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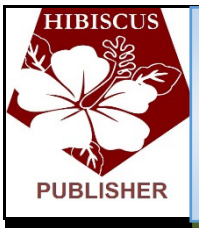

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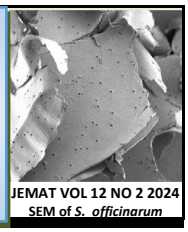

Assessing Household Water Insecurity and Financial Capacity for the Cleaned Water Supply Services in Coastal Fishing Communities: A Case Study in Lok Dangkaan Village, Pitas, Sabah

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ABSTRACT

Water security is a critical issue in rural coastal communities, and it has been proven to impact their health and socioeconomic productivity. Moreover, significant drought seasons may create prominent challenges for the communities. The objectives of this study are twofold: (1) to assess household water insecurity experiences and (2) to explore willingness to pay and ability to pay for better water supply for the Lok Dangkaan Village, Pitas district, a remote area with frequent drought climate in Sabah. A structured questionnaire was utilised in a cross-sectional survey of 45 households to gather information on demographics, socioeconomic status, and water-related concerns. The water insecurity was measured using the Household Water Insecurity Experiences Scale (HWISE). While the water consumption and affordability were measured by the ability to pay (ATP) and willingness to pay (WTP), with monthly water bills and water fee indicators respectively. Descriptive statistics and chi-square tests were used to analyze the data. The study found that most households engaged in fishing, have low incomes and limited access to basic amenities. Water quality is poor, though waterborne diseases are rare. Eighty-two percent of the households do not have access to clean water. The average estimated daily water consumption is 183.56 litres, with substantial variability. 75.6 percent of the households said they could afford to pay RM0.10 for every 1000 litres. On the other hand, their average monthly water bill during the dry season was RM121.67. The high level of water insecurity in Lok Dangkaan Village underscores the urgent need for improved water access and quality. While the forthcoming mini water treatment plant may address some issues, continued support and targeted interventions are necessary to enhance water security in the community.

INTRODUCTION

In Malaysia, reliable water is still lacking and an ongoing issue. It is a pressing concern in rural coastal communities, where access to safe and affordable water significantly impacts health and well-being, moreover during drought season. In general, according to the United Nations [1], water is secure if it has adequate quantities of acceptable quality water, high safety, and usability. This novel study focuses on Lok Dangkaan Village, Pitas district of Sabah, with coordinates 6.9233°N, 117.0370°E. Households in the residence often rely on limited and variable water sources, raising concerns about water quality and affordability, given that there is a concerted plan to improve water supply for the region. The village primarily comprises fishermen with modest incomes, potentially affecting their ability to pay for water services and water security experiences. Given the backgrounds of the scope of study, this study explicitly aims to fill the gap by emphasising the lack of detailed research on water insecurity in rural coastal communities of Sabah.

This study particularly aims to investigate household water insecurity experiences in the context of socio-demographic factors and impending infrastructures like mini water treatment plants in Lok Dangkaan Village. High water insecurity is related

to high food insecurity, as stressed by [2]. Water insecurity can be enhanced through better water management for sustainability. The importance of water management such as water supply and water use has been discussed by [3] for Bandung, Indonesia; [4] for Australian Indigenous communities; [5] for villages in central Kazakstan; [6] for the Wei River Basin, China; [7] for Kenyir Lake, Malaysia, among others. However, this aspect has been lacked attention to researchers especially in low-socioeconomic regions of Sabah. Hence, this study also aims to evaluate residents' water consumption and financial affordability, given that there is potential improvement in water supply.

The localized data on affordability, water quality perceptions, and household coping strategies is important for water management sustainability. Lack of water management will decrease water consumption efficiency, and households will opt for alternative sources such as cheaper or free sources or other sources that are out of habit ([8]; [5]). Hence, understanding water insecurity experiences, consumption, and affordability is crucial for designing effective interventions and policies to enhance water access and quality in rural coastal settings. In addition, it may become water management guidelines for the concerted plan to improve water supply using a mini water treatment plant in the area.

Water is imperative for health and household socioeconomic productivity. Many researchers have investigated the issues of water security and its impact on health and biological consequences such as [9]; [10]; and [11]. Moreover, in significant weather changes areas. [12] have highlighted the significant impact of drought conditions on behaviour toward water insecurity, particularly groundwater issues in Ghana, Malawi, South Africa, and Ethiopia. The study found that an early detection mechanism of water shortages is urgently needed to buffer the effects of rainfall variability in the regions and, eventually water accessibility.

