# SPATIAL INEQUALITIES IN MALAYSIA'S NON-REVENUE WATER RATES ISSUES, CHALLENGES AND MANAGEMENT STRATEGIES

Chee Hui, Lai* and Ngai Weng, Chan
*School of Humanities, Universiti Sains Malaysia*
*Corresponding author's e-mail: chlai87@yahoo.com

**ABSTRACT:** In Malaysia, high non-revenue water (NRW) rate is amongst the country's top water issues. NRW rates of all states in the country vary greatly, with the rates ranging from 18.2 to 62.4 per cent. This huge spatial variation is due to variations in management efficiency of the water operator, amount of funding for NRW reduction programme and level of public awareness. This paper aims to examine the effect of the spatial inequality on NRW management in Malaysia's states by comparing NRW rates between states with different area sizes. The study is mainly based on literature review and secondary data. The results show that states with smaller surface areas recorded lower NRW rates but the smallest state was found to record the highest NRW rate. Factors such as service's coverage area, population density, water supply network density, dispersal of the city area, and location of the water users, and type of water users also have significant impacts on NRW management. For example, high water supply network density, poor water resources availability and high demand in Penang have forced the state's water operator to increase its efficiency in NRW management. In contrast, low water demand, low population density, and less commercial area in Perlis are found to be the reasons of high NRW rate in the state. In conclusion, spatial factors can impact NRW as smaller states can better manage NRW due to the smaller water service areas covered. However, states cannot use size of service area and spatial variations as excuses for high NRW as the study found that adequate funding, proper planning, effective management, efficient service, and proactive strategies of water operator are more important factors that can have significant impacts on the NRW rates.
*Keywords*: non-revenue water (NRW), water loss, surface area, spatial variation, water service

## INTRODUCTION

Non-Revenue Water (NRW) refers Table 1 to treated water lost from a water supply network before it passes through consumers' water metres. Generally, NRW is defined as the sum of water loss and unbilled authorised consumption. Causes of NRW are divided into three different categories, with the first and most common cause of NRW being water lost from pipe leakage, pipe burst, overflow of water utility's storage tanks, and other forms of water lost physically, this type of NRW is defined as real loss. The second type of NRW is water lost commercially from metre inaccuracy and unauthorised consumption (e.g. water theft, illegal pipe connection, etc.). Third is, unbilled authorised consumption referring to the water provided free by the water utility, for example water used for firefighting (Lambert and Hirner, 2000). In many developing countries, high NRW rate is one of the water issues threatening the countries' water security and large amount of clean water "disappeared" from its water supply network causing huge losses to the economy, societal, and environmental aspects (Frauendorfer and Liemberger, 2010). In Malaysia, high NRW rates are hindering the country's effort to sustain its water supply. Many of the state's water service providers (WSPs) have been struggling to reduce its NRW rates despite huge amount of investment (Lai et al., 2013). Referring to Figure 1, in 2013, Malaysia's NRW hovers at an average rate of 36.6 per cent, with the states' NRW rates ranging from 18.2 per cent to as high as 62.4 per cent (MWA, 2014). Reducing NRW effectively is a complicated task which requires technical and non-technical strategy. Lack of funding, poor public participation, lack of competent staffs, and lack of management unit's interest in reducing NRW have been reported as the most common challenges faced by Malaysia's WSPs in reducing NRW rate (Lai et al., 2013).

Table 1: International Water Association (IWA) Standard International Water Balance and Terminology

<table>
<tr><td rowspan="9">System Input Volume</td><td rowspan="4">Authorized Consumption m$^3$/ year</td><td rowspan="2">Billed Authorized Consumption m$^3$/ year</td><td>Billed Metered Consumption (including water exported)</td><td rowspan="2">Revenue Water m$^3$/ year</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption m$^3$/ year</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water m$^3$/ year</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses m$^3$/ year</td><td rowspan="2">Apparent Losses m$^3$/ year</td><td>Unauthorized Consumption</td></tr>
<tr><td>Metered Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses m$^3$/ year</td><td>Leakage on Transmission and/ or Distribution Mains</td></tr>
<tr><td>Leakage and Overflow at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to the point of Customer Metering</td></tr>
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Figure 1 Source: Lambert and Hirner (2000)

