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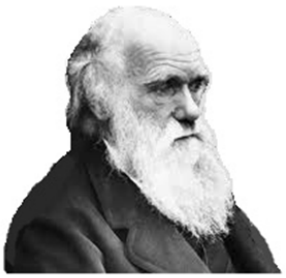

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An integrated assessment of vulnerability to water scarcity measurement in small islands of Indonesia

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ABSTRACT

Water scarcity, especially in the small islands of Indonesia, has caused trouble for social maintenence of water needs. While many instruments have been developed to measure community vulnerability indexes, the majority do not reflect the overall condition. Therefore, this research will formulate a vulnerability index for water fulfillment in small islands, using a comprehensive method so that the result can be used as a reference in policy-making. This research applied the deductive-positivist approach of the quantitative method. It started off with establishing the dimensions of vulnerability: exposure, adaptive capacity, and sensitivity. These were then operationalized into indicator/parameter of indexes to measure vulnerable conditions. The result shows that this vulnerability index can be utilized as a basis for policy decision-making as it considers the attributes that had proved to be sustainable. To reduce vulnerability in small islands, there is a need for a policy that considers community capacity and adaptive patterns that could improve their social and economic capital.

***Keywords*:** vulnerability index, small islands, fresh water, adaptation, social capital, sustainability

1. INTRODUCTION

Recent debates regarding climate change and water scarcity in small islands are gaining scientific, as well as political attention. This is mainly because, based on the newest climate change scenario, of the escalating nature of their vulnerability [1, 2, 13, 17]. On a political level it appears that the debate around vulnerability creates so much tension that parties are unable

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to move beyond the preamble of the convention that identifies specific vulnerabilities, such as "*low-lying and other small island countries, countries with low-lying coastal, arid and semi-arid areas or areas liable to floods, drought and desertification, and developing countries with fragile mountainous ecosystems*".

These complexities extend to academia, as well as scholars from various fields and traditions, use different criteria to measure and define vulnerability [2].

Because of the relatively small size of the islands, water became a very scarce goods. Ground water is usually not fit for consumption [5, 28]. It is different with the mainland region, the societies that live in small islands are experiencing difficulty in fulfilling water needs. Sufficient water availability in terms of quantity and quality are the requirements in achieving MDGs target [26]. Such problems are affected by the characteristics of hydrology, topography, type of soil, and climate. Beside that, human behavior in utilizing water also affects water resource conditions in small islands [3, 11, 19].

Past studies have proven that small islands in Indonesia were experiencing water resource vulnerability, marked by the difficulty in obtaining fresh water. Poor water condition and limited water volume are common phenomenon in small islands [3, 8, 10, 23].

To get a better understanding on water vulnerability level in small islands, development of various vulnerability indexes has been carried out. However, most of the said indexes tend to only be partially done and focused on one specific aspect or dimension, such as environment, or only social aspect [6, 15, 18, 22, 23].

To date, there have been no research able to come up with comperehensive vulnerability index by combining the three dimensions in one single index formulation. Therefore, it is very interesting to study and develop a concept of vulnerability index on water resource, especially the fulfillment of water in small islands.

This is certainly very important because of: (a) Indonesia is an archipelago consisting of approximately 17 thousand of islands and some 13 thousand of them are small islands [11]; (b) the existence of development program, especially on the fulfillment of water in small islands, is a need of an instrument to measure vulnerability level to support the program. Based on that, the research problems are: (a) How to formulate a vulnerability index to fulfill water needs in small islands?; (b) How is the adaptive pattern of the community in small islands in dealing with water crisis?; and (c) How is the policy alternative in sustainably fulfilling water needs in small islands?

Generally, water scarcity symbolizes the unbalance between water supply and the demand of a certain social-ecological system. Water scarcity signifies problem in fulfilling human and/or environmental needs sufficiently in a given time. This concept has been challenged, and the nature of scarcity is now undergone change from which it was initially oriented only on the physical aspect and technical solution, shifting to social, economical, cultural, and political aspect [2, 16, 29].

Physical scarcity or commonly known as water scarcity refers to the limited amount of water in a certain period. Attempts to determine water scarcity tends to use per capita and yearly water availability [1, 4]. Other than that, a more comperehensive indicator aims to include economic and social factors [2, 23], but with limited empirical implementation so far. However, the most important thing to remember is that water scarcity is more than just physical problem, but a relative social construct affected by biophysical condition and human behavior, and the relationship between those two [14].

2. METHOD AND RESEARCH FRAMEWORK

This research applied a deductive-positivist approach which makes it a quantitative study. However, it is also a type of explanatory confirmatory research. The formulation of vulnerability index for water fulfillment in small islands is carried out through literature review, functional relation of a selected dimension and parameter, as well as measuring vulnerability. After vulnerability index is obtained, next is Rapid Appraisal Water (RAP-Water) analysis to determine the sustainability of water fulfillment in small islands. The data used for the analysis of vulnerability index and their sustainability consisted of primary and secondary data. For the primary data, the unit of analysis is the community, and the unit of observation is head of household. Using multi-stage random sampling technique, 257 samples were drawn. The secondary data are obtained from related istitutions, such as data on rain fall, water availability, disaster occurrence, population density, poverty, land coverage, and so on.

This research is located in the Province of Eas Nusa Tenggara, Indonesia. This province is selected because of its natural dry climate with limited availability of water. This province belongs to Nusa Tenggara archipelago whose records are in low water availability compared to other islands in Indonesia. As a sample of location, three islands were selected, and they are: Ende Island, Solor Island, and Semau Island. Image of the research location is shown in **Figure 1** below.

Figure 1. Research Location

Vulnerability is something that characterized small islands, such as poverty, isolation, disaster prone, inadequacy of infrastructure, and also fresh water scarcity. One of the obstacles on the development of small islands is the limited availability of water resource [3, 8, 10, 23,

24]. Inadequacy of water resource, because of topographical, morphological, and soil condition in small islands, affecting water crisis condition in small islands, so that the development of small islands needs to be done by looking at the current problem and the water capacity existing in the small islands. The vulnerability of small islands community is shown on social, economic, or environment. The natural condition of small islands, which is prone to crisis, has raised the importance of finding a solution to the problem.

The concept of vulnerability developed by Turner indicates that to reduce small islands vulnerability, there is the need to improve their adaptive capacity through various capital resources possessed by a community [25]. Adaptive capacity of small islands can be strengthened by giving intervention or policy, either through improving their existing adaptive capacity or by a well planned infrastructure development based on their potential capabilities. With that, there will be a declining level of vulnerability in water scarce-small islands through natural adaptation pattern, as well as from the participation of the community. This condition will impact on the increasing welfare and sustainability.

The research framework is as illustrated in **Figure 2** below.

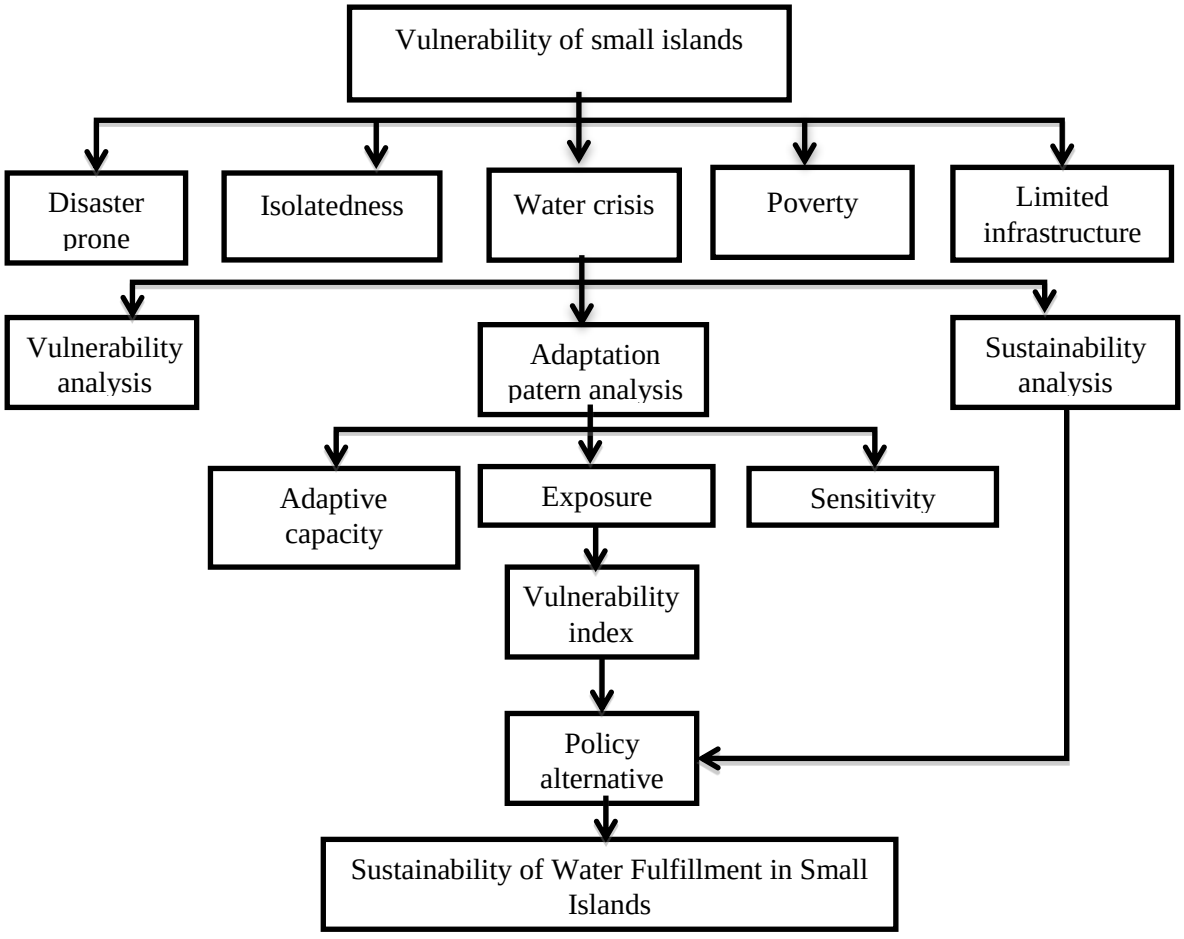

Figure 2. Research Framework for the Formulation of Vulnerability Index to Support Water Fulfillment in Small Islands.

