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Influence of Rainfall and Vegetation Against Unconfined Groundwater Potential Withing Coral Sand Layer in Satando Island at Pangkep Regency, South Sulawesi

Sultan, A. M. Imran, M. Arsyad Thaha, dan Muhammad Ramli

Abstract- ***Population growth in the island will affect water resource potential in island, addition to geological conditions and rainfall. For that reason, this research aimed to see influence of rainfall in the island Satando against potential unconfined groundwater in the coral sand layer in the area of this small island, which will be useful to provide information to local governments and communities of the island on the importance of maximizing rainwater there to sink in and get into the coral sand layer in the area so as to preserve the unconfined groundwater on the island. The research method is done by several approaches include literature and secondary data, field activities of primary data for measuring the condition of the surface of the groundwater in wells resident on the island Satando totaling 20 wells during the rainy season, a season of transition and drought as well as the compilation of all data obtained. Based on data from groundwater level changes are correlated with conditions and intensity of rainfall that occurred on the island, then analyzed influence of rainfall on the unconfined groundwater potential in the coral sand layer Satando island. Total population of 537 inhabitants, require minimal fresh water a year 11767,3M^3, potential water on the Satando island a year 10557.7 meter^3, so that the deficit needs 1209.6 M^{3}is causing water shortages island residents about 68 days (2 months). Dependence potential of water in wells in coral sand layerwith the intensity of the rainfall conditions that occurred on the Satando island for 33.69% of the intensity of daily rainfall that occurred.The influence of vegetation in particular the effect of very significant breadfruit tree roots where the potential wells are nearby existing vegetation is greater than the breadfruit tree that has no vegetation. Policy management of groundwater on Satando island is to control the use of water and disposal of remnants channeled into absorption wells were created in the yard, arranging the disposal of household waste and toilet, as well as any home maked rainwater tanks. Residents must control and controlling the birth rate and improve the level of education of children of school and also preserve breadfruit tree vegetation with replant and increase the population in the side yard to plant vegetables and other seasonal fruits.***

Keywords: rainfall intensity, resident dug well, coralsand, unconfined groundwater.

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Sultan, Doctoral Student of Civil Engineering, Postgraduate,Hasanuddin University, P. Kemerdekaan KM-10 Makassar, Indonesia.

A. M. Imran, Lecturer , Department of Geology Engineering, Hasanuddin University, Makassar, South Sulawesi, Indonesia.

M. Arsyad Thaha, Lecturer , Department of Civil Engineering, Hasanuddin University, Makassar, South Sulawesi, Indonesia.

dan Muhammad Ramli, Lecturer, Department of Geology Engineering, Hasanuddin University, Makassar, South Sulawesi, Indonesia.

I. INTRODUCTION

1.1 Background

Since the mid1960s, the world has begun to pay attention to the small island state of various aspects, fornatural resources, ecosystems biology, environmental pollution and intrusion. Linkages of population and area, problems of cultural, socio-economic conditions. The understanding of the existing problems of small island. In its development internationally, it was agreed that the presence of water resources in small island has become an important aspect for business development and management and preservation in small island(UNESCO, 2002). The small island is an island with a land area smaller than 2000km^2(Falkland, 1995) where as small island with an area smaller than 100km^{2}expressed as the very small island(Dijon, 1984). Small island as part of an archipelago area has a number of comparative advantages in the form of non-biological resources and biodiversity such as fish, mangroves, coral reefs, seagrass beds and other marine organisms and their ecosystems. These advantages have become the basis for the development of the region. But behind a number of advantages, this geographic region turned out to save a number of limitations. One of them is going ketebatasan water resources. For a small island region, especially in the tropics, some limiting effect on the water resources of which are symptoms of sea water intrusion and the limited land area especially those that can serve as a catchment. Water resources management system by ignoring the limitations mentioned above can cause some damage to the water system and result in a decrease in the quality and quantity of water in the island. On the other hand, the water system small island region is also sensitive to natural changes in symptoms such as global warming, tides and waves, changes in the transitional area augmentation and periodic due to the change of seasons. In the area of small islands where surface flow system only has a short travel time, this resulted in the utilization of water resources for such area relies more on ground water. The existence of ground water is highly dependent on local geological conditions and rainfall in the area, in addition to other influences such as tidal, global warming and sea wave. By looking at the relationships and linkages so that research on the effect of rainfall on the free soil water potential in the sand layer Satando reef on the island as one of the small islands in the category of very small islands in the region Pangkep, South Sulawesi.

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1.2 Objectives and Benefits

The research objective wastoinfluenceof rainfall in thesmall islandonthe unconfined Waterground potentialinthe coral sand layerin the island.The benefit isto provide information tolocal governmentsandcommunitiesof the islandon the importance ofmaximizing theexistingrainwatertoseepandinto thecoral sand layerinthe areaso as topreservethe unconfined waterground potentialon the small island.

II. LITERATURE REVIEW

2.1. Balance Of Water

The water balance is the relationship between total water supply and total water demand in a basin of water in which there are components of the hydrological cycle, the water balance equation as follows: $I = O \pm \Delta S$, with:

I = water entering the water basin (water supply)

O = the water coming out of the water basin (needs)

ΔS = change in the catchment basin of water

This catchment area can change the valueis positive or negative, depending on the condition of the water basin. The water balance of a basin of water associated with the development of water resources, which is to be a potential water basin water resources better if the water supply is greater than water requirements, water balance equation for the valueis: $\Delta S = I - O$ ΔSvalueis the value of the water balance can be positive or negative, depending on the condition of the water basin. To perform the calculations necessary water balance components of water demand and availability of water potential components.

2.2. Potential Water Availability

Water availability can be categorized into: a) Availability of rainwater b) availability of river water c) Availability of water springs d) Availability of catchment surface. e) The availability of groundwater

2.2.1. Availability of Rainwater

Rainwater that falls on the surface area of the water basin as a whole does not become runoff, but partly lost by the process of infiltration, interception and evaporation. Thus the availability of rainwater does not directly show water availability within a planning area, but to get an overview of the availability of water from rainwater necessary calculations with synthetic unit hydrograph (Snayder method) or using NRECA method and other methods according to the availability of data. NRECA for the calculation of the area of study required data input: Rainfall 15 daily, evapotranspiration, Value initial moisture and catchment groundwater. To calculate the average rainfall can be calculated by the method:

