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The Relationship between Total Income and Groundwater Utilization on Fluviomarine Landform Area in Jakarta

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Abstract. Approximately 40% of Jakarta is below sea level when the tide is in, which is referred to as a fluviomarine landform. This study aims: (a) to analyse the relationship between total income and household water demand, and (b) to analyse the relationship between total income and the proportion of groundwater utilisation. It uses quantitative and qualitative analysis survey methods, as well as sampling methods, to represent the population. The population of this research is comprised of households that use groundwater on land units made from two classes of landform, two classes of settlement pattern, and three classes of settlement density. To determine the 30 wells, samples with proportional random sampling of the land units formed with groundwater samples have been taken at a radius of 100m from each well sample of 110 households. Quantitative and qualitative approaches have been used to prove the research aims. The analysis of this study indicates that the total income is proportional to household water demand but that it is inversely proportional to the share of groundwater utilisation. The results also show that groundwater is not the only source to fulfil household water demand, and that it is necessary to utilise other sources of water.

Keywords: Fluviomarine Landform; Water Demand; Groundwater Utilization; Jakarta.

Abstrak. *Jakarta memiliki 40% wilayah yang berada di bawah permukaan air laut pada saat air pasang, yang secara geomorfologis disebut bentuklahan fluviomarin. Tujuan penelitian ini adalah untuk mengetahui hubungan antara pendapatan total rumah tangga dengan kebutuhan air dan juga untuk mengetahui hubungan antara pendapatan total rumah tangga dengan proporsi pemanfaatan airtanah bebas untuk memenuhi kebutuhan air rumah tangga pada bentuklahan fluviomarin di Jakarta. Penelitian ini menggunakan survei dengan analisis kuantitatif dan kualitatif serta menggunakan sampel untuk mewakili populasi. Populasi yang diteliti adalah masyarakat pengguna airtanah bebas pada berbagai unitlahan yang dibuat berdasarkan kombinasi dari dua kelas bentuklahan, dua kelas pola permukiman dan tiga kelas kepadatan permukiman, sedangkan untuk menentukan 30 sumur sampel dengan proporsional random sampling dari unitlahan yang terbentuk dengan sampel pengguna airtanah diambil pada radius 100 m dari masing-masing sumur sampel yaitu sebanyak 110 rumah tangga. Pendekatan kuantitatif dan kualitatif dengan korelasi non-parametrik digunakan untuk menjawab semua tujuan penelitian. Hasil analisis menunjukkan bahwa semakin besar pendapatan total semakin besar kebutuhan air rumahtangga. Semakin besar pendapatan total semakin kecil proporsi pemanfaatan airtanah untuk memenuhi kebutuhan air rumah tangga. Hasil penelitian juga menunjukkan bahwa airtanah bukan satu-satunya sumber pemenuhan kebutuhan air rumah tangga, maka perlu diupayakan untuk menambah sumber pemenuhan kebutuhan air selain dari airtanah.*

Kata Kunci: *Bentuklahan Fluviomarin; Kebutuhan Air; Pemanfaatan Airtanah; Jakarta.*

1. Introduction

The population of Jakarta grew 4.4% between 2000 and 2010, increasing from 8.3 million to 9.6 million, and the city accounted for 1.41% of the population growth rate. This condition has resulted in an increase in habitation that will generally reduce the amount of open space (Badan Pusat Statistik, 2010). Jakarta experienced a rapid development of land-use change, from a vegetation region into a developed region. The increasing number of residential developments, industrial and office areas, and infrastructure facilities to support the activities, have exploited many areas. The increase in population density has caused an excessive exploitation of groundwater, which still continues. The establishment of regional development and groundwater exploitation caused an intensification of land subsidence, caused by natural and human factors (Abidin *et al*., 2011).

Jakarta is called a *kampong* city, where 60% of the city consists of informal settlements. Most of the settlements in Jakarta have a high density of 600 peoples per hectare. These settlements grow naturally without any clear control and direction even to the riverbanks or around the railways, and are inhabited by people who are generally in the middle to lower economic classes. Village relocation from riparian areas has been a prolonged problem since the 1990s (Steinberg, 2007). When housing prices are not affordable, informal settlements become the most realistic option (Zhu and Simarmata, 2015). Population concentration has resulted in the inevitable and excessive exploitation of groundwater (Abidin *et al*., 2011; Setiawan *et al*., 2011).

