Environmental Vulnerability of Indonesian Households: The Case of Water Scarcity

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Abstract

Water scarcity has adverse health consequences in the form of morbidity and even mortality. Globally, 2 in 5 people, including in Indonesia, are affected by water scarcity. However, research on water scarcity in Indonesia is limited. Therefore, in this paper, we sought to address the correlates of water scarcity among households in Indonesia. We analysed data from the 2nd round of Baseline Health Research conducted by the National Institute of Health Research and Development, Ministry of Health, Republic of Indonesia. We set self-reported yearlong experience of water scarcity as the only dependent variable. Then we grouped the potential covariates into five groups, namely spatial, environmental, housing, demographic, and socio-economic variables. Finally, we fitted a multivariable logistic regression model to the data with average marginal effects (AMEs) and its 95% confidence interval (CI) as measures of association. We observed that households that reside in rural areas are more likely to experience water scarcity, besides differences of water scarcity probability across different regions. Households located near a swamp, a forest, a beach, and in a slum area were also found to report higher probability of water scarcity. Moreover, households with unimproved water source for cooking and hygiene, unimproved drinking water source and distant water source were also found to more likely to experience water scarcity compared those with improved and on-premise water sources. These associations still hold when demographic and socio-economic variables were included in the final multivariable probit regression model. The findings of this paper will enhance our understanding of water scarcity experience among Indonesian households and provide additional evidence for policymaking in the water sector in Indonesia. Further studies should collect information on the number of water shortages experienced by households in a year.

Keywords: Water scarcity, water shortages, housing, drinking water ladder, Riskesdas.

1. INTRODUCTION

Water scarcity has adverse health consequences in the form of morbidity and even mortality. It was estimated that, globally, 4 billion people face water scarcity for at least one month during the year, while half a billion of which experienced water scarcity throughout the year (Mekonnen & Hoekstra, 2016). Climate change could further reduce water supply (de Wit and Stankiewicz, 2006; Füssel, Heinke, Popp, and Gerten, 2012; Immerzeel, van Beek, and Bierkens, 2010). If not anticipated, this phenomenon coupled with increasing world population could increase pressure on the global environment and worsen water scarcity (McDonald, Green, Balk, Fekete, Revenga, Todd, & Montgomery, 2011; Rom & Pinkerton, 2014; McMichael, Woodward, and Muir, 2017).

Despite this growing problem, research on water scarcity is limited. Máñez, Husain, Ferse, and Máñez Costa (2012) were among the first to conduct a study on water scarcity in an Indonesian Archipelago. Another study on water was done by Irianti, Prasetyoputra, and Sasimartoyo (2016), which presented data regarding drinking water ladder and its determinants using multivariable regression technique. However, they only explored the drinking water source and did not assess water scarcity experience

among Indonesian households.

However, studies with larger coverage and more information are needed to guide policy making in the water sector in Indonesia. Therefore, in this paper, we sought to address the correlates of water scarcity among households in Indonesia.

2. MATERIALS AND METHOD

2.1.   Data Source

For this paper, we drew data from the 2010 Indonesia Baseline Health Research (*Riset Kesehatan Dasar*, henceforth Riskesdas 2010). Riskesdas is a nationally representative health survey conducted by the National Institute of Health Research and Development (NIHRD) of the Ministry of Health, Republic of Indonesia (NIHRD, 2010). The first round of Riskesdas was conducted in 2007 and the latest one was conducted in 2013. This study used the second round (2010) for several two reasons. First, the variable that was used as the only dependent variable was not available in the 2013 round. As such, the latest round available was used. Second, the 2010 Riskesdas was the last round that collected household expenditure (food and non-food items) as an indicator of socio-economic status (SES) of household.

2.2.   Ethics Statement

Ethical Clearance (No. LB.03.04/KE/928/2010 in 8th of March, 2010) for the 2010 National Basic Health Research has been issued by the Institutional Review Board (IRB) of the NIHRD, Ministry of Health, Republic of Indonesia. All datasets have been de-identified by the Data Management Laboratory of NIHRD to preserve the anonymity of respondents. No additional ethical clearance was sought as such.

