

Development of Sea Water Distillation Model in an Effort to Overcome Water Crisis in Small Islands (Case Study: Ende Island, NTT)

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ABSTRACT

Indonesia is an archipelagic country with more than 13.000 islands in total. Some of them are small islands with total population less than 20% of the country's population. However, there is a crucial problem in those small islands, the lack of raw water. One of the small island who experienced this problem is Ende Island, Nusa Tenggara Timur. Ende's people having trouble in collecting drinkable raw water, so that they have to buy more expensive water from other city or using brackish water which could caused disease. This research aim to analyze potential water resources, analyze water demand, and examines water resources management in Ende Island. Research method used by this research is quantitative descriptive by analyzing water balance in research site and looking for the right water resources management model to implement in the site. Based on the research, water resources in Ende Island is unable to meet people's demand. Therefore, there is a need for a continuous proper management of water resources. Comparison test reveal that recommended technique for water supply in small islands especially Ende Island is sea water distillation, consider that Ende Island does not have watershed and low rainfall intensity. However, sea water distillation tools developed today still has some shortcomings which make them hard to operate. Therefore, a simple raw water distillation tool was developed to support continuous water usage in those small islands.

Keywords: water crisis, sea water distillation, small islands, ende islands

1. Introduction

Indonesia is an archipelago stretching from Sabang to Merauke. Badan Informasi Geospasial (2014) said that "currently registered and coordinated island are 13.466 islands in total" including small islands which have less than 2000 km². Those small islands inhabited by approximately 20% Indonesian population.

It's huge potential what makes people stay in the small islands. They have abundant natural resources such as coral reefs, sea grass, mangrove forests, fishery, and conservation area which could become nautical tourism destination. But, behind it's potential, there are crucial problems in those small islands.

Common problem in small islands is unavailability of raw water for domestic consumption. Surrounded by sea sometimes makes water in the islands not safe for drink. People mostly drink from brackish water with high salinity level. Sometimes they have to buy expensive water from other island.

In respond to water problem in those small islands a declaration known as Millenium Development Goals (MDGs) at Johannesburg Summit 2002 declare that in 2015, half of worlds population which does not have access to drinking water, should obtain them. Indonesia itself at the summit targetted 81% population should have access to better

water sources in 2015 including the small islands.

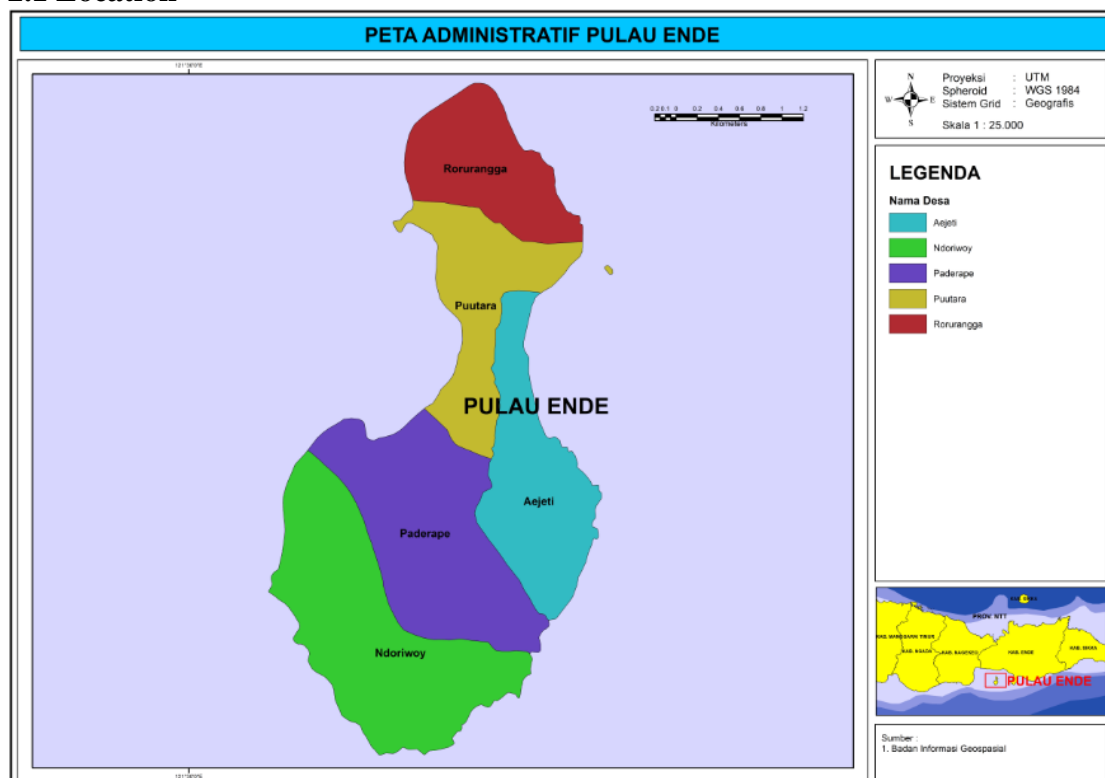
One of the small islands is Ende Island located in Kabupaten Ende, Provinsi Nusa Tenggara Timur (Picture 1). Ende's population have the same problem with other small islands, unavailability of raw water for daily usage. Even they could not meet minimum standard of 30 litre/day for rural area.