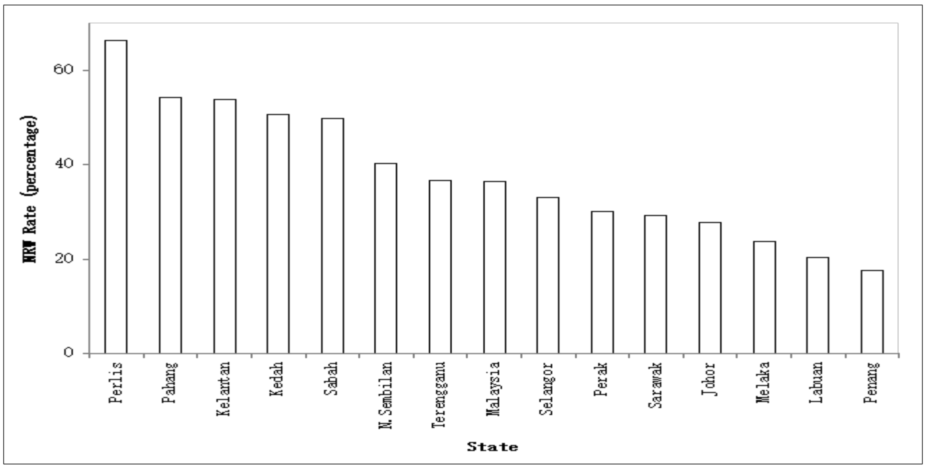


Figure 1: NRW Rates of All States in Malaysia in 2013
Source: MWA, 2014

## SPATIAL FACTORS INFLUENCING NRW MANAGEMENT

Spatial and geographical factors are major considerations of water utility in managing water supply and demand in a city (Amarasinghe et al., 2005). For example, spatial variation between two cities can cause big differences in population, urbanisation, income, domestic residential areas and industrialisations in the cities which can cause big differences in water demand. Moreover, the location of a city or a residential area can affect the water supply strategies as the flowing pattern of rivers and location of water infrastructures (e.g. dams, reservoir, water piping and water treatment plants) need to be taken into account in planning water supply strategies (Amarasinghe et al., 2005; Wells et al., 2014). In the aspect of NRW management, population density and population growth in different space is suspected to be the factors influencing water utility in managing NRW (Gonzalez et al., 2012). The study conducted by Gonzalez et al. (2012) suspects that water management in a city with higher population density and population growth is more complex because of the complexity of its water supply networks. And the findings also points out that several dispersed population centres could result in worse management of the supply infrastructure in the outlying areas. Thus, if the points from Gonzalez et al., (2012) study is correct, spatial inequality could be a factor influencing Malaysia's water service providers (WSPs) progress in reducing NRW rate. To date, there are only limited studies on how spatial factors influence NRW rates in Malaysian states. Therefore, this paper aims to discuss the effect of spatial inequality on NRW management in Malaysia's states. Specifically, this paper first compares the NRW rates in between the states that have big surface area with the states that have small surface area. Second, this study examines the issues and challenges faced by the water operators in managing NRW in different states, namely the relationship of surface area, population density and geographic variations.

## METHODOLOGY AND RESEARCH MATERIALS

The study employed qualitative interview, literature review and secondary NRW data in Malaysia. Secondary data such as journal article, research report, government documents, and other reports were also used to support the study findings. In particular, this research studied water statistics published by *Suruhanjaya Perkhidmatan Air Negara* (SPAN) and Malaysian Water Association (MWA) in recent years. Moreover, qualitative interviews were also carried out with key informants (representatives of state's WSPs and SPAN) to obtain their opinions on the challenges confronting the states in reducing NRW.