The city of Jakarta grew over a very long period of time and became a silent witness to development in Indonesia (Hutabarat, 2002; Hutabarat Lo, 2010). It has become the largest metropolitan city, as well as the most dense and important city in Indonesia, being the centre of state administration and business (Steinberg, 2007; Firman, 2009; Brunn *et al*., 2012). The city of Jakarta also plays an important role in national and international trade, becoming an investment centre for foreign investors, not only in manufacturing but also construction and service. This has boosted Jakarta's economy and has made it a popular site of urbanisation. Economic and social changes have also had an impact on changing land use patterns. Settlements in downtown Jakarta have turned into commercial areas, offices, and elite settlements such as apartments. In addition, the expansion of the city of Jakarta has caused several major problems such as congestion, slums, environmental pollution, and an increasing gap between the rich and poor, while the management and planning of the city still needs to be addressed. Development in downtown Jakarta influences the development of satellite cities in the vicinity such as Depok, Bogor, Tangerang and Bekasi. These satellite cities grew in terms of service, residential and industrial sectors, in order to support the city of Jakarta (Steinberg, 2007; Brunn et al., 2012).

Approximately 40% of Jakarta below sea level when the tide is in, in addition to the presence of coastal swamps, which increase the possibility of floods (Gunawan, 2010). This region is called a fluviomarine landform (Marsoedi et al., 1997), as it is influenced by fluvial as well as marine processes (Tamod *et al*., 2016). Floods in Jakarta occur in the basin, alluvial plains and coastal environments (Aerts *et al*., 2009; Marfai *et al*., 2009; Ward *et al*., 2010; Marfai *et al*., 2013). Utilisation of urban space with physical development and a significant increase in population, can also affect the repeated periods of flood-stricken areas. Land conditions with borders of land in the form of floods are not suitable for developing regions, and have been designated as wetlands used to hold water during floods since the 1960s; until now, however, such areas have been utilised for various purposes of the city. The channel system was unsuccessful due to Jakarta's flat topography, meaning that water could not flow by gravity alone. The presence of mud sedimentation also clogged the water flow, so the channel development is only to tackle the flood in a moment (Gunawan, 2010; Sakethi, 2010). This condition is coupled with the infiltration of water into the soil and very low permeability (Pramono, 2016).The results of flood scenario modelling in Jakarta show that the use of land has increasingly affected settlements, with widespread floods with that have also exhibited an increasing depth (Marfai *et al*., 2013). Tamod *et al*. (2016) mentioned that this area might be the meeting point of rain water (runoff and percolation) and sea water, which allows the entry of sea water to fill the aquifer.

This study is important because population growth and Gross Regional Domestic Product (GRDP) tend to increase over time, followed by an increase in water demand. The level of prosperity in Jakarta is relatively higher than other provinces in Indonesia, and shows positive economic growth. Jakarta's GRDP was 125,533.8 in 2011 and increased to 174,824.1 in 2014. This is also reinforced by the reduction of the unemployment rate in Jakarta, which was 10.83% in 2011 and dropped to 9.84% in 2014 (Bappenas, 2015). During the last three years, households consuming plumbing and bottled water have continued to increase to more than 85% (BPS Provinsi DKI Jakarta, 2015). The use of groundwater through drilling wells and *pantek* wells in Jakarta is still high. This has an impact on land subsidence, which poses a serious threat to Jakarta residents. The amount of use of groundwater from drilling wells and *pantek* wells in 2014 was 8,850,144 m^3 from 4,473 wells. This is an increase from 7,864,787 m^3 from 4,231 well points in 2011 (BPS Provinsi DKI Jakarta, 2016).

Groundwater contamination is generally caused by human activity. The higher the level of human activity in a place, the higher the level of household waste produced and if not properly managed, this can cause a decrease in groundwater quality (Takem *et al*., 2009; Bahar *et al*., 2010; Rani and Sasidhar, 2010; Akoteyon *et al*., 2011; Hastuti and Wardiha 2012; Strohschön *et al*., 2012; Affum *et al*., 2015). The sewage channel is the main cause of water contamination in Jakarta. This is due to the lack, or inadequacy, of facilities capable of handling the vast level of waste disposal, both from domestic and industrial activities. Agricultural activities in upstream areas also increase water pollution in the form of pesticide and fertiliser sedimentation. This has impacted the condition of Jakarta Bay as the most polluted bay in Indonesia (Kantor Menteri Negara Lingkungan Hidup, 1997). In addition, excessive groundwater extraction in the coastal areas of Jakarta has led to seawater intrusion (Onodera *et al*., 2008; Setiawan *et al*., 2010).

The study demonstrated a relationship between the magnitude of water demand and the increase in the total household income. Similarly, modelling the relationship between total household income and the proportion of groundwater utilisation for the fulfilment of household water demand can illustrate the proportion of groundwater utilisation in line with the increase in the total household income. Therefore, this study has two objectives: to analyse the relationship between total income and household water demand; and to analyse the relationship between total income and the proportion of groundwater utilisation.