In an attempt to resolve the problems there should be an efficient, integrated, and sustainable water management in small islands including Ende. Therefore this paper was written to:

- 1) Analyze water resources potential di Ende Island
- 2) Analyze water demand in Ende Island
- 3) Review appropriate water resources management model

2. Method

2.1 Location



Resource: Data Process Result, 2016

Picture 1 Peta Administrasi Kabupaten Ende

Research location is Ende Island, Kabupaten Ende, Nusa Tenggara Timur. This island located at $8^{\circ}52'0''\text{LU}$ $121^{\circ}31'0''\text{BT}$ with area of $63,03 \text{ km}^2$. Ende island surrounded by Sawu Sea.

2.2 Research Method

This research conducted using quantitative descriptive by analyzing potential and water demand in research location and looking for an applicable water resources management model.

- Water Potential Analysis
Analysis of water potential done by collecting related data to water resources in

research location which is meteorological water and surface water. Meteorological water calculated from rainfall average using rainfall station data.

Average weighed model used to calculate water availability according to rainfall in every village (Muliranti dan Hadi, 2013, hlm 25). The equation formula is as follows:

$$V : (P1 \times A1) + (P2 \times A2) + \dots + \dots\dots\dots(1)$$

Explanation :

V : Volume (water availability in litre)

P : Rainfall (mm)

A : Village area(km²)

- Water Demand Analysis
Water demand calculated from the number of villagers multiplied by standard villager's water demand per day. Standard villager's water demand per day in Ende Island is 30 litre/day. The equation formula to calculate domestic water demands are as follows (Martopo, 1984):

$$Kd = n \ d \ \sum \ p \ d \ \dots\dots\dots(2)$$

Kd : Domestic water demand (litre)

n : Days in month

d : Water demand assumption(30 litre/day)

$\sum \ p \ d$: Population

- Deciding Water Resources Management Model
After water potential dan demand discovered, then water resources management model could be decided to resolve water problem in Ende Island.
- Water Resources Management Model Development

3. Discussion

3.1 General Description

Ende Island is an island located in the southeast of Flores Island. Ende have 7 villages with 7083 inhabitants in 2011. Ende has a very critical water crisis. Governor of NTT categorize Ende as one of seven which has clean water crisis in his province.

In order to get a bucket of clean water, villagers have to walk very far from their home and the only water they got is brackish water. The view of fighting over water is still common until today. Brackish water which is obtained by the villagers used as every day water usage such as drinking, cleaning, cooking, etc. However, they have to do a very tight saving, especially in a long dry season.