Basically, vulnerability is a tendency of how easy an entity suffers disruption and damage, affected by external and internal factors. Specifically, vulnerability concept consists of three dimensions: (1) exposure, (2) sensitivity, (3) adaptive capacity. In this research, the parameters for exposure are: (a) yearly rainfall, (b) population density, (c) disaster occurrence, (d) forest cover. Meanwhile, sensitivity parameters entail: (a) water resource diversity, (b) estimated time to obtain water, (c) water usage. Lastly, adaptive capacity entails: (a) number of family member, (b) income, (c) education, (d) willingness to pay, (e) perception of climate change, (f) women role in water management, and (g) social capital.

3. RESULTS AND DISCUSSION

3. 1. Formulation of Vulnerability Index

Based on the field result from the three islands (Solor, Semau, and Ende), it can be derived that from three dimensions (adaptive capacity, sensitivity, and exposure) there are thirteen subdimensions which are important to be used to formulate vulnerability index. After data input and normalisation are performed, followed by data weighted using composite index [12], as well as measuring the standard deviation, the results are shown in **Table 1**.

Table 1. Dimensions and Vulnerability Variables with Score

Dimension	Code	Variable	Ende Island	Solor Island	Semau Island
	KA1	Number of household members	0.073	0.018	0.000
	KA2	Income	0.024	0.074	0.000
	KA3	Education	0.050	0.074	0.000
	KA4	WTP (IDR/lt)	0.055	0.073	0.000
	KA5	Perception towards climat change	0.000	0.067	0.065
	KA6	Woman role on water management	0.009	0.000	0.070
	KA7	Social capital	0.074	0.000	0.022
Sensitivity	S1	Diversity of water resource (type)	0.000	0.066	0.066
	S2	Travel time to water source	0.000	0.075	0.048
	S3	Water usage	0.000	0.008	0.069
Exposure	K1	Yearly rainfall	0.014	0.071	0.000
	K2	Population density	0.016	0.072	0.000
	K3	Number of disaster occurence, Anticipation for disaster	0.066	0.000	0.000
	K4	Forest cover	0.075	0.000	0.047

It can be seen in Table 1 that the scores after being weighted are between 0 and 0.075 value. The Table explains vulnerability index on each dimension with 0-1 score. Score closer

to 1 means a higher vulnerability. Then, vunerability index of water crisis for each island and dimension can be arranged, as shown in **Table 2**.

Table 2. Water Vulnerability Index in Small Islands Per Dimension

Region/ Island	Vulnerability Dimensions			Vulnerability Index	Rank
	Adaptive capacity	Sensitivity	Exposure		
Ende Island	0.564	0.000	0.599	0.46	2
Solor Island	0.608	0.709	0.505	0.60	1
Semau Island	0.310	0.871	0.165	0.39	3

Table 2 shows us that when we take a look comprehesively, Solor island is the most vulnerable one against water crisis, followed by Ende island, and Semau island. Nonetheless, not all dimensions in Solor island suffer from a high vulnerability compared to the other two. In Solor island, the most vulnerable dimension is the adaptive capacity, while in Ende island the most vulnerable one is exposure. In Semau island, it is sensitivity.

The formulation of said index, can be used as an instrument to calculate the vulnerability index in small islands. The proof is that statistically all dimensions and subdimensions are significant enough to be used as a differentiator among various variables in those dimensions and subdimensions.

3. 2. Adaptive Pattern of the Community in Small Islands in Dealing with Water Crisis: The Power of Resilience

One of the attempts to reduce community's vulnerability in fulfilling water needs is by giving technological aid in the form of Rain Water Storage (RWS) tank. But due to the difference in the management pattern, the result is also different. The following are the examples in Ende and Solor islands in the RWS management, based on social capital in relation with the adaptive pattern of the community.

Based on the survey, Solor Island has larger social capital than Ende Island with the communal assistance pattern. The differences are in the pattern of assistance delivery and management pattern. The government through PNPM Mandiri program (a community-driven development program) had given assistance in the form of 40 RWS tanks to village residence since 2011. One RWS tank is designed to be used communally for 2-5 households in Labelen village. RWS tank is built in one villager's house, with water distribution agreed among the residences. Head of neighborhood unit *(Ketua RT)* manages the demand of water from the residents, analyzes and decides whether to distribute the RWS, or that to be sold for IDR. 2,000 per 5 buckets.

Meanwhile the pattern of assistance in Ende island is having lesser social capital value compared to Solor island. This condition can be explained based on a field evidence in Rendoraterua and Roruangga villages. In between 2007 and 2008, the inhabitant of Ende island received aid from UNICEF in the form of RWS tanks as the source for fresh water. Through

this assistance, each household in the island already has RWS tank to be used during dry season. Residents in Rorurangga village use the water only for consumption. For daily needs they use brackish water from the well.

This is because there are no other water sources in the village. When water supply runs out, the residents must draw water from the neighboring Numba village, situated about 6 km from theirs. Beforehand, there was the attempt to distill salt water in Rorurangga village, but it failed due to constantly diminishing fresh water production, and also that the running cost was not affordable to the community.

The condition explains that the lower the social capital in a certain location or community, the more vulnerable the community is. Solor island with a communal assistance pattern has higher social capital because of its social network. The strong bonds of the community are built through the inter-society interactions. Conversely, in Ende island with individual assistance pattern, there is lower social capital score because of the individual characteristics of the assistance affected the low chance of inter-society interaction. This implies a low chance of possibility of interaction between inhabitants.