2.3.   Study Population and Sample Size

The 2010 Riskesdas collected health data from 251,388 individuals living in 69,300 households spread across 33 provinces at the time of the survey. As the study population is households, all information at individual level will be aggregated to household level. Listwise deletion was performed to handle missing values (Dong and Peng, 2013), leaving an analytic sample of 65,051 households (93.87% of full sample).

2.4.   Dependent Variable

The main outcome of interest in the study was household's experience of water scarcity during the past year. In the 2010 Riskesdas, the households were asked this question: "Was it easy to fulfill the drinking water necessity throughout the past year?" There were three possible responses: (1) Yes (easy), (2) Difficult in the dry season, (3) Difficult throughout the year. We merged the last two categories and coded it as an indication that a household has experienced some difficulty in fulfilling the drinking water necessity whether only in the dry season or throughout the past year (coded 1 for "Yes" and 0 for "No").

2.5.   Explanatory Variables

In total, there were 25 explanatory variables which were grouped into five categories, namely Spatial, Environmental, Housing, Demographic, and Socio-economic. The Spatial Variables consists of region of residence and place of residence. The Environmental Variables consists of whether the household resides near a pond, swamp, river, forest, mountain, beach, densely populated area, ranch, paddy field, plantation, and whether the household is located in a slum area. The Demographic Variables consists

of sex of household head, marital status of household head, age of household head, number of household members, and number of under-5 children in the household. The Socio-economic Variables consists of education of household members and per-capita household expenditure.

2.6. Statistical Analysis

We fitted a multivariable probit regression model with average marginal effect (AME) and its 95% confidence interval (CI) as measures of association (Long and Freese, 2014). We performed all of the statistical analyses using Stata version 13.1 (StataCorp, 2013).

3. RESULTS AND DISCUSSION

3.1. Sample Characteristics

Table 1 presents the sample characteristics of the analytic sample in the form of percentages. It is reported that 18.37% of the households (95% CI: 18.07 – 18.67) reported experiencing water scarcity throughout the year, whether it was difficult only in the dry season or difficult throughout the past year. The table also shows the variance inflating factors (VIF) of the explanatory variables when the final regression model was fitted. The mean of VIF is only 5.18 which is far below the minimum value where severe collinearity is warranted (Gujarati, 2004).

Table 1. Characteristics of the analytic sample (N = 65,051)

Variables	Categories	N	%	VIF
Experienced water scarcity in the past year	No (Ref.)	53,102	81.63	-
	Yes	11,949	18.37	-
Region of residence	Java-Bali (Ref.)	2,533	3.89	-
	DKI Jakarta	34,459	52.97	1.17
	Sumatra	13,862	21.31	1.69
	Kalimantan, Sulawesi & NTMP	14,197	21.82	1.94
Place of residence	Urban area (Ref.)	32,792	50.41	-
	Rural area	32,259	49.59	3.07
House located near a pond	No (Ref.)	60,930	93.66	-
	Yes	4,121	6.34	1.13
House located near a swamp	No (Ref.)	61,281	94.20	-
	Yes	3,770	5.80	1.17
House located near a river	No (Ref.)	49,766	76.50	-
	Yes	15,285	23.50	1.43
House located near a forest	No (Ref.)	57,547	88.46	-
	Yes	7,504	11.54	1.46
House located near a mountain	No (Ref.)	53,010	81.49	-
	Yes	12,041	18.51	1.58
House located near a beach	No (Ref.)	61,658	94.78	-
	Yes	3,393	5.22	1.11
House located near a densely populated area	No (Ref.)	34,138	52.48	-
	Yes	30,913	47.52	2.34
House located near a ranch	No (Ref.)	58,800	90.39	-