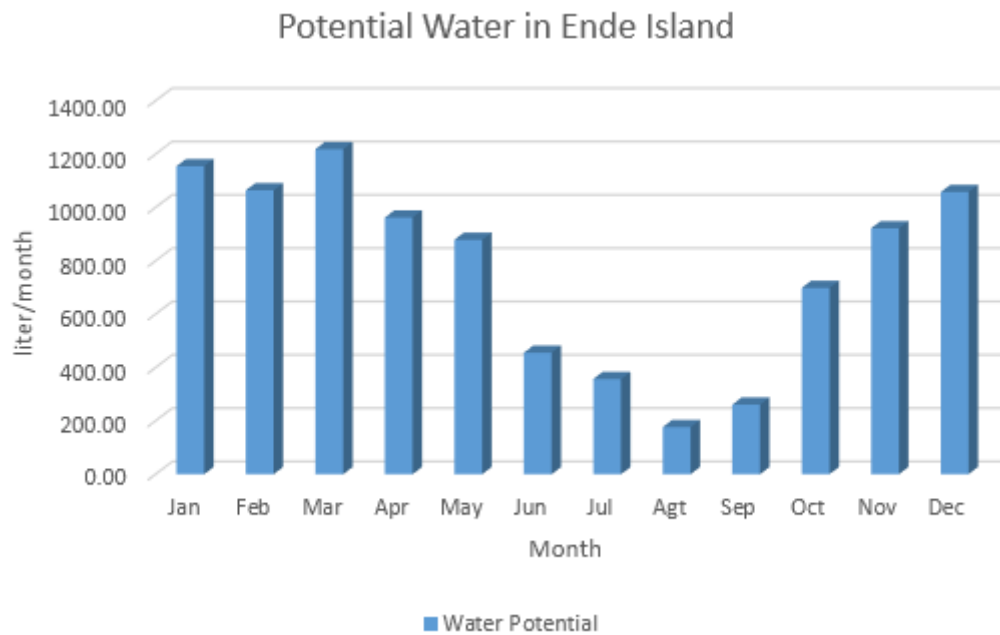
Brackish water which is obtained by the villagers usually cooked half baked or around 60°C. According to locals, if the water cooked to long up to 100°C, then the level of salinity with go higher because most of its freshwater evaporated. As the result many Ende's inhabitants got infected by digestive disease such as diarrhea.

The fact that most of Ende's well contain brackish water is not a secret. But, there is an unexposed fact that those wells contain e. coli bacteria according to health department research in 2007. Water consumed by Ende's inhabitants were very dangerous if not cooked well.

3.2 Water Potential Analysis

Ende Island doesn't have surface water sources except sea water. Therefore, the inhabitants of the island utilize shallow groundwater for daily needs. Because of its rare existence, especially in long dry season, people have to lined up on available well or buy them from other city.

Other than surface water sources, meteorological water will be discussed (Picture 2). According to water potential calculation in Ende Island, the highest rate is on March with 1218,69 litre/month, while the lowest rate is 176,33 litre/month on August. However, the highest rate on March is still very low compared to other other regions in Indonesia.