Improving adaptive capacity highly determines community resilience in dealing against water crisis which is frequent to them. The following is an illustration of community resilience by looking at the effect of two capitals (economic and social capitals) in Solor and Semau island.

It is certain that generally the community in Solor island relies on social capital as the resilience against water crisis. As confirmed through the field survey, in Solor there are unwritten values and norms regarding the management of public well that it can only be used during dry season which shows reflections of social capital as the resilience of social norm. It was reinforced by the local rituals in Solor island which is usually done once a year before entering the fasting month of Ramadhan; cleaning and taking care of the public wells.

The ritual is performed by many people in Solor island and a means of social interaction for people in Solor island, as well as activities that serve to reinforce the values and social norms related to the unwritten rules regarding water usage. Then form of resilience of the people in Solor island is reflected by the availability of RWS management on neighborhood level where the RWS tank also given to the Solor community to every 2 to 5 households that has shared rules in the management of RWS.

Resilience of the water crisis on the social network dimension was reflected in the lack of cooperation towards development of clean water by residents, although this was not many in number, as residents tend to help each other in getting fresh water and establish networking in purchasing water in Adonara through the help of fishermen at IDR. 2,000 for every jerry can. Lastly, reflection of confidence in the dimensions of the community in Solor island that the author has assumed is affected by “social norm” strengthened by “social network” in the community in Solor island. From the field evindence, there were no indication of misappropriation of fresh water usage by the water manager on a neighborhood level.

From the explanation of social capital as a form of resilience in Solor island, it was loaded with a social interaction that made them lacking interaction with outsiders in Solor in dealing with water crisis because they are just “water buyers” depending on their economic capital. So that they will be less aware of how values and social norms that exist in the society related to the water usage, and due to the lack of interaction with others make them less able to establish network in the community and that their network may be smaller compared to those who have a social capital because of the lack of economic capital as a form of resilience of the water crisis.

Then, due to the lack of social interaction with other party, it is likely that they are less familiar and less aware of the other party that contributes to low trust and enormous suspicions towards the other party. It can be able to explain because the main resilience of the community in Semau island depends highly on the economic capital that determines how big is their access to the water resource in order to meet needs, and that they have to "interact" to other party which has the access to water resource to establish social network with said party.

Semau Island, which generally relies on the strength of the economic capital, for example on their self-help installation of RWS tank using less than IDR. 15 million rupiahs that can be utilized for a small number of households. From the use of this communal RWS, each member of the family also has values and rules of water usage. The example is a reflection of the positive relationship between economic capital with social networks and social norms in some communities in Semau. Then the adhered values and rules on the usage of RWS lead to the formation of " trust" on one another in addition the kinship based trust. However, the economic capital used by the people in Semau island is highly dependent on environmental conditions, such as "seaweed farmers " that are highly dependent on the sea conditions, so that under the occurence of environmental disturbance on marine ecosystems, causing a harvesting failure of "seaweed" in Semau, it will cause the lost of the resilience ability of the society in Semau during water crisis conditions.

Based on the above explanation, it can be seen that there are differences in the form of community resilience between Solor and Semau islands. The tendency, based on the available data, is that there are unwritten rules, villagers obedience towards unwritten rules, the availability of water resource management, the existence of community joint effort in managing and treating public well and the strong trust between the society in using water in Solor island shows that their resilience is leaning to get a sustainable social capital.

Although it can not be denied that there are also forms of resilience based on economic capital in Solor, it is less likely to be committed by Solor inhabitants where those with high social capital tend to come from the lower economic capital. It also happened in Semau but slightly different from what happened in Solor. In Semau, the data obtained are in the efforts to overcome the water crisis through the purchase of water to parties having the access to clean water, so that Semau inhabitans possess economic capital resilience from experiencing water crisis.

The low social capital in Semau may be affected by poor infrastructure in the island, making it difficult for the community to interact with each other, so that the public depended on individual economy, or at the group level, on the basis of kinship.

3. 3. The Sustainable Fulfillment of Water Needs in Small Islands

There are five dimensions which, being used to determine the value of sustainability, are ecological dimensions with 7 attributes (diversity water source, quality of raw water, geographic proximation over water resources, forest cover, rainfall, reservoir conditions, balance of annual water resources); the economic dimension with four attributes (price of raw water, WTP, water purchasing power of the community, and poverty); social dimension with four attributes (traditional wisdom in obtaining clean water, togetherness in water management, conflict of status on water resources utilization, the role of CSR in the provision of clean water); institutional dimension with 5 attributes (community water management institution, regulations of water management, government assistance in the provision of clean water, planning of raw water management, local budget allocation for the conservation of raw water); and dimensions

of technology/infrastructure with three attributes (infrastructure providing raw water, water treatment technology, water resource infrastructure).

Based on the Rap -Water analysis score results, the data, as in **Table 3** below, is obtained.