2. Research Method

a. Study Area

The fluviomarine landform in Jakarta is located in the northern part of Jakarta (6°5′13″–6 °14′5″ S and 106 °41′9″–106 °58′42″ E), as presented in Figure 1.The region is in the form of alluvial plains and beach ridges that are often hit by floods and groundwater contamination caused by human activity and sea water intrusion. In this situation, there are many households that still use groundwater.

b. Datasets and Collection

The groundwater referred to in this study is the unconfined aquifer. This study uses a survey research design, because the symptom is an empirical symptom or symptoms that already exist. The object studied is the characteristics of an object: the households that use groundwater. The population of this research consist of the households that used groundwater on land units made from two classes of landform, two classes of settlement pattern, and three classes of settlement density. To determine the 30 wells, samples with proportional random sampling of the land units formed with groundwater samples were taken at a radius of 100m from each well sample of 110 households. The primary data was conducted twice through interviews, during the dry season in August 2015 and the rainy season in January 2016.

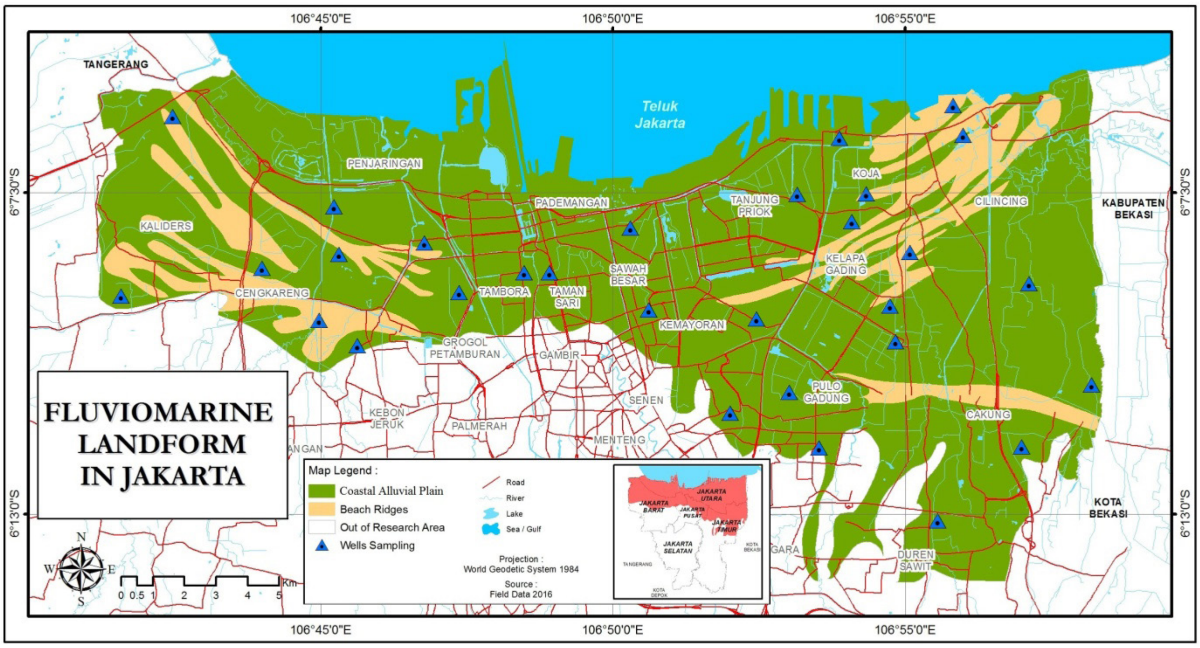

Figure 1. Research Location

c. Analysis

The data was analysed using quantitative and qualitative techniques. The quantitative analysis technique was used for describing data input, the percentage of respondents' answers, and non-parametric correlation analysis. The qualitative analysis technique was used to interpret the results of the non-parametric correlation. The results of this research will be discussed alongside the findings of other research projects.

3. Results and Discussion

a. Total Household Income

The total household income is the total income of all employed household members. The average total household income is over 3.2 million rupiah (Rp). The greater the total household income, the more household needs can be fulfilled, including the household water demand. The small number of households that usually work in the informal sector, such as food stall, are self-employed households with a below minimum income in Jakarta. This group still depends on groundwater for most sources of water supply. This is in line with the statements of Muta'ali (2012) that the level of income affects the amount of water demand. Revenue is one of the parameters used to determine the socio-economic conditions of households. Increased economic capacity of the community will increase the water demand, along with the facilities owned and the increasing demands of life. According to Yunus (1987), relatively homogeneous socio-economic conditions usually appear in a single unit of residential environment. The total household income based on the type of settlement is presented in Table 1.