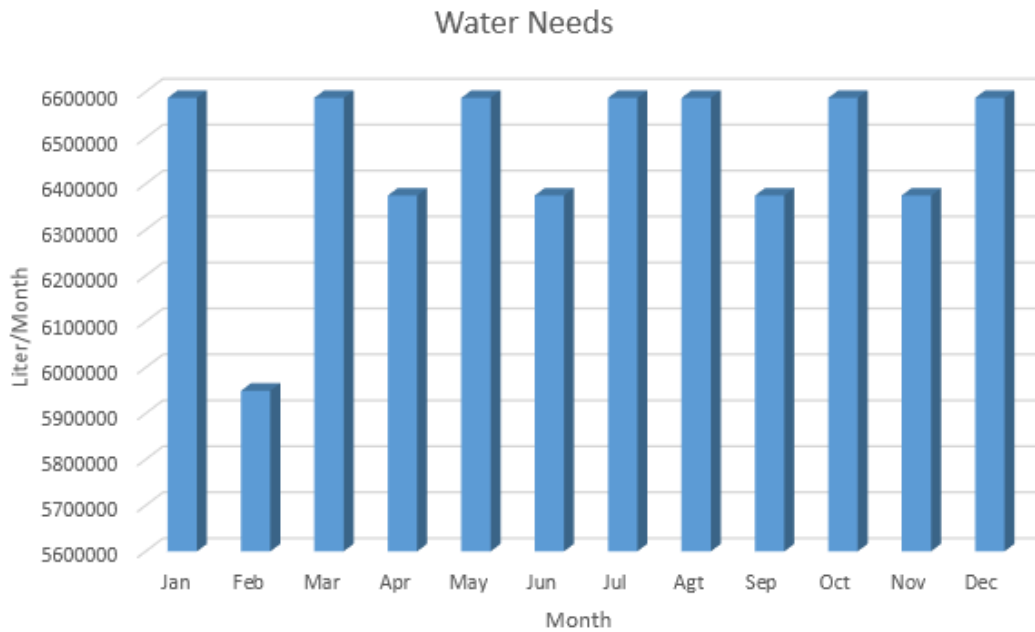


Resource: Data Process Result, 2016

Picture 2 Water Potential in Ende Island

3.3 Water Demand Analysis

Based on domestic water calculation using Mastopo's formula, then water resources in Ende Island are as follows (Picture 3).



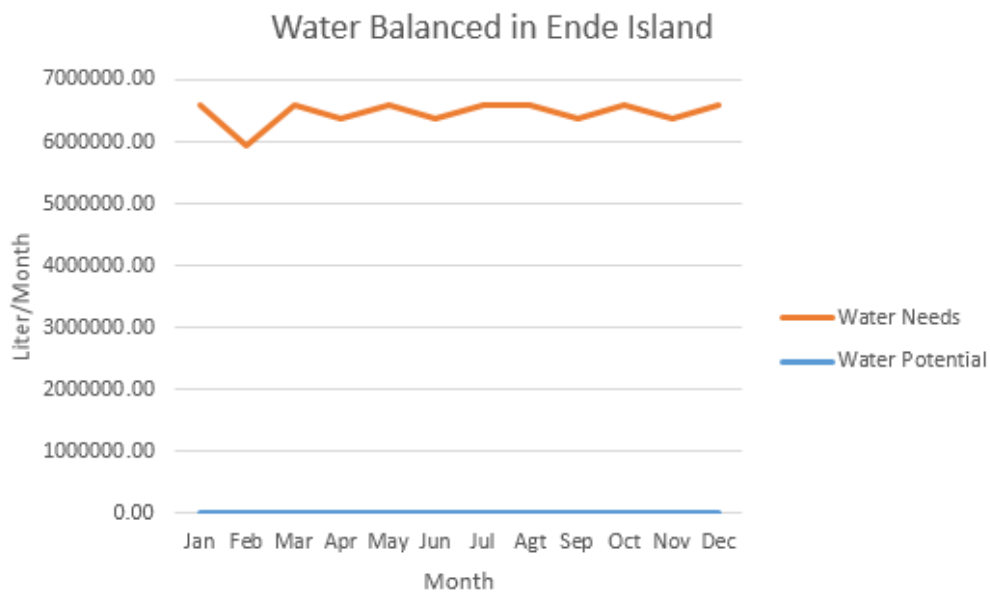
Resource: Data Process Result, 2016

Picture 3 Water Supply in Ende Island

Fact from Picture 3 shown that domestic water demands from Ende’s inhabitants are high reaching an average of 6587190 litre/month.

3.4 Water Balance Analysis

Nasution and Syaifullah (2005, p 235) generally states that “water balance explains the relationship between the flow of water entering (input) with a stream of water coming out (output) in an area within a certain time”. Based on water balance analysis in Ende Island, it can be seen that there is a huge distance between demands and water availability (Picture 4). This is caused by low rainfall and small areas. Therefore, even though Ende’s inhabitants could save all the rainfall it still couldn’t satisfy their’s needs.