Table 3. Rap-Water Analysis Score

Island	Ecology	Economy	Social	Institution	Infrastructure and Technology	Average
Ende	46.03	34.95	69.20	45.76	33.88	46.49
Solor	33.14	34.95	87.61	43.39	33.88	47.12
Semau	37.87	66.88	37.33	42.45	33.88	44.20

The data above (Table 3) show that Solor island has the highest sustainability value with the average score at 47.12; followed by Ende island at 46.49; and Semau island with total score 44.20. If we refer to sustainability range criteria, where score between 0 and 25 is considered not sustainable, 26 to 50 as less sustainable, 51 to 75 as averagely sustainable, and 76 to 100 as highly sustainable, then the sustainability of the three islands are considered bad. This means that the raw water availability and sustainability in these islands are low. This is in line with the vulnerability index after analysis which also shows vulnerable condition of the society in terms of the raw water availability.

To see the variables that are sensitive to the sustainability of water supplies in small islands, the leveraging result for each analyzed dimensions shows that for the ecological dimension, as shown in **Figure 3**, generally can be seen that the catchment area/forest cover, geographical proximation on water resources and rainfall became the most sensitive variable towards the sustainability of water in small islands.

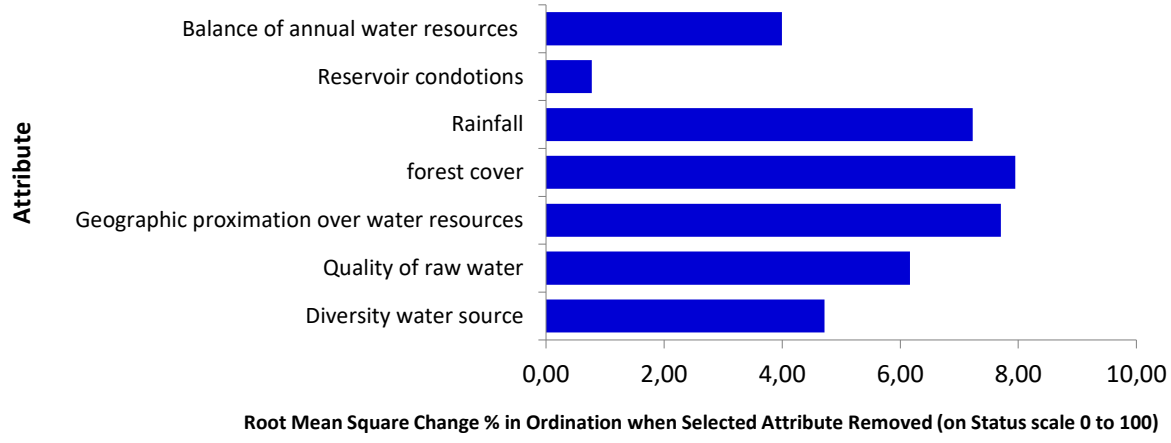

Figure 3. Leverage of Ecological

This is in line with the real conditions in which the raw water is a function of the catchment area. In this case, the larger the total area of forest cover in small islands, the most likely water resources will be maintained, while the distances in obtaining water in small island

has been a big problem for people in small islands, as it creates high costs, which most poor can not afford. This condition causes the sustainability of the raw water supply becomes very sensitive. Rainfall is another important variable in the procurement of raw water, but during the field research it is extremely difficult to obtain, with the composition of the rainy season of only 3 months every year, causing rainfall variable became very sensitive to the sustainability of raw water.

For the economic dimension, as shown in **Figure 4**, the price of raw water becomes the most sensitive variable towards the sustainability of raw water in small islands. In line with the ecological dimension, where the water is difficult to obtain due to ecological characteristics, such as few vegetation covers, occasional rainfall and also geographical distance over water resources, causing the price of water to be very high. Poverty exacerbates this condition because of their ability to pay, although high, cannot catch up with the price increase. Community's WTP and poverty are the variables that are also sensitive to the sustainability of water supplies in small islands.

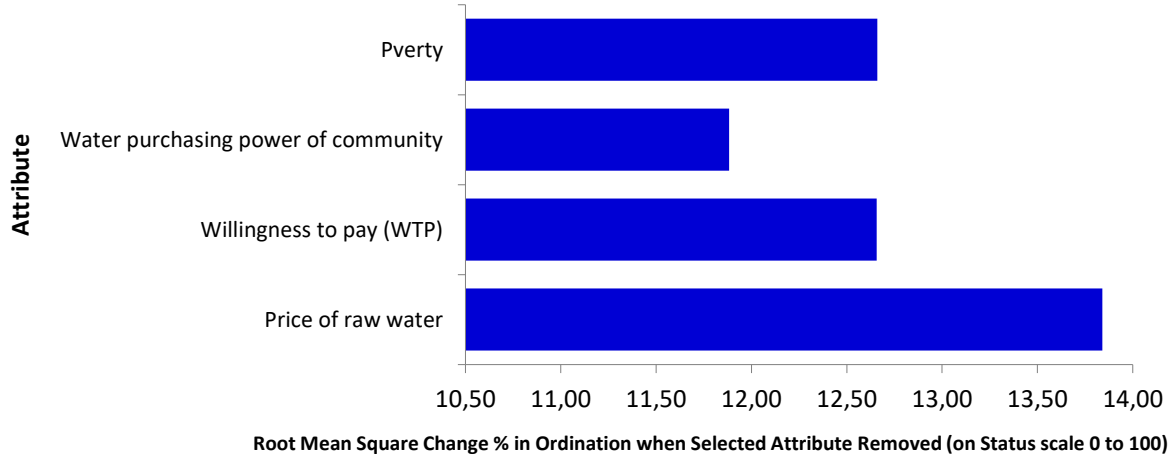

Figure 4. Leverage of Economic

For the social dimension, as shown in **Figure 5**, the sustainability of water supplies in small island turned out to be very sensitive to water resource conflicts. Even though, Solor and the two other islands have local wisdom, and also a good kinship in water management (social sustainability value are relatively moderate (between 50-60%), but occasional conflicts are the most sensitive in determining the sustainability of water supplies in small islands.

