systems. Estimating such impacts first requires a thorough understanding of water supply networks, but this presents a difficult logistical challenge due to the lack of regulation or registration of nontraditional supply mechanisms. Considering the rate of growth within the informal water sector and its prominent role in water supply in developing cities, it is of paramount importance to better understand the sector, including its environmental impacts.

Access to sufficient volumes of safe drinking water is an important means to curtailing the spread of waterborne and water-associated diseases and reducing child mortality (Montgomery and Elimelech, 2007). Understanding of the informal water services sector is crucial to curtail the spread of waterborne diseases, manage resource use, and improve services in any municipality where the sector plays an important role. Unlike rural water and sanitation interventions where sustainability metrics have been presented previously (Montgomery et al., 2009), there exist no objective measures of sustainability for urban informal systems. Due to the unregulated and often illegal character of the sector, information is difficult to gather. To date, over 10,000 water businesses have been documented in 49 countries, but very few published studies are quantitative or comparative in nature (Solo, 1999a).

In studying the informal sector in Kisumu, our purpose is to quantify resource flows in the informal system, and examine spatial variation in pricing, demand, and water source. We compare resource use in the informal sector to the conventional municipal sector, and use census data to gain a better understanding of spatial variation in the informal sector. While it is outside of the scope of this study to create a precise mass-balance of all water used in the city, we did seek to a statistically significant sample within the city to credibly compare the scale of energy use and pricing across different water provision types and locations. Furthermore, the data gathering and analysis techniques presented here could be used by city planners to understand the sector in other areas where it plays a prominent role.

2. Methodological and Ideological Options

2.1. Study Site

With an official population of nearly one million (2009 Kenyan Census), Kisumu, which is located on the banks of Lake Victoria (Fig. 1) has grown by 80% in the previous decade (Kenya Bureau of Statistics, 1999). Water shortages have been reported in Kisumu since the 1980s (KIWASCO, 2007). KIWASCO, the Kisumu Integrated Water and Sewerage

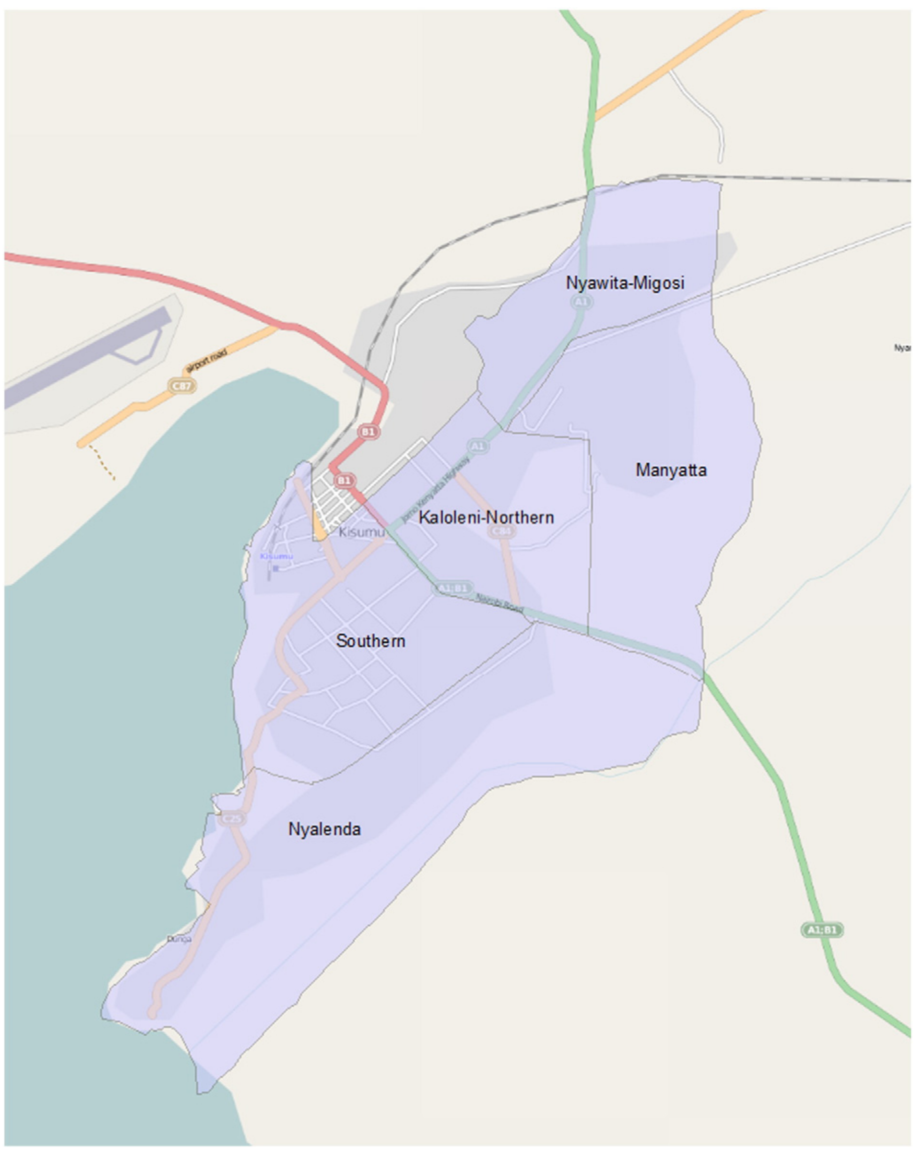

Fig. 1. Map of Kisumu, including neighborhood boundaries used for data analysis.