Table 1. Total Household Income Based on Type of Settlement

Type of Settlement	Total Household Income (IDR 000,000)					Total
	< 3.2	3.2 – 6.4	6.4 – 9.6	9.6 – 12.8	> 12.8	
Organic settlements	14	40	26	5	1	86
Planned house	1	5	9	4	5	24
Total	15	45	35	9	6	110

b. Household Water Demand

The household water demand is the amount of water needed to fulfil the various needs of households' daily activities. The water demand increases with the increasing number of household members. The total household water demand depends on the number of household members and the various purposes of demand. The increase in the number of household members results in an increase in household water demand. Likewise, the increased in the needs to be fulfilled results in an increase in household water demand. Household water demand in the dry season is approximately more than in the rainy season. This is associated with a number of activities that are carried out only in the dry season, such as watering the yard and gardening. However, households that are often flooded have a greater demand for household water needs in the rainy season especially the increase in water needed to clean house following flooding. There are two types of household water demands, namely nuclear families who need less than 300 litres/day and extended families who need more than 900 litres/day. The average household water demands according to the various needs are presented in Table 2.

Table 2. The Average Household Water Demands According to Various Needs

Requirement	Water Demand (litres/person/day)	
	Dry	Rainy
Cooking	3.00	3.00
Drinking	2.50	2.50
Raw material washing	2.50	2.50
Cookware and cutlery washing	10.00	10.00
Bathing and brushing of teeth	55.00	55.00
Ablutions	10.00	10.00
Laundry	15.00	15.00
House cleaning	5.00	5.00
Vehicle washing	8.00	8.00
Yard watering	2.00	0.00
Gardening	2.00	0.00
Toilet usage	20.00	20.00
Other	20.00	20.00
Total	155.00	151.00

The results of this research indicate that the water demand is much higher than the limit set by The National Standardization Agency of Indonesia (Badan Standardisasi Nasional, 2002), whereby the use of water for city residents is set at 120 litres/person/day (lpd). Compared to Wardhana's (2004) finding that the total water requirement is 150 lpd, the findings of this research show a little more than 155 lpd during the dry season and 151 lpd in the rainy season. The greatest water requirement is to meet the need for baths and the brushing of teeth, while the smallest demand is for watering the yard and gardening, which is only done during the dry season.

The total water demand in the dry season is higher than in the rainy season. This is consistent with the statement of Linsley and Franzini (1972) that water demand will be greater in warm, dry climates than in humid climates. This is related to the types of water needs in the dry season that require more water, such as watering the yard and plants. The total water demand, in both dry and rainy seasons, is between 134 – 172 lpd, with an average of 155 lpd in the dry season and 151 lpd in the rainy season. The average total of water needs of household members in the organic settlements was smaller compared to the planned houses. People who live in planned houses have more use for water because of many types of need, such as washing motor vehicles (including households that own multiple vehicles) and watering the wider yard. If water usage is reviewed with regards to settlement density, it is observed that high-density settlements tended to useless water than medium- or low-density settlements, because the watered yards were narrower and contained fewer plants.

c. Sources of Household Water Demand Fulfilment

Sources of water demand fulfilment are not only from groundwater but also from rainwater, drinking water companies, water carts, and bottled water. Rainwater is collected in advance, in a tub, from the roof, to fulfil various purposes. Drinking water companies use water from *Perusahaan Air Minum Jakarta Raya* (PAM Jaya), which is distributed to households through pipelines at a price of IDR 7,200.00/M^3. Water waggons come from drinking water companies and are first stationed in one place before distributing water to homes that do not have a drinking water company network, with carts consisting of 10 jerry cans with 10 litres of capacity each, at a price of IDR 3,000.00/jerry can. The source of bottled water is gallons that come from the factories at the cost of IDR 16,000.00, and gallon water refills cost IDR 6,000.00. Prices fluctuate for cart water and bottled water, depending on the distance from the base to the house, and the amount of source available. The sources of household water demand fulfilment are based on various purposes, as presented in Table 3.

Table 3. Sources of Household Water Demand Fulfilment Based On Various Purposes

Requirement	Sources of Water Demand Fulfilment				
	Rainwater	Ground-water	PAM Jaya	Water carts	Bottled water
Cooking		*	**	***	*
Drinking			*	*	*****
Raw material washing		***	***	*	
Cookware and cutlery washing		****	**		
Bathing and brushing of teeth		****	***		
Ablutions		****	**		
Laundry		*****	**		
House cleaning	*	*****	*		
Vehicle washing		*****	*		
Requirement	Sources of Water Demand Fulfilment				
	Rainwater	Ground-water	PAM Jaya	Water carts	Bottled water
Gardening	*	****			
Toilet usage		****	***		
Other		*****	*		

Note :

*	:	The least(< 20 respondents)
**	:	Less (20 – 40 respondents)
***	:	Moderate (40 – 60 respondents)
****	:	More (60 – 80 respondents)
*****	:	The Most (> 80 respondents)

The least number of households that still use groundwater for cooking are in organic settlements. Most respondents use bottled water for drinking and a few still use drinking water companies and water carts. Bottled water is used for drinking through more practical methods such as a dispenser. In addition, groundwater is still predominantly used to fulfil various household purposes that do not involve direct consumption, such as for sewage and cleaning the house. There were various household water fulfilment sources, indicating that groundwater is no longer able to fulfil the demand for household water.