For institutional dimensions, as shown in **Figure 6**, the most sensitive attributes are the water management planning and its governance. Conditions research field indicated that there have been no systematic efforts in the form of local or central planning to deal with water scarcity in relatively isolated small islands. Based on interviews with local government, the budget allocation for the provision of clean water is very limited. Even though, as shown in the social analysis results, the CSR aid programs were very important and senitive towards the procurement of raw water in small islands. Regulations are also an attribute that they are sensitive to the dimensions of institution. The conflict being sensitive to the social dimension is a reflection of the importance of management of water in small islands. Until now, water governance has not been regulated on the research fields. The community has not yet obtained

their right to water which is a basic human need. In this case, the local government having the resources of small islands located in remote areas, need to be encouraged to planning and good governance, and optimal for the procurement of raw water. This governance can refer to the results of the analysis of Rap-Water on other dimensions that are considered sensitive.

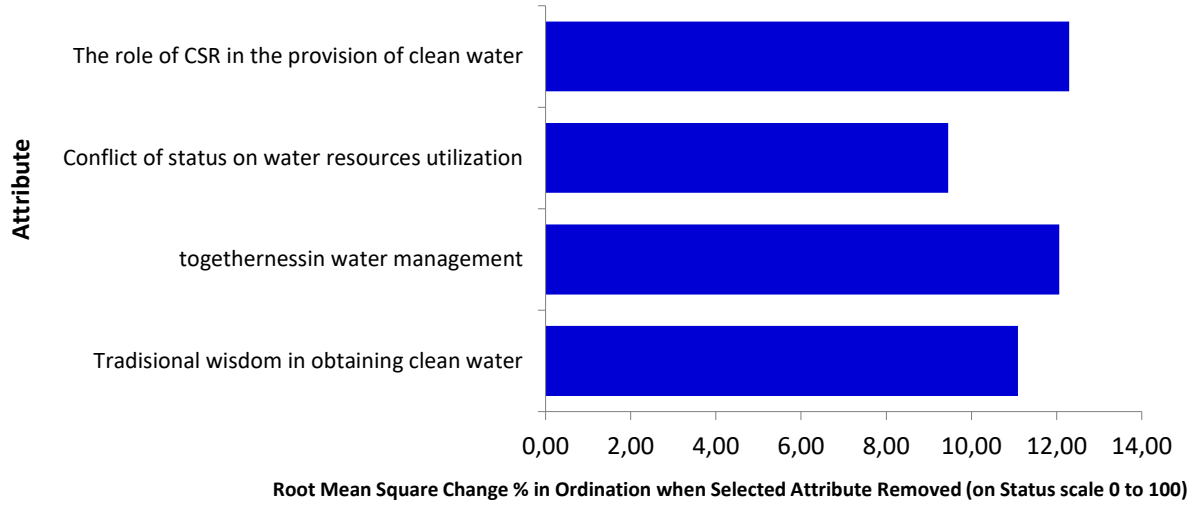

Figure 5. Leverage of Social

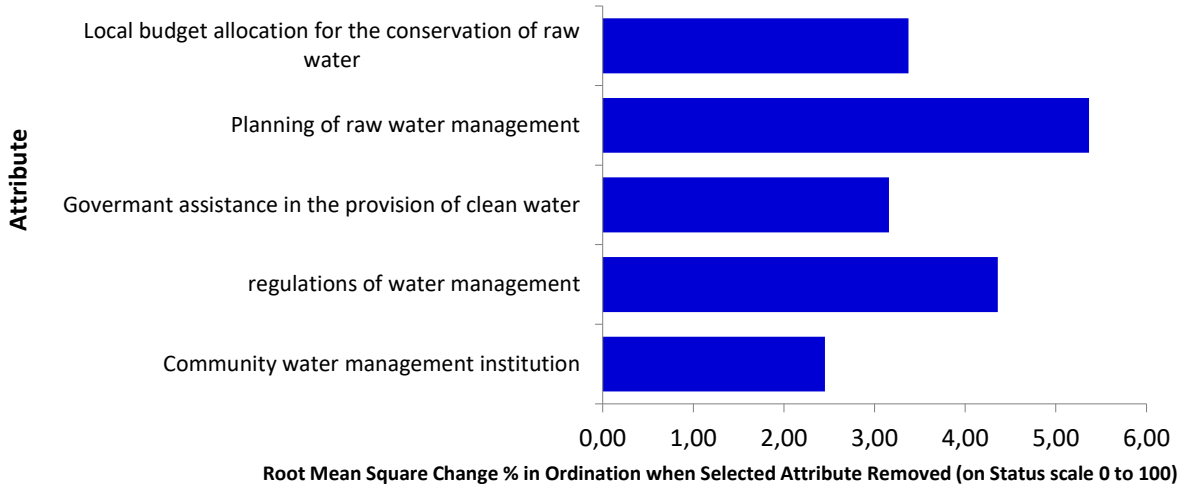

Figure 6. Leverage of Institutional

Analysis of infrastructure and technology leverage, as shown in **Figure 7**, indicates that the most sensitive attributes is water treatment technology in the form of re-use, recycling, or the processing of seawater into fresh water. Until now, there has been a lot of technology as it is introduced in the area of small islands in the research area.