Resource: Data Process Result, 2016

Picture 4 Water Balanced in Ende Island

3.5 Sea Water Destillation Model Analysis

To determine water supply model in Ende done with comparison study between rainfall harvest, hydraulic pipe and sea water destillation as follows.

1. Rainwater harvesting

Rainwater harvesting defined as a way to gather rain water or surface water when the rainfall level is high and used them when the rainfall level is lower. (Harsoyo, 2010, p 34). Rainwater harvesting directly proportional with meteorological potential. However, research location only have low rainfall level, so rainwater harvesting could not meet their demands. Rainwater harvesting stills need to be done for daily needs even though it could not cover fully.

2. River Water Utilization

River Hydraulic pipe could not be done in Ende Island because Ende does not have watershed. Therefore hydraulic pipe design could not meets water demands because of unsupportive geographical condition.

3. Sea water destillation

Sea water destillation is a method to convert salty sea water to freshwater. Sea water destillation could be done in several methods, two most famous method is reverse osmosis and destillation. But there's exist weaknesses from this method, they are as follows.

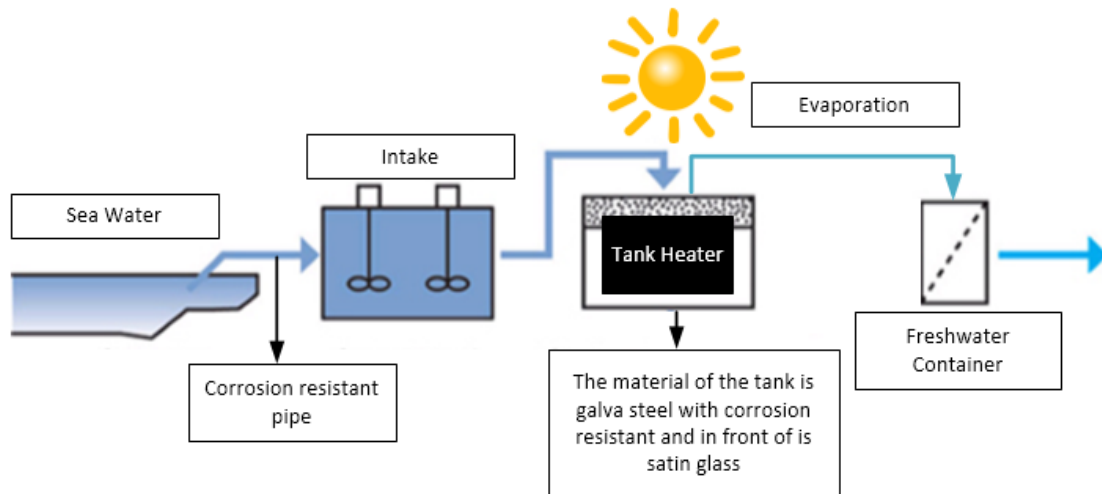
- a. Most of sea water destillation infrastructure built by the goverment needs large power supply while small islands like Ende power supply usually very limited. Ende actually have a complete destillation equipment but could not be used because inadequate power supply.
- b. Destillation infrastructure material not rustproof makes the tools rusty and the water processed is not worth drinking. This happen in Maratua Island, Kalimantan Timur.
- c. Because of incomplete community empowerment, people less understand how important the maintenance of the infrastructure.

Based on comparison analysis, efficient water supply method between rain water harvesting, river hydraulic design, and sea water distillation is the sea water distillation. Seen from it's geographical location as a small island with small rainfall level and the absence of watershed, sea water distillation is the best solution.

3.5 Simple Sea Water Destillation Design

The concept of sea water destillation is a process to remove it's salinity to get drinkable freshwater for animal, plant, and human (Walangare, dkk, 2013, p. 2). Salvato (1972) said that sea water conversion to freshwater could be done by artificial heat destillation, solar heat destillation, electrodyalisis, osmosis, hydation gas, freezing, etc. As for raw water destillation proposed as follows (Picture 5).