There are seven source types of water demand fulfilment (Table 4). All of the types can be found in organic settlements, whereas in planned houses, only type 2 and type 4 can be found. This indicates that the organic settlement has a more heterogeneous community, having more types of water need fulfilment, while planned houses are usually inhabited by a more homogeneous community. There are three source types of water demand fulfilment that exist only on organic settlements in the dry season (type 1, type 3 and type 5), while in the rainy season, these are type 1, type 3, type 5, type 6 and type 7. The use of rainwater had started to be used in households for house cleaning and watering pot plants. Although Kodoatie (2005) is of the opinion that the water requirement can be fulfilled by groundwater or surface water, this research shows that rainwater has been used to fulfil most household water needs.

Table 4. Source Type of Household Water Fulfilment in Rainy Season Based on Type of Settlement

Type of Settlement	Source of Household Water Demand Fulfilment							Total
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	
Organic settlement	8	13	3	24	30	6	2	86
Planned house	0	1	0	23	0	0	0	24
Total	8	14	3	47	30	6	2	110

Note :
Type 1 = Groundwater and water carts
Type 2 = Groundwater and bottled water
Type 3 = Groundwater and drinking water company
Type 4 = Groundwater, bottled water, and drinking water company
Type 5 = Groundwater, water carts, and bottled water
Type 6 = Groundwater, bottled water, and rainwater
Type 7 = Groundwater, bottled water, water carts, and rainwater

d. The Proportion of Groundwater Utilisation to Fulfil the Household Water Demand

Household water demand fulfilment comes from a combination of groundwater, bottled water, water carts, drinking water companies, and rainwater. The proportion of groundwater utilisation is known by calculating the total water requirements jointly fulfilled from various sources. Households in organic settlements tend to have a greater proportion of groundwater utilisation compared to planned houses. High-density settlements also have a tendency to have a larger proportion of groundwater utilisation compared to low-density settlements. The proportion of groundwater utilisation in the dry season ranges from 5.32% to 98.85%, while in the rainy season this ranges from 4.74% to 98.78%. When compared to the research of Kodoatie and Sjarief (2008), which posits that 80% of the urban water supply of urban communities is derived from groundwater, the results of this study indicate that there are similarities in organic settlement households, where the proportion of groundwater used to meet the need for clean water is still large, many of which are proportionally larger than 80%.

In contrast to the proportion of groundwater utilisation in planned houses, however, few still use groundwater (< 20%). The proportion of groundwater utilisation that meets the total water demand based on the type of settlement, is presented in Table 5.

Table 5. Proportion of Groundwater Utilization toward the Total Water Demand Based on Type of Settlement

Type of Settlement	Proportion of Groundwater Utilization (%)					Total
	< 20	20 – 40	40 – 60	60 – 80	> 80	
Organic	7	6	5	2	66	86
Planned house	15	6	2	0	1	24
Total	22	12	7	2	67	110