## RESULTS AND DISCUSSIONS

In order to know how spatial factors influence the states' NRW rates, data concerning surface areas, urban population, population density, and water network density of all the states were analysed as they determine spatial variation. The results are presented in Figure 2, Figure 3, Figure 4, and Figure 5. First, the study investigates the differences of NRW rates with different states' surface areas. Referring to Figure 2, the three states which recorded lowest NRW rates in 2013 were the three smallest states in Malaysia. With the exception of Perlis state, the other three small states (Penang, Melaka, and Labuan) in Malaysia recorded NRW rates below 25 percent in 2013. According to Figure 3 which shows the NRW rates and urban populations in all states in Malaysia, it was found that states with higher urban population recorded lower NRW rates. In contrast, states with lower urban population recorded higher NRW rates in 2013. For example, three (Penang, Melaka, and Labuan) out of four states with urban population equal or more than 50 per cent recorded NRW rates below than 25 percent in 2013.

Referring to Figure 4 for the states' NRW rates with population densities, the three states that has lowest NRW rates in the country have higher population density if compared with the other states in Malaysia. Generally, except Selangor, the states which have population density with more than 400 people/ $km^2$ recorded lower NRW rates in 2013. In contrast, states with lower population densities recorded higher NRW rate in 2013. In addition, this study also examines the states NRW rates with network density, the results are presented in Figure 5. Referring to Figure 5, the states with higher network density recorded lower NRW rates in 2013. Penang, Melaka, and Labuan were three out of five states that had network density with more than 3 km length of pipe/ $km^2$ of surface area, and the results show the NRW rates of these three states were below 25 per cent in 2013. Again, Selangor State and Perlis State are the two exceptions with high network density but high in NRW rates. Overall, it seems the small states in Malaysia with high network density, high population density, and high urban population tends to have low NRW rates.

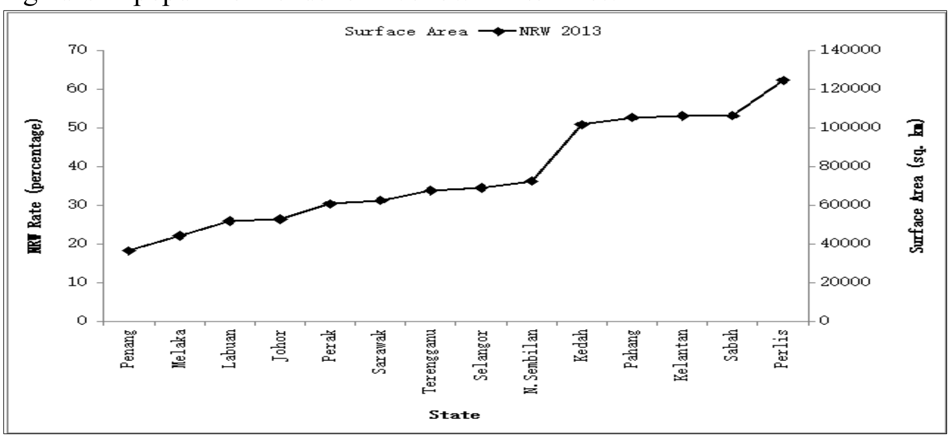


Figure 2: States' NRW Rates in 2013 and States' Surface Areas
Source: MWA (2014); Department of Statistic Malaysia (2010)