Variables	Categories	N	%	VIF
	Yes	6,251	9.61	1.19
House located near a paddy field	No (Ref.)	46,825	71.98	-
	Yes	18,226	28.02	1.67
House located near a plantation	No (Ref.)	51,716	79.50	-
	Yes	13,335	20.50	1.52
House located in a slum area	No (Ref.)	51,710	79.49	-
	Yes	13,341	20.51	1.37
Water source for cooking and hygiene	Piped water (Ref.)	13,706	21.07	-
	Improved	38,425	59.07	7.62
	Unimproved	12,920	19.86	3.80
Water source for drinking	Piped water (Ref.)	19,779	30.41	-
	Improved	35,840	55.10	8.87
	Unimproved	9,432	14.50	5.19
Distance to drinking water source	On premise (Ref.)	34,313	52.75	-
	≤ 5 minutes	19,902	30.59	1.80
	6-30 minutes	9,563	14.70	1.46
	> 30 minutes	1,273	1.96	1.08
House is on stilts	No (Ref.)	55,211	84.87	-
	Yes	9,840	15.13	1.44
Housing index score (in units)	*Mean*	-	0.00	1.92
Sex of household head	Male (Ref.)	55,733	85.68	-
	Female	9,318	14.32	2.12
Marital status of household head	Never married (Ref.)	2,342	3.60	-
	Currently married	55,986	86.06	28.46
	Divorced/bereaved	6,723	10.33	4.59
Age of household head (in years)	*Mean*	-	46.63	17.37
Number of household members (in persons)	*Mean*	-	3.81	7.65
Number of under-5 children	None (Ref.)	46,668	71.74	-
	One	16,014	24.62	1.66
	Two or more	2,369	3.64	1.18
Education of household head	None/incomplete primary	16,455	25.30	5.28
	Elementary school	20,275	31.17	5.64
	Junior high school	9,541	14.67	2.96
	Senior high school	13,909	21.38	3.72
	College or higher (Ref.)	4,871	7.49	-
Percapita monthly household expenditure (in logarithmic form)	*Mean*	-	13.11	48.96

Notes: Ref. = Reference category
Source: Authors' calculation of the 2010 Riskesdas

3.2. Multivariable Regression Results

The final multivariable regression model was statistically significant (Wald χ^2 = 4077.30; P < 0.001) with Tjur's Coefficient of Determination of 7.10% and area under ROC curve of 69.16% (see Figure 1).
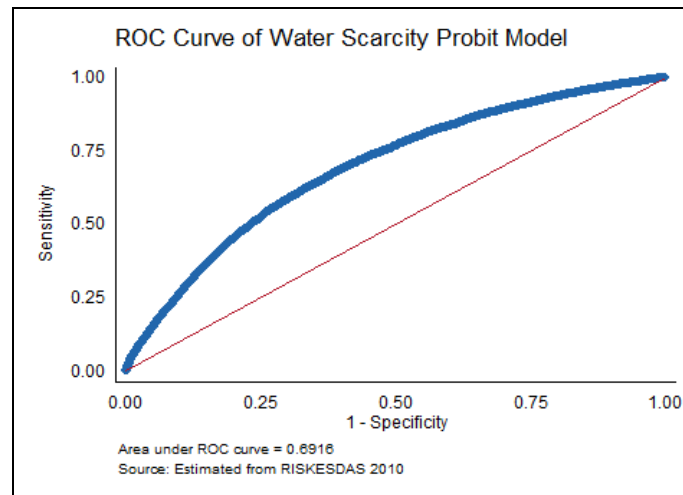

Figure 1. ROC curve of the water scarcity probit regression model

Table 2 presents the regression results of the final multivariable probit regression model. Most of the explanatory variables were found to be significantly associated with the dependent variable.

Table 2. Regression analysis of the correlates of water scarcity (N = 65,051)

Variables	Categories	AME	95% CI	
Region of residence	Java-Bali (Ref.)	-	-	
	DKI Jakarta	-0.0299 ***	-0.0475 -	-0.0123
	Sumatra	0.0192 ***	0.0109 -	0.0274
	Kalimantan, Sulawesi & NTMP	0.0052	-0.0034 -	0.0137
Place of residence	Urban area (Ref.)	-	-	
	Rural area	0.0419 ***	0.0348 -	0.0489
House located near a pond	No (Ref.)	-	-	
	Yes	-0.0128 **	-0.0246 -	-0.0009
House located near a swamp	No (Ref.)	-	-	
	Yes	0.0146 **	0.0026 -	0.0266
House located near a river	No (Ref.)	-	-	
	Yes	-0.0060 *	-0.0130 -	0.0010
House located near a forest	No (Ref.)	-	-	
	Yes	0.0249 ***	0.0157 -	0.0342
House located near a mountain	No (Ref.)	-	-	
	Yes	-0.0010	-0.0090 -	0.0071
House located near a beach	No (Ref.)	-	-	
	Yes	0.0282 ***	0.0159 -	0.0406