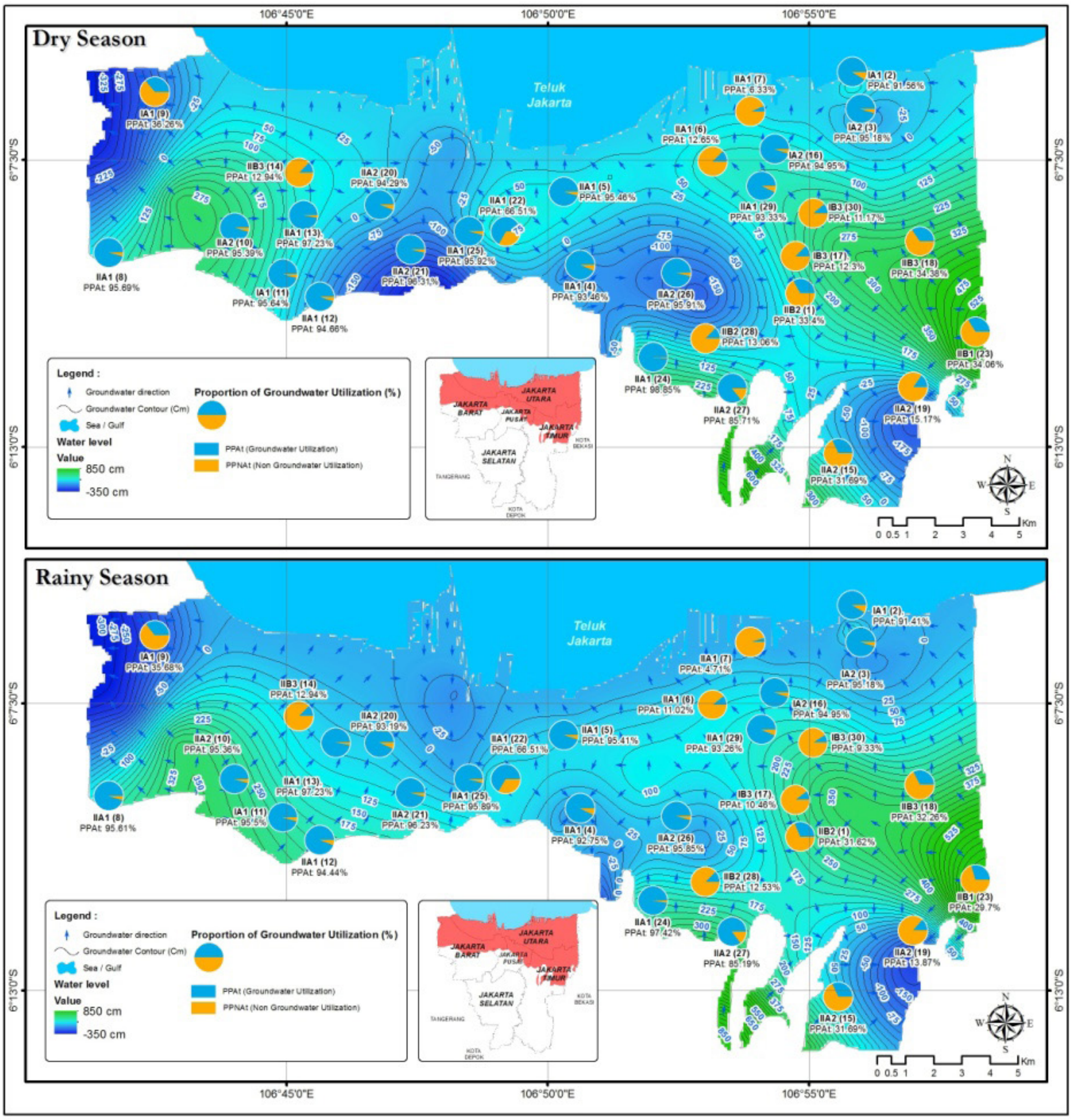

Figure 2. Spatial Distribution of Groundwater Utilization and Water Level

Trends in the proportion of groundwater utilisation in organic settlements are still great, and many use groundwater. This condition is visible in the areas of Grogol, Petamburan and Kemayoran where groundwater is still utilised by many households whose proportion of water utilisation is still large. The water level in the area is concave and below sea level. This means that the intake and utilisation of groundwater in this area is still high. The decrease of water level indicates a change from the effluent river to the influent river. This is similar to that of Ahmad *et al*. (2009), who argue that the decrease of water level also occurs in the urban settlements near Kahota industrial triangle area, Islamabad, Pakistan.

d. Relationship between Total Income and Domestic Water Demand

The results of the correlation analysis with SPSS demonstrate a relationship between total monthly household income and household water demand per day, based on the season. Based on the results of the correlation it is known that correlation coefficients (r count) are 0.593 and 0.586 in the dry season and the rainy season, respectively. The r count value is compared to the r table with the error level of 1% (99% of confidence level), and N = 110. The r table value for N = 110, which is located between the r table for N = 100 (i.e. 0.256) and N = 125 (i.e. 0.230). Evidently, both r count values are greater than the r table value, so that Ho is rejected and Ha is accepted. There is a significant positive relationship (p = 0.000), with moderate level of relationship (r count is between 0.40 and 0.599) between the total household income and the need for household water in the dry and rainy seasons. This means that the larger the total monthly household income, the greater the water needs of the household.

The determinant coefficient is obtained from the square of the correlation coefficient (r^2), which is 0.35 and 0.34 in the dry and rainy seasons, respectively. This means that variants occurring in the variable of household water demand per day can be explained by variants that occur in the variable of total household income per month, which is 0.35 and 0.34 in the dry and rainy seasons.