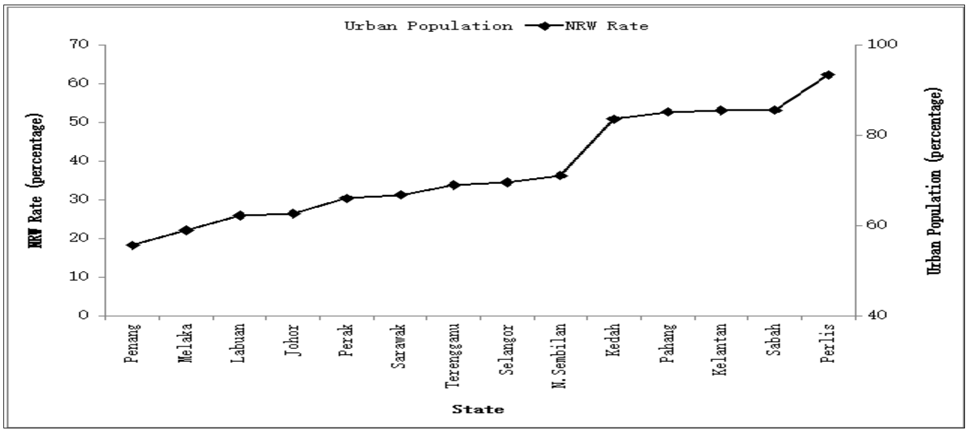


Figure 3: States' NRW Rates in 2013 and Urban Population (based on the data in 2010)
Source: MWA (2014); Department of Statistic Malaysia (2010)

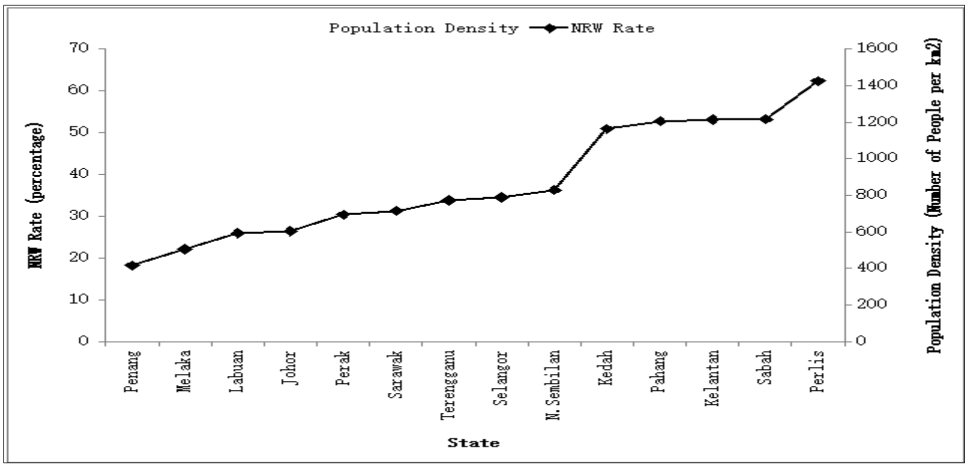


Figure 4: States' NRW Rates in 2013 and Population Densities (based on the data in 2010
Source: MWA (2014); Department of Statistic Malaysia (2010)

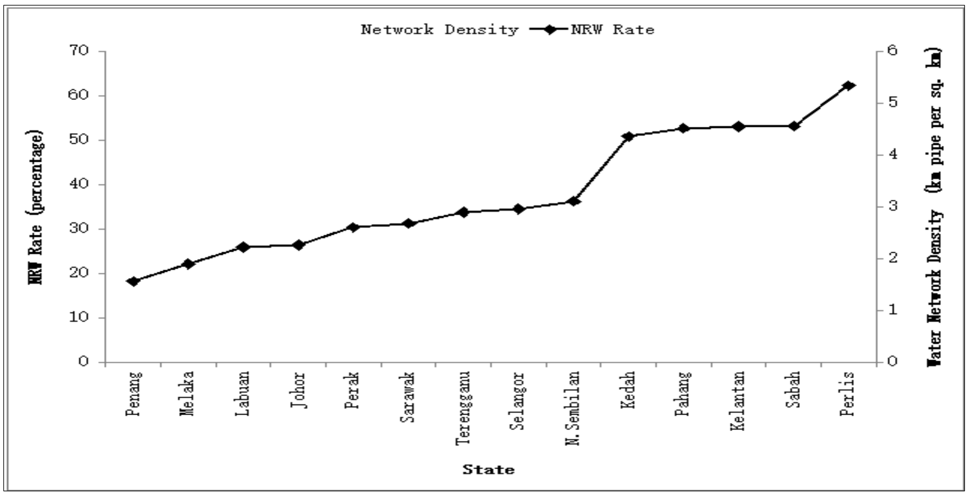


Figure 5: States' NRW Rates and Network Density in 2013
Source: MWA (2014)