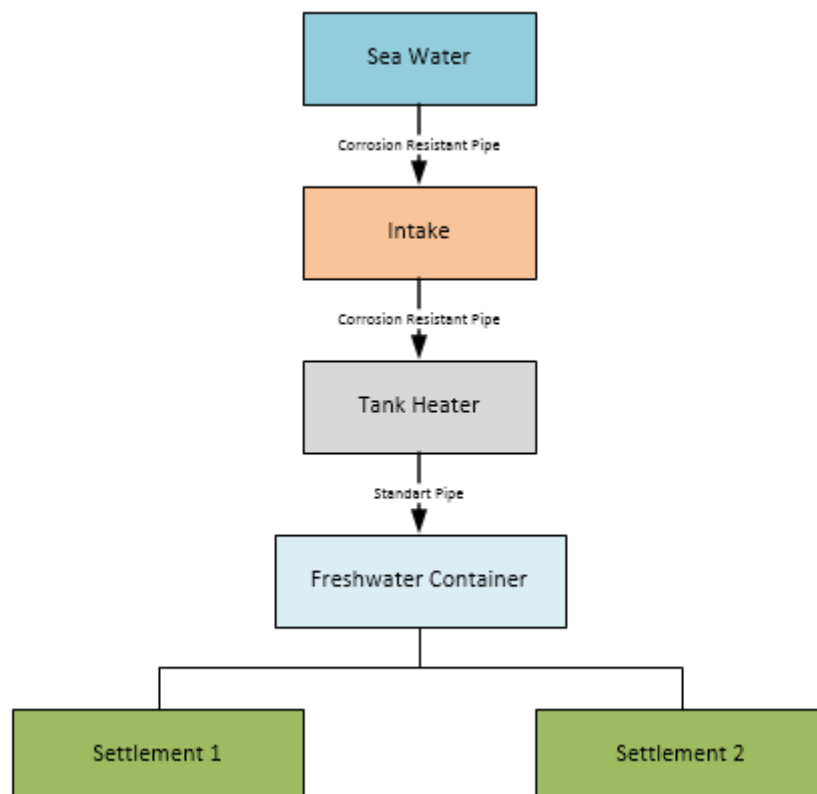
The main material for salty water destillation is galva steel, galva is a type of metal which have corrosion-resistant caused by sea water. The choice for galva is a result from a few material evaluation which have better capabilities. Furthermore, the material could become good conductor in sea water on heating process by painted in black.



Resource: Data Process Result, 20166

Picture 5 Simple Sea Water Distillation Design

Pipe from tank is used to condensing freshwater and distribute it to freshwater container. Next, water from the container brought to people's houses. The amount of water distributed depend on container volume and region's temperature. This is the sceme for raw water supply by sea water distillation technique. (Picture 6).



Resource: Data Process Result, 2016

Picture 6 Water Supply Scheme

3.6 Model Limitations

As for its limitation for sea water distillation model are as follows:

- *Energy sources.* This model use solar energy to heat the tanks, which makes it only happens at noon. While at night, this model could not work.
- *Heating time.* There is no time measure to heat the tools to work.
- *Container capacity.* The capacity of freshwater container depend on water input, tank capacity, energy sources and the speed of the destrillation process. The experiment for calculating freshwater container has not be held yet.

3.7 Raw Water Supply Sustainability Efforts

The effort for raw water supply should be sustainable. Requirements for sustainable for raw water supply as follows (Deepa Narayan, 1995).

- Clean water component working: quality and discharge rate of water resources; operation and maintenance; cost recovery;
- Community empowerment: management capabilities; decision making; knowledge and skill; community trust;
- Local institution position: autonomy; leadership support; system for learning and problem solving.
- Environmental Conservation: Water resources protection; freshwater infrastructure maintenance;
- Cooperation between institution: planning; action;

4. Conclusion

Based on the research that has been done, then clean water supply for small island inhabitants especially in Ende Island, NTT is using salty water distillation to freshwater. But, this method should be evaluated in maintenance and operational where there were tools that could not work because of lack of energy resources or the tools is not meet drinkable water standard.

Therefore, there should be a new design of sustainable raw water destillation process by improving current technology so that the tools could fully working to resolve water crisis in small islands.

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