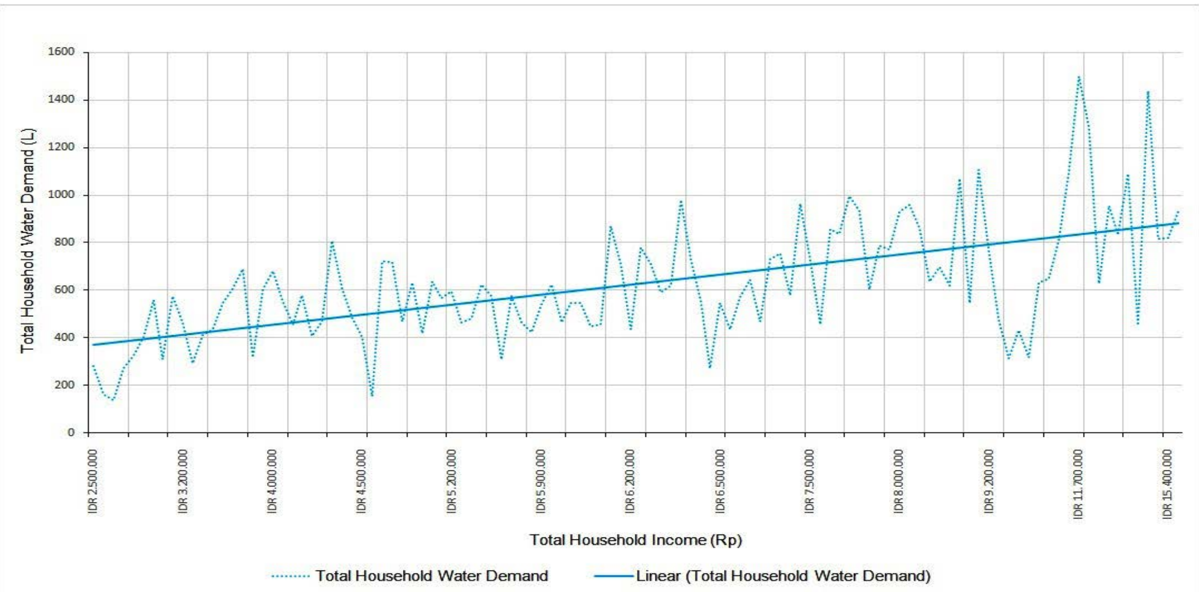

Figure 3. The Relationship Model between Income and Total Household Water Demand

There is a relationship model between the total monthly household income and household water demand, whereby the greater the total household income per month, the greater the household water demand. The increase in total household income does not automatically increase the water demand, but an increase in total household income results in an increased ownership of valuables such as motorcycles and cars, and increased ownership of such items results in an increase in total household water demand. As previous studies have demonstrated, there is a relationship between income and total household water demand

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(Linsey and Franzini, 1972; Domene and Sauri´, 2006; March and Sauri´, 2010; March *et al*., 2012). Water consumption is influenced by economic status; consumption per capita in poor areas is much lower than in richer regions. Rising prosperity and the welfare of the population will increase the demand for water.

This level of water consumption is still far below the United States, which has an average of 378.54 lpd (Mack and Wrase, 2017), while Canada has a water consumption level of 769 lpd (Chenoweth, 2008). This research shows that the minimum water usage of 134 lpd is already far above the estimate Gleick (1996), which is 50 lpd, but almost the same as that expressed by Saurí (2003), 131 lpd, and Chappells and Medd (2008), 130 lpd. The research findings indicate that the greatest water needs are as high as 172 lpd. This is almost the same level as found in research on the metropolitan region of Barcelona, 178 lpd (Saurí, 2003), but is still far below England' level of 190 lpd (Chappells and Medd, 2008).

e. Relationship between Total Income and Proportion of Groundwater Utilization to Fulfil Households Water Demand

The results of the correlation analysis with SPSS demonstrate a relationship between total household monthly income and the proportion of groundwater utilisation used to fulfil the household water demand based on the seasons. Based on the results of the correlation between the total monthly household income and the proportion of groundwater utilisation to fulfil household water demand, it is known that correlation coefficients (r count) are -0.501 and -0.494 in the dry and rainy season, respectively. The r count value is compared to the r table with the error level of 1% (99% of confidence level), and N = 110. The r table value for N = 110 is located between r tables at N = 100 and N = 125, which are 0.256 and 0.230, respectively. Evidently, both r count values are greater than the value of the r tables, so that Ho is rejected and Ha is accepted. In conclusion, there is a significant negative correlation (p = 0.000) with a moderate relationship level (r count is between 0.40 and 0.599) between the total monthly household income and the proportion of groundwater utilisation needed to fulfil the household water demand in the dry and rainy seasons. This means that the larger the total household income, the smaller the proportion of groundwater utilisation needed to fulfil the household water demand.

The determinant coefficient is obtained from the square of the correlation coefficient (r^2) which is 0.25 and 0.24 in the dry season and rainy season, respectively. This means that variants that occur in the proportion of groundwater utilisation variable can be explained by variants that occur in the variable of total monthly household income, which is 0.25 and 0.24 in the dry and rainy seasons.