A qualitative interview was done with a representative from Johor's WSP to discuss its WSP challenges in reducing NRW. The interviewee from Johor mentioned that Johor's WSP is actually facing bigger challenges in reducing NRW rate in the rural areas. Compared with solving a NRW-related issue in rural area, a NRW-related issue in urban area usually can be solved in a shorter time. For example, repairing a leaking pipe in urban area is quicker then repairing a leaking pipe in rural area. The rational behind is that a leaking pipe along the roadside in urban area can be more easily discovered compared to a leaking pipe along the roadside in rural area, as there are more road users passing by the road in urban area and thus the chance of the leaking pipe seen and reported is higher. Besides, the interviewee from Johor also mentioned that more resources have to be allocated in urban areas to build comprehensive NRW management system as the water demand in urban area is higher, and water security in urban areas are more vulnerable than in rural area. For example, a pipe burst issue happened in the city centre can cause thousands of people staying in a few 30-floor condominiums to face water supply issue because the population density is much higher. In contrast, a pipe burst issue happened in the rural area may only cause water supply interruption to a village which has only about 200 to 500 people.

A qualitative interview was also carried out with a representative from Penang's WSP to discuss NRW management in Penang State. The Penang's interviewee mentioned that one of the reasons forcing the state's WSP to invest more resources in reducing NRW rate was high water demand and low water availability of Penang State. The Penang's interviewee said that the primary reason Penang state had to maintain its NRW rate at a low rate is because the state has to ensure that the water supply is not disrupted 24 hours a day especially to the industries in industrial areas where many factories are located. Some of these factories need water for commercial purpose, for example, to produce goods. Moreover, due to the high population density and low water availability in Penang, the management unit of the WSP understood that NRW rate has to be kept at a low rate in order to sustain the state's water supply. Penang State cannot depends solely on extracting the water resources from the Sungai Muda River, which is a river located at Kedah State for sustaining the water supply, reducing NRW and water wastage is a must-do task for the Penang WSP.

The above discussion has explained why a state with smaller surface area, higher urban population, higher network density, and higher network density would have lower NRW rate. This is because spatial and geographical factors can influence WSP's efficiencies and strategies in reducing NRW rate. Penang's case indicates that the Penang's WSP has to maintain its NRW rate at a low rate to sustain water supply because of low water availability in the state due to the location of the rivers. The Johor's case explains that resources invested in rural and urban areas for NRW reduction could differ because of the differences of population density. In Malaysia, Penang and Melaka are among the most developed states with more urbanised areas, industrial areas, and higher population density in its residential areas. All these factors influence their WSPs to reduce its NRW rates for sustaining water supply of the states. Besides, high population density and high network density of Melaka and Penang probably caused the NRW issues to be easily discovered by the people compared to other states. This can influence a WSP's efficiency in solving NRW issues.

## CONCLUSION

In conclusion, spatial and geographical factors could influence WSP in carrying out NRW reduction activities by influencing the WSP's strategies, policies, and decision in dealing with NRW-related issues. However, it does not mean that a NRW rate in a big state cannot be reduced to a lower rate, because reducing NRW effectively requires management of other factors, for example, funding, human capacity of WSP, technical capacity of WSP, and the level of public involvement in NRW reduction activities. The spatial and geographical factors must be taken into account when WSP plans its NRW reduction strategies. For a WSP based in a state having smaller surface areas, spatial and geographical factors do not seem to be the major factors hindering WSP's progress in reducing NRW, but other factors stated above have to be well managed in order to improve WSP's performance in reducing NRW. For WSP with broader service coverage area, it is advisable for the WSP to have service centres and teams located at both rural and urban areas in order to increase the efficiency of its staffs in solving NRW-related issue. Rather than depending solely on staffs who works in the states' headquarter of WSP, the responsibility of carrying out NRW reduction activities have to be delegated to the service centres or teams who are based in a particular service areas. If spatial factors can be better managed, the WSP will be able to achieve lower NRW rate by increasing its efficiency in solving NRW-related issue.

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