[9] argue that water security can be captured through residents' experience with water access, use, and acceptability. A few factors including individual behaviour and socio-demographics can influence water usage or consumption. In terms of behaviour, in general, individuals' attitudes towards water including in consuming water will affect their behaviour towards water. In addition, residents with a lack of knowledge and attitudes towards goods like water will have low-security levels or be risk-tolerant of the goods ([13]; [14]). According to [15] and [16] an individual risk taking in consumption behaviour will affect largely the individual's purchase decision. Higher uncertainties are expected to reduce the possibility of making consumption and the possible loss. The vice versa applies to risk-averse individuals.

Next, in terms of socio-demographics, water consumption or usage may be affected by household income, household size, climate factors, and water prices. [17] For Hamadan Province, Iran, household size is a significant factor in water consumption, followed by price and climate factors. In contrast, a study by [18] for Germany in about 600 water supply areas shows that the water demand is less likely to be influenced by household size and share of wells. On the contrary, it is affected by climate factors besides the household income factor, which are rainfall patterns. However, household water demand can be directly calculated from the consumption purposes usage. [19] highlight that high water usage in rural Southern Poland was due to additional purposes, which are typical for rural households such as water use for animal breeding. The study found that rural households need water about 59.0 dm^3 per hour which is 1.5 times in suburban households (36.0 dm^3). However, despite efforts to assess water availability, reliability, and affordability, many households remain to face challenges in accessing clean and reliable water sources. It was found that there is still a lack of concerted plans to prepare the public for shifting from supply management to demand management which may include i) enhancement in water-related knowledge, ii) encouragement of residents to conserve and use water in efficient manners, iii) application of socio-technological strategies including smart metering of water consumption and use of water-efficient devices ([4]; [20]). In addition, holistic and multi-sectoral policies are needed to tackle the issues of inequalities in access to resources. A field study by [21] suggests that conserving water resources, improving rural livelihood, and sustainable infrastructure development and risk management are among the potential steps.

DATA AND METHODOLOGY

This study employs a cross-sectional survey design to assess water security and financial capacities within a coastal village, including all 45 households in the area. The validity of the survey questionnaire to be employed in a low- and middle-income county is mentioned in [22]. The sampling method involved a complete enumeration of households to ensure comprehensive coverage. Data were collected using a structured questionnaire divided into four sections: i) household head/ member background; ii) socioeconomic status & household facilities; iii) water source and quality; and iv) household water insecurity experiences.

The water insecurity was measured using the Household Water Insecurity Experiences Scale [23], which assigns scores indicating water security or insecurity based on a summative scale. There are four items in the scale, namely i) worry about enough water for household needs, ii) changed plans due to water problems, iii) not as much water to drink as liked, and iv) unable to wash hands due to water problems. Responses to the four items are as follows: never (0 times), rarely (1–2 times), sometimes (3–10 times), often (11–20 times), always (more than 20 times), do not know, and not applicable/I do not have this. Never is scored as 0, rarely is scored as 1, sometimes is scored as 2, and often/ always is scored as 3. Responses are added together for a summative score. A score of ≥ 4 indicates household water insecurity. Descriptive statistics and chi-square tests were used to analyse the relationship between household water insecurity experiences and socio-demographic variables. To understand the interactions between water access, affordability, and water security within residences, a direct approach was used, including calculating the households' willingness to pay (WTP) water per litre and current ability to pay (ATP) monthly water fees.

RESULTS AND DISCUSSION

Respondents' socio-demographic

The descriptive statistics from the demographic and socioeconomic characteristics of the 45 household respondents are presented in **Table 1**. The data provides a respondent profile with predominantly male and married respondents, where most individuals hold the role of head of household. The average age is 43 years, with a standard deviation of 12 years, and they have lived in their current residence for an average of 42 years, with a standard deviation of 13 years. Ethnically, the majority are Bajau Ubian, and all participants practice Islam. Educationally, the group primarily completed primary school, followed by secondary school, and had no formal education. This demographic profile reflects a stable, long-term resident population with a strong ethnic and religious homogeneity.

Table 1. Characteristics of households.