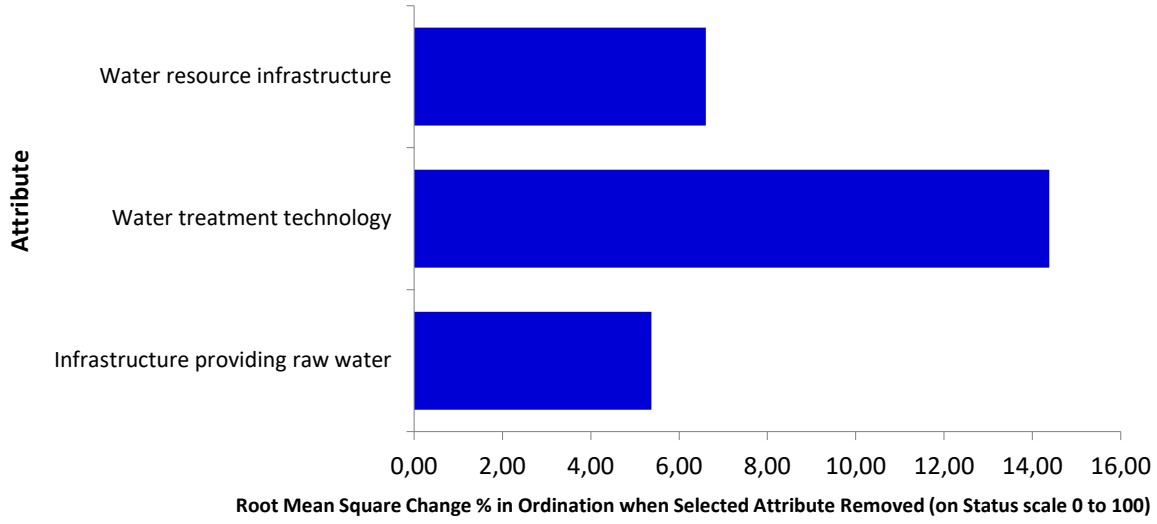

Figure 7. Leverage of Infrastructure and Technology

Analysis of infrastructure and technology leverage, as shown in **Figure 7**, indicates that the most sensitive attributes is water treatment technology in the form of re-use, recycling, or the processing of seawater into fresh water. Until now, there has been a lot of technology as it is introduced in the area of small islands in the research area.

4. POLICY IMPLICATIONS

On the arranged index formulation, based on statistical result, it comes out that the formulation is valid and reliable to be used to calculate the vulnerability index of small islands in dealing with water crisis. Therefore, generally the previous studies are still relevant [9, 20, 21]. However, if we study them further, especially on the sub-dimension part, there are several sub-dimensions that has not yet occurred before, but statistically significant for the measurement of vulnerability index.

On the adaptive capacity dimension, there are sub-dimensions: the willingness to pay (WTP), perception towards climate change, and social capital. If we refer to the previous works [9, 20, 21, 24], they have yet to express such sub-dimensions as the important elements in the formulation of vulnerability index so, that it can be said that the subdimensions are very valuable findings in this research. Meanwhile, on the exposureness dimension, the three subdimensions formulated in the index are evidently a new finding. The three subdimensions are just confirming the theory by previous scholars [9, 20, 24], while the view of [21, 27] apparently is not getting empirical confirmation in this research.

Furthermore, the formulation of the index in portraying empirical condition on the three islands. Based on vulnerability index, it can be said that Solor island is the most vulnerable compared to Ende and Semau islands. However, when we look further it turns out that not all dimensions have a high vulnerability in Solor island. There are variations of vulnerability on the three dimensions in the islands. Data shows that in the adaptive capacity, Solor island is the

most vulnerable one. Meanwhile, on sensitivity dimension, Semau island is the most vulnerable. And on exposureness, Ende island is the most vulnerable.

It cannot be denied that vulnerability is quite related to the physical environment, but one of the resources that can be used to overcome the problem is technology. However, using the same technology, but with different management and usage pattern, it turns out to influence the growth of social capital within the society, which enables them to reduce the level of vulnerability. Field evindence shows that although using the same technological assistance, although with different management and usage pattern, the resulting social capital is different.

For example, social capital of the community in Solor island is higher compared to that in Ende island. It is affected by two types/dimensions of social capital. Firstly, structural social capital (outside of individual), which in Solor island there are institutions or joint forum to commonly manage the RWS. Moreover, there is a rule that limits resident's access to water by giving them 3-5 buckets of water at the most. Conversely, in Ende island there are no such thing because the management is done by individuals in each household. Secondly, cognitive characteristic inherent in the society in doing a collective cleaning of the RWS facility, even has been internalized as manifestation of the customs to clean up water source. Conversely, on the island of Ende, there is no value as the basis for such an action.