Variables	Categories	AME	95% CI		
House located near a densely populated area	No (Ref.)	-		-	
	Yes	-0.0250 ***	0.0000	-	0.0000
House located near a ranch	No (Ref.)	-		-	
	Yes	0.0154 ***	0.0059	-	0.0248
House located near a paddy field	No (Ref.)	-		-	
	Yes	0.0033	-0.0034	-	0.0101
House located near a plantation	No (Ref.)	-		-	
	Yes	0.0063 *	-0.0011	-	0.0136
House located in a slum area	No (Ref.)	-		-	
	Yes	0.0195 ***	0.0123	-	0.0267
Water source for cooking and hygiene	Piped water (Ref.)	-		-	
	Improved	0.0303 ***	0.0200	-	0.0405
	Unimproved	0.1174 ***	0.1044	-	0.1305
Water source for drinking	Piped water (Ref.)	-		-	
	Improved	0.0232 ***	0.0106	-	0.0358
	Unimproved	-0.0287 ***	-0.0414	-	-0.0160
Distance to drinking water source	On premise (Ref.)	-		-	
	≤ 5 minutes	0.0323 ***	0.0253	-	0.0393
	6-30 minutes	0.0218 ***	0.0129	-	0.0307
	> 30 minutes	0.0591 ***	0.0375	-	0.0808
House is on stilts	No (Ref.)	-		-	
	Yes	0.0418 ***	0.0337	-	0.0499
Housing index score (in units)	*in units*	-0.0150 ***	-0.0182	-	-0.0118
Sex of household head	Male (Ref.)	-		-	
	Female	-0.0152 ***	-0.0264	-	-0.0040
Marital status of household head	Never married (Ref.)	-		-	
	Currently married	0.0149 *	-0.0024	-	0.0323
	Divorced/bereaved	0.0166	-0.0033	-	0.0365
Age of household head	*in years*	-0.0009 ***	-0.0011	-	-0.0007
Number of household members	*in persons*	0.0011	-0.0009	-	0.0031
Number of under-5 children	None (Ref.)	-		-	
	One	-0.0097 **	-0.0170	-	-0.0023
	Two or more	-0.0117	-0.0274	-	0.0041
Education of household head	None/incomplete primary	0.0552 ***	0.0412	-	0.0692
	Elementary school	0.0413 ***	0.0281	-	0.0544
	Junior high school	0.0319 ***	0.0180	-	0.0457
	Senior high school	0.0086	-0.0043	-	0.0215
	College or higher (Ref.)	-		-	
Percapita monthly household expenditure	*in logarithmic form*	-0.0135 ***	-0.0185	-	-0.0084

Notes: AME = average marginal effect; CI = confidence interval; Ref. = Reference category;

Variables	Categories	AME	95% CI

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation of the 2010 Riskesdas

It was observed that households that reside in rural areas are more likely to experience water scarcity, besides differences of water scarcity probability across different regions. Households located near a swamp, a forest, a beach, and in a slum area were also found to report higher probability of water scarcity. These findings related to spatial disparities are consistent with extant literature. Irianti et al (2016) shows that households residing in urban areas, compared to their rural counterparts, are more likely to have access to improved drinking water sources.

With regard to environmental variables, households with unimproved water source for cooking and hygiene, unimproved drinking water source and distant water source were also found to more likely to experience water scarcity compared those with improved and on premise water sources. In terms of socio-economic variables, more affluent households (based on their percapita monthly expenditure level) have lower probability of experiencing water scarcity. This is likely because more affluent households are more likely to have access to improved water sources (Dungumaro, 2007; Adams, Boateng, and Amoyaw, 2015; Rahut, Behera, and Ali, 2015; Irianti, Prasetyoputra, Sasimartoyo, 2016). These associations still hold when demographic variables were included in the final multivariable probit regression model.

3.3. Study Limitations

The cross-sectional form of the 2010 Riskesdas data set hinders the establishment of causality. Nevertheless, the associations between variables could still be useful to prompt more advanced studies that are closer to establishing causality.

4. ACKNOWLEDGMENTS

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