	Count	%	Mean	Standard deviation
A) Respondents' demographic				
Head of household (1=yes)	35	77.8%		
Male	35	77.8%		
Years of residence			42	13
Age (year)			43	12
Ethnic				
Bajau Ubian	44	97.8%		
Sungai	1	2.2%		
Religion				
Islam	45	100%		
Marital status				
Married	45	100%		
Education level				
No formal education	9	20%		
Primary	20	44.4%		
Secondary	16	35.6%		
B) Socioeconomic background				
Occupation				
Fisherman	33	73.3%		
Farmer	1	2.2%		
Private employee	1	2.2%		
Housewife	10	22.2%		
Household income per month (RM)				
Less than RM500	19	42.2%		
500-1500	24	53.3%		
1001-1500	1	2.2%		
1501-2000	1	2.2%		
Receive allowance scheme of RM350/month				
Yes	3	6.7%		
No	34	75.6%		
Not applicable	8	17.8%		

In terms of socioeconomic background, the majority of individuals in the community are fishermen (73.3 percent), with a smaller proportion engaged in farming (2.2 percent), private sector work (2.2 percent), or housewives (22.2 percent). In terms of monthly household income, most households earn between RM500 and RM1000 (53.3 percent), with 42.2 percent earning less than RM500, and only a small fraction earning above RM1000. Regarding the Living Allowance Payment Scheme of RM350 per month, the majority of respondents do not receive it (75.6 percent), while only a few receive it (6.7 percent).

The characteristics of households, including access to electricity, source of drinking water, construction and flooring materials of housing, and possession of various durable goods, are summarised in **Table 2**. The majority of the households (60 percent) lived in a house constructed entirely from wood materials, while 26.7 percent lived in a house made from concrete, brick, or tile floor. Only a small proportion of homes of the households are made of a mix of concrete and wood materials (6.7 percent). Most residents are the owners of the house either from inheritance or not (73.3 percent), while the remaining do not own the house (26.7 percent). Regarding eligibility for the Prosperous People's Housing Program (PPRS), previously known as the Poor People's Housing Program (PPRT), only 10 out of 45 households in the village had received it. Amenities such as electricity in the residences are limited to electric generators only (84.4 percent) and the rest live with no electricity sources.

Table 2. Housing characteristics.

	Count	%
Housing structure		
Entirely wood	27	60%
Concrete	12	26.7%
Wood and concrete	3	6.7%
Not applicable	3	6.7%
House possession		
Yes	33	73.3%
No	12	26.7%
Method of housing possession		
Inheritance	32	71.1%
Prosperous People's Housing Program (PPRS)	10	22.2%
Not applicable	3	6.7%
Electricity possession		
Electric generator	38	84.4%
Do not own	7	15.6%

Household possession of durable goods is illustrated in **Fig. 1**. In general, the communities show a mix of possessions of access to durable goods, but in limited quantities. Durable goods are classified into three categories: consumer electronics, furniture, and vehicles. For consumer electronics, the majority of the households own a handphone for communication (36 out of 45), followed by entertainment appliances (television and radio, with 26.7 percent and 2.2 percent, respectively). For furniture, they possess at least a dining table, sofa sets, and table fan in less than 10 percent of observations. While for vehicles, about half of the households own a fishing boat, and less than 10 percent of households own automobiles like motorcycles and cars.

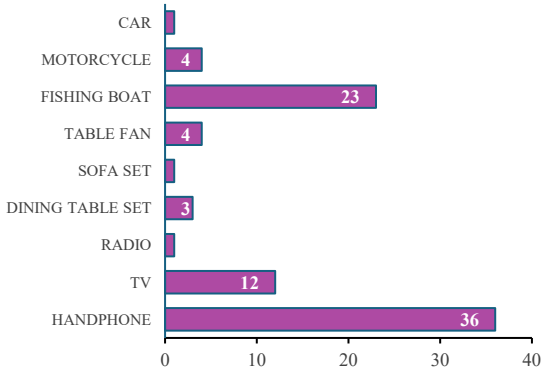

Fig. 1. Household durable goods. Note: Other durable goods omitted from the figure with zero observation are refrigerator, ceiling fan, washing machine, sewing machine, MyTV/Astro, computer/laptop, internet, and bicycle.

Households' water source experiences

Regarding water sources experiences, about 98 percent of households in the village use water sources from wells or groundwater and 2 percent from rainfalls source. Most of them rate the water source quality as low or very low in terms of colour, taste, smell, and safety for drinking uses (see **Table 3**). This leads to their decision to boil the water source before drinking usage (100 percent) but no or limited actions to filter (8.9 percent) or treat the water before drinking.

Table 3. Percent of water quality and insecurity experiences.