The above conditions indicate there is a relationship between the management and utilization patterns of a technology and the continuity in meeting water needs with social capital. The working of the two dimensions of social capital, both structurally and cognitively, as proposed by [29] showed, that the level of social capital in Solor island can be quite high. This is evidenced by the commitment of citizens to cooperate, sacrificing personal interest, and subject to the common rules. The conditions of social capital is an important aspect to reduce vulnerabilities in fulfilling fresh water needs in small islands.

Another interesting finding in this study is that even though, the economic capital of a society is good enough, characterized by a high income and expenses, it did not necessarily make their social capital high. People of Semau island that rely more on economic capital, such as independently building a relatively expensive RWS tank, at a certain level do have a good social capital, but only in the family environment, and it is based on ties of kinship. However, at a higher level such as neighborhood it failed to improve. This suggests that high economic capital cannot encourage social capital growth widely. Conversely, in Solor, a high social capital was influential to the high economic capital, in terms of financial outlay it can press so as to meet other needs. Such social capital condition is still in micro-level and not yet related to the social capital in macro-level [30]. The low level of social capital in Semau and Ende islands in micro-level, both in cognitive and structural dimension, actually can be supported if a partcipation room is opened in macro-level. This was demonstrated in the UNICEF RWS tanks aid, that was less able to contribute to social capital growth because of the lack of public participation in policy making. Conversely, community driven (PNPM) program, using communial RWS assistance, has created room for the growth of social capital because it was able to open up the community participation in the macro-level decision making.

Therefore, the alternative policies that meet the needs of clean water provision in small islands using five dimensions that are tested is very important, let alone all of them show indications of sustainability. The test results showed that the ecological dimension, the seven attributes, with the most sensitive being the catchment area/land coverage, is geographical poximation over water resources, and rainfall. Meanwhile, on the economic dimension, of the four attributes, the most sensitive is the price of raw water, poverty, and people's WTP raw

water. Similarly, the social dimension, among the four attributes, is the most sensitive with the conflict utilization of water resources and the role of CSR in raw water provision. Furthermore, in the dimensions of the institution, among the four attributes, the most sensitive is the raw water management planning and regulatory management (governance), whereas in the dimensions of infrastructure/ technology, among the three most sensitive attributes are the management technologies (reuse, recycling, etc.).

Sensitive attributes in the various dimensions of the above indicate that the necessary policies for vulnerability reduction fulfillment of clean water for people in small islands that are based on models that have been developed. Therefore, the model applied is an important policy to consider the five dimensions and their attributes. Model policies aid the individual technologies are only considering several irrelevant aspects. To that end, a comprehensive policy making, involving multistakeholders are very urgent to do. For example, reservoir development policy needs to be supported by the movement of reforestation to improve forest cover. Similarly, the development of technologies such as RWS need to be supported by good management institutions and aimed at increasing community's social capital and improving the economic capital of the community. In addition, it should also support the development of other infrastructure, such as roads and infrastructure to support the community access to clean water sources. Thus, through these policies, the level of vulnerability of the community will be further reduced in each dimension and its attributes.

5. CONCLUSIONS AND RECOMMENDATIONS

In the formulation of vulnerability index on the water fulfillment, there were discovered 14 parameters which belong to three dimensions: (1) seven parameters on adaptive capacity, (2) three parameters on sensitivity, (3) four parameters on exposure. Concerning the application in the three small islands, it can be found that island with the highest vulnerability is Solor island (0.60), followed by Ende (0.46), and the lowest is Semau island (0.39). However, not all dimensions are experiencing high vulnerability in each island. Adaptive capacity is the most vulnerable dimension in Solor island, while in Semau island it is sensitivity, and in Ende island it is exposure.

The adaptation pattern of the community in dealing with water crisis is through building or utilizing rain water storage (RWS) tank, either by self-financing or from external source. The finding that is interesting is that the more communal the facility is, the more it is able to strengthen community's social capital in overcoming water crisis, and in contrast, individual assistance turns out to weaken social capital. There are two types of community's resilience patterns: (a) resilience based on social capital, and (b) based on economic capital. Each of the resiliences is having its own superiority, as well as drawback. We also found out that social capital based resilience tends to come from those having low economic capital.The policy alternative for the fulfillment of fresh water needs in small islands sustainably by using five dimensions along with their attributes, which are: ecology (7 attributes), economy (4 attributes), social (4 attributes), institutional (5 attributes), and technology/infrastructure (3 attributes); it turns out effective to be used as the basis for policy making. This shows the stability of the model. This condition also serves to prove that the system has a significant level of confidence and can be used to measure the sustainability of the raw water supply in small islands.

Based on the above conclusions, the following can be recommended:

Firstly, the formulation of water resource utilization and support policy is based on vulnerability index. The more vulnerable people in the fulfillment of clean water is increasingly urgent to be handled.

Secondly, there is the need to consider forms of development that are able to increase the stock of social capital of the community, instead of weakening it.

Thirdly, promoting assistance in the form of CSR programs to manage the existing water resource and to develop capacity buliding of the community to design their own economy or even to develop infrastructure and technology, in order to increase raw water supply.

Lastly, we need a comperehensive and holistic policy by involving multiple stakeholders. The policy for the development of infrastructure and technology needs to be under one package of plan supported by reboisation effort to increase the land coverage. Likewise, it needs the support of a good management institution which pushes for the increasing of social capital of the community, as well as improving their economic capital so that the small island community's level of vulnerability is getting lowered.

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