The magnitude of this standard deviation relates to the large variation in the proportion of groundwater utilisation at the same income level. In addition to income, habit factors also play a large role in selecting sources of household water fulfilment. There is a relationship model between total monthly household income and the proportion of groundwater utilisation to fulfil the household water demand, where the greater the total household income per month, the smaller the proportion of groundwater utilisation to fulfil the household water demand. Increased revenue affects households' ability to choose alternative sources of water in addition to groundwater, such as drinking water companies, water carts, and bottled water. Fulfilling water needs through sources other than groundwater has resulted in increased household expenditure on water; for example, drinking water companies charge IDR 7,200/ m^3; water carts charge IDR 3,000/jerry can; and bottled water cost IDR 16,000/gallon. The groundwater cost is included in the cost of electricity, as part of water pump operations.

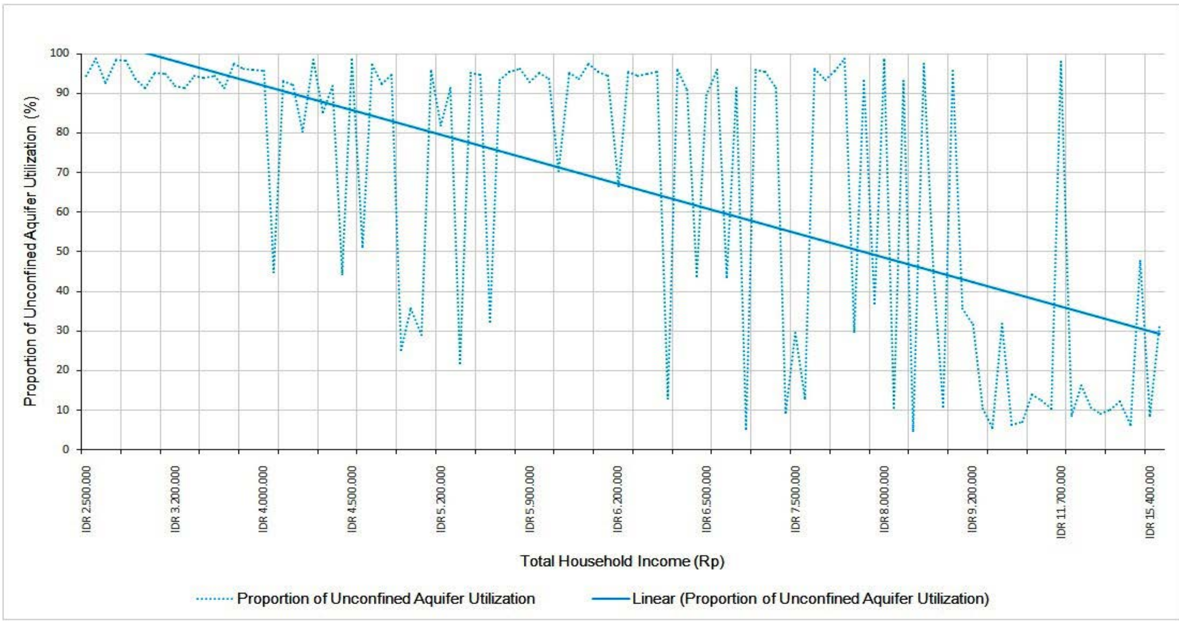

Figure 4. The Relationship Model between Household Income and the Proportion of Groundwater Utilization Needed to Fulfil Household Water Demand

The result is consistent with that expressed by Kamulyan (1996), that the types of sources ranging from raw water to clean water can come from rainwater, surface water, and groundwater; however, this study did not find surface water to be a source of water fulfilment. The use of excessive groundwater in coastal cities has caused seawater intrusion. Seawater intrusion has in turn caused the contamination of groundwater, resulting in decreased quality (Park *et al.*, 2011; Chandrasekar *et al.*, 2013; Jayalakshmi *et al.*, 2014). One of the factors contributing to the use of excessive groundwater is the influence of urbanisation (Onodera *et al.*, 2008; Hastuti and Wardiha, 2011).

4. Conclusion and Recommendation

Total income was proportional to water demand but inversely proportional to the share of groundwater utilisation on fluviomarine landform in Jakarta. Groundwater was not the only source to fulfil water demand, and it was necessary to utilise other sources of water. Groundwater is unable to fulfil all household water demands; therefore, rainwater becomes an alternative source of fulfilling the water demand. Additional sources are needed to fulfil both the government and the community's demand for water, such as expanding the PAM network to areas not currently served by PAM services, and the construction of rainwater treatment plants (IPAH).

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