	Very low/ Never	Low/ Rarely	Moderate/ Sometimes	Good/ Often
A) Water quality				
Colour	13.3	66.7	17.8	2.2
Taste	6.7	71.7	11.1	11.1
Smell	6.7	55.6	22.2	15.6
Safety for drinking	4.4	62.2	22.2	11.1
B) Water insecurity				
Worry about enough water for household needs	4.4	42.2	31.1	22.2
Changed plans due to water problems	17.8	62.2	15.6	4.4
Not as much water to drink as liked	8.9	24.4	37.8	28.9
Unable to wash hands due to water problems	37.8	60.0	2.2	0

Household water insecurity experiences vary, but most residents report relatively infrequent issues. Only 4.4 percent of residents never worry about water for household needs, while 42.2 percent worry rarely and 31.1 percent sometimes. A smaller portion (22.2 percent) often worries about their water supply for household needs. Regarding changes in plans due to water problems, 62.2 percent experience this rarely, 15.6 percent sometimes, and a small number (4.4 percent) often. When it comes to having less drinking water than desired, 8.9 percent never experience this issue, while 24.4 percent experience it rarely, 37.8 percent sometimes, and 28.9 percent often. Most residents (37.8 percent) never face issues with handwashing due to water problems, and 60 percent face this issue rarely, with very few (2.2 percent) experiencing it sometimes. There are no reports of severe or constant problems with water access in the community.

The majority of households in the community are categorized as water-insecure household (82.2 percent), indicating significant concerns or difficulties with water access. In contrast, only 17.8 percent of households are considered water-secure, suggesting that they do not experience substantial water availability or quality issues. This highlights a prevailing challenge with water security within the community. The high percentage of households who perceived water as insecure indicated significant concerns or a high constraint with water accessibility, safety, and usability in the village. However, these ambiguous findings about the households' concern about water safety may be related to consumers' lack of knowledge or high-risk tolerant behaviour [13]. In addition, the quantities of household water consumed per day may indirectly contribute to the categories of water insecurity experiences.

For safety issue, the data indicates that waterborne diseases are infrequent in the community. Most residents (95.6 percent) report never experiencing sickness from waterborne diseases. A small minority (4.4 percent) experiences such illnesses 1-2 times every two months, with no reports of more frequent occurrences or cases occurring more than twice a month. This suggests that while waterborne diseases are a concern for a few, they are not a widespread issue for the majority.

Water insecurity experiences and water affordability estimations

To examine household water insecurity experiences, this study reports whether households with secured and unsecured water source choices differ based on selected household characteristics. Prior to the test, we present household water consumption per day by household size for general information. **Table 4** illustrates estimated daily water consumption across different household sizes. On average, households consume about 200 litres of water per day. This mainly applies to households with 4 and above household members. In contrast, households with 1-3 members consume an average of 129.17 litres per day, with a relatively low standard deviation of 48.70 litres, indicating stable water usage. However, noting that there is considerable variability in water usage for medium-sized households.

Table 4. Water consumption by household size (estimated).

		Estimated water consumption per day (litres)	
		Mean	Standard deviation
Household size	1-3 members	129.17	48.70
	4-6 members	203.70	167.15
	More than 6 members	201.67	42.62

Next, the association between household experiences with secure and unsecured water sources and household characteristics is shown in **Table 5**. However, only occupation and household income show a marginal statistically significant association with water insecurity at a 10–20 percent significant level. Regarding association size effects, **Table 5** shows that water insecurity is more common among households with 1-3 members (91.7 percent) as compared to larger households (66.7 percent for those with more than 6 members). Water insecurity is prevalent across different income levels, with those earning less than RM500 or RM500-RM1000 experiencing higher rates of water insecurity (84.2 percent and 83.3 percent, respectively). This is consistent with the high proportion of households possessing a fishing boat experiencing higher water insecurity (86.4 percent). In addition, this study found a high association between water insecurity and those with no formal or primary education level and stated occupation as a fisherman.

While certain trends are observed, none or limited household factors show a statistically significant relationship with water insecurity, possibly due to sample size limitations and expected cell counts in the chi-square tests. However, the findings are inline with a recent study by the [24] in farming and indigenous Sabah context which suggests knowledge on the study context is one of the main challenges to increase the outputs. Thus, further actions in increasing the knowledge and awareness on water security are needed to the communities.

Table 5. Relationship between respondents' household water insecurity experiences and their selected background.

