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Domestic water supply, residential water use behaviour, and household willingness to pay: The case of Banda Aceh, Indonesia after ten years since the 2004 Indian Ocean Tsunami

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ABSTRACT

In this study, we developed a preliminary assessment of current domestic water supply and use in Banda Aceh, Indonesia, a city that was hardest hit by the Indian Ocean Tsunami of 2004. The motivation was to develop understanding of the status and future direction for improvement of domestic water supply after 10 years of post-tsunami reconstruction. For this purpose, we collected primary and secondary information from both water utility and residential households. In particular, we conducted household survey to examine water use behaviour in relation to domestic water supply by local utility, public perception on water supply service, and household willingness to pay (WTP) for reliable water supply. Our study results show that domestic water supply in the city has been improving in service coverage but is subject to high percentages of non-revenue water, financial loss, and poor performance. Despite available tap water, residential households access multiple water sources differentially between drinking and non-drinking purposes. All survey respondents are willing to pay for reliable water supply service, with median WTP estimated at approximately 190% of current household monthly water bill. Most respondents have a concentrated WTP distribution whose mean depends mainly on household income, family size, and water use behaviour. The study findings fill in the knowledge gap in the literature while informing improvement of domestic water supply in Banda Aceh, Indonesia.

1. Introduction

On 26 December, 2004, a powerful Sumatra-Andaman earthquake of moment magnitude 9.1–9.3 occurred in the northern Indian Ocean about 250 km off the west coast of Sumatra, Indonesia (Lay et al., 2005). The earthquake generated a massive tsunami with the maximum wave height of up to 24–30 m, causing 230,000–280,000 fatalities while severely damaging coastal human settlements, properties and infrastructure, particularly in Indonesia, Thailand, Sri Lanka, India, and Maldives (Diacu, 2009). The total cost of damages was estimated at $15 billion at least (Farrell et al., 2015). The 2004 Indian Ocean Tsunami is by far the worst natural disaster of its kind in recorded human history (Athukorala, 2012).

Given the significance of the tsunami and its devastating impact, many studies have been developed surrounding the science and management aspects of the disaster as well as settlement reconstruction and restoration. For example, Röbke and Vött (2017) provided a thorough treatise on the tsunami phenomenon from a geoscientific point of view. Athukorala (2012) examined the nature and effectiveness of international humanitarian aid efforts after the tsunami disaster. Matsumaru (2015) compared the post-tsunami reconstruction process in Indonesia and Sri Lanka from the point of view of a "Build Back Better" philosophy. Yet, there is currently a knowledge gap in the literature that examines and documents urban water supply, one of the fundamental needs of urban society, in the disaster affected area, despite substantial aid poured in post-disaster to help reconstruct and restore urban settlements and public facilities including water supply system (e.g., The Guardian, 2014; Masyrafah and McKeon, 2008).

This study is dedicated to developing understanding of current domestic water supply and use behavior in Banda Aceh, Indonesia, the most affected city by the tsunami. It is intended to synthesize information from both water utility and residential water users in the urban area to examine specifically the below questions: 1) how is the current municipal water supply for domestic use? 2) what are major issues and challenges faced by domestic water supply? 3) how do urban households access and use water and perceive the water supply service of local utility? and 4) to what extent are urban households willing to pay (WTP) for reliable water supply? The study is expected to fill in the

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current knowledge gap while informing future development of water supply system in the area, promoting achievement of the sustainable development goal (SDG) for water - universal and equitable access to safe and affordable drinking water for all by 2030.

The paper is organized as follows. Section 2 describes the study area, the Banda Aceh city, encompassing its demographic background, tsunami impact, climate conditions and water resources. Section 3 summarizes the method used for collecting information and data, including questionnaire design for household survey, and the modelling approach to eliciting and analysing household WTP for reliable water supply. Section 4 presents the study results, covering the state of domestic water supply and challenges, characteristics of survey respondents, local perception on water supply service, residential water use behaviour, and household WTP for water supply service and underlying driving factors. Section 5 discusses the results and management implications. In the end, Section 6 concludes the paper.

2. The study area: Banda Aceh

2.1. Demographic background and tsunami impact area

The study area Banda Aceh is the capital city of the Province Aceh, Indonesia, located on the northern tip of the Sumatera Island (Fig. 1). The city occupies a total land area of about 61 km^2, with an average altitude of 0.8 m above the mean sea level (Badan Pusat Statistik, 2014a). Administratively, Banda Aceh is divided into 9 districts (i.e., Meuraxa, Jaya Baru, Banda Raya, Baiturrahman, Lueng Bata, Kuta Alam, Kuta Raja, Syiah Kuala, and Ulee Kareng) and 90 villages. According to Badan Pusat Statistik (2014a), land use in the city is dominated by residential land, which covered about 50% of the urban area in 2013 (see Table 1). As of 2013, Banda Aceh had a total population of approximately 250,000 (Badan Pusat Statistik, 2014a), and the occupations of citizens were mainly in the trade and service sector, which accounted for 84% of the population, followed by farmers at 4% (Badan Pusat Statistik, 2014b).

Table 1
Land use classification in Banda Aceh in 2013.

Land Use	Area, ha	Percentage, %
1. Protected area		
a. Riparian area	179.9	2.93
b. Mangrove forest	434.38	7.08
c. Green open space	552.72	9.01
d. Reserved area	16.65	0.27
2. Cultivated area		
a. Residential area	3,042.63	49.59
b. Business area	522.23	8.51
c. Office area	149.56	2.44
d. Tourist area	51.31	0.84
e. Non-green open space	25.39	0.41
f. Fishery area	32.07	0.52
g. Public service area	293.86	4.79
h. Port area	11.76	0.19
i. Empty area	341.55	5.57
j. Open water	482.02	7.86

Source: Badan Pusat Statistik (2014a).

Banda Aceh was the most affected city and severely damaged by the 2004 tsunami due to its location at the forefront of the northwest coast of Indonesia that is the closest to the epicentre of the earthquake and tsunami (e.g., Cluff, 2007; Matsumaru et al., 2012). The tsunami inundation in the city travelled about 3–4 km inland, affecting nearly

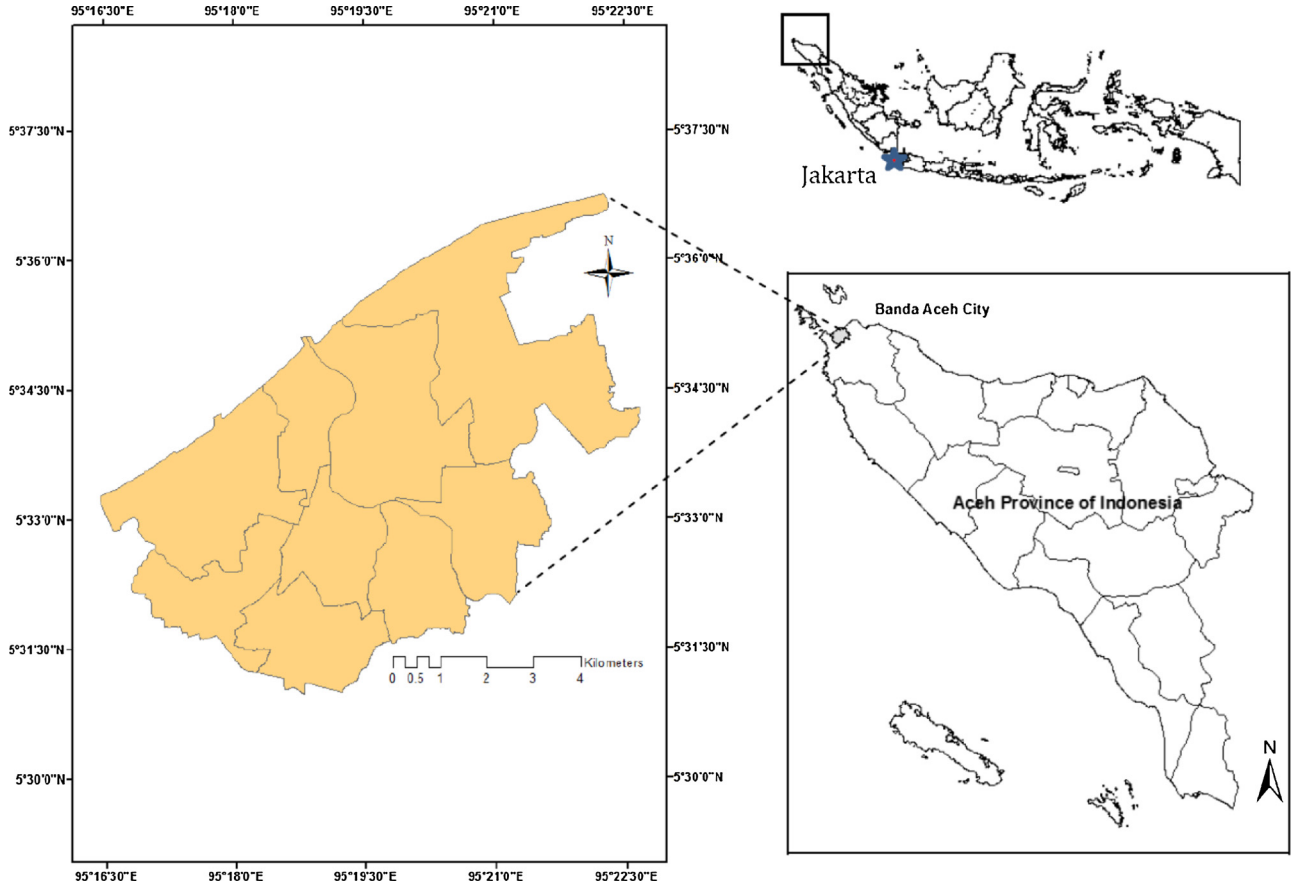

Fig. 1. Geographic location of the study area Banda Aceh, Indonesia.
Source: Achmad et al. (2014)