	Water secure		Water unsecure		
	Count	%	Count	%	p-value
Household size					0.420
1-3 members	1	8.3%	11	91.7%	
4-6 members	5	18.5%	22	81.5%	
More than 6 members	2	33.3%	4	66.7%	
Household income per month (RM)					0.178
Less than RM500	3	15.8%	16	84.2%	
500 - 1000	4	16.7%	20	83.3%	
1001 - 1500	1	100.0%	0	0.0%	
1501 - 2000	0	0.0%	1	100.0%	
Owning fishing boat					0.477
No	3	13.6%	19	86.4%	
Yes	5	21.7%	18	78.3%	
Education level:					0.312
No formal education	3	33.3%	6	66.7%	
Primary	2	10.0%	18	90.0%	
Secondary	3	18.8%	13	81.3%	
Occupation:					0.064
Fisherman	7	21.2%	26	78.8%	
Farmer	0	0.0%	1	100.0%	
Private employee	1	100.0%	0	0.0%	
Housewife	0	0.0%	10	100.0%	

Regarding households' water financial affordability, **Table 6** offers a detailed estimation of the willingness to pay (WTP) and ability to pay (ATP) given that there is a planned mini water treatment plant with a capacity of 30,000 litres per day. In terms of households' ability to pay for water sources, the ATP shows that on average households are able to pay RM121.67 per month, which is based on their current water expenditure per month in the common or drought seasons. However, to note that the ATP standard deviation of RM178.29 indicates that the residence's financial affordability largely varies.

Table 6. Willingness to pay and ability to pay for water sources from a mini water treatment plant.

	Count	%	Mean	Standard deviation/ n
Household water consumption per month (RM)			121.67	178.29
Household willingness to pay (WTP)				
RM0.10 per 1000 litre or M^3	34	75.6%		
RM0.20 per 1000 litre or M^3	11	24.4%		
Water consumption per household per day (litres)			183.56	135.68
Water consumption per household per month (litres)			5,506.80	4,070.48
Household water consumption per month (RM) (estimated) (Tariff RM0.10)			0.55	
Household water consumption per month (RM) (estimated) (Tariff RM0.20)			1.10	

Note: Water consumption per household per month (litre) 's median and percentile at 75 percent is 5400 and 6000 respectively.

Next, the WTP data reveals that 75.6 percent of people are willing to pay RM0.10 per 1000 litres, and 24.4 percent are willing to pay RM0.20 per 1000 litres. The average daily household water consumption is 183.56 litres, and the median monthly consumption is 5,400 litres, with a wide range from 1,500 to 30,000 litres. With an estimated water consumption per month is 5506 litres per household and the categories of willingness to pay per 1000 litre or per cubic metre are 10 and 20 cents, the expected water consumption per month needed for households is between RM0.55 to RM1.10. The value is about 100 times lower than their reported financial affordability or ability to monthly pay for water.

The findings suggest that the planned water treatment plant greatly benefits households in achieving equality in access to resources. However, the daily water consumption level per household is just an estimated value. Besides, even though water capacity (for about 3 days without water for the village) and household financial affordability (100 times savings) are in advantageous, related entities and policymakers should make strategic water management policies for water equitability. Water supply and demand capacity needs to be monitored to conserve and use water efficiently. Hence, approaches such as in aspects of knowledge [13]; technology applications [4]; and development [21] should be empowered to ensure water sustainability in the remote area. It also may become a guideline for future water source plants and eventually help the nation's and global Sustainable Development Goals (SDG-6) agenda of water for all.

CONCLUSION

This study highlights significant water insecurity challenges faced by households in Lok Dangkaan Village, Pitas district of Sabah, despite ongoing efforts to improve water supply. The findings reveal that a substantial majority (82.2 percent) of households experience general water insecurity, primarily due to poor water quality and inconsistent supply. Although waterborne diseases, mainly from the wells or groundwater sources, are infrequent, the community's reliance on inadequate water sources underscores the need for better solutions. The analysis of willingness to pay (WTP) and ability to pay (ATP) indicates a clear preference for lower water costs, with most households willing to pay RM0.10 per 1000 litres or per meter cubic. Their average ability to pay for water, especially during the drought, is RM121.67 per month, demonstrating considerable financial strain among households. The planned mini water treatment plant, with a capacity of 30,000 litres per day, represents a critical step towards addressing these issues. However, to effectively tackle water insecurity, it is essential to implement ongoing monitoring and support mechanisms. This includes considering flexible pricing models, improving water quality, and ensuring financial assistance is available to those in need. Overall, enhancing water security in Lok Dangkaan will require a multifaceted approach that integrates infrastructural improvements with socioeconomic support to create sustainable and equitable water access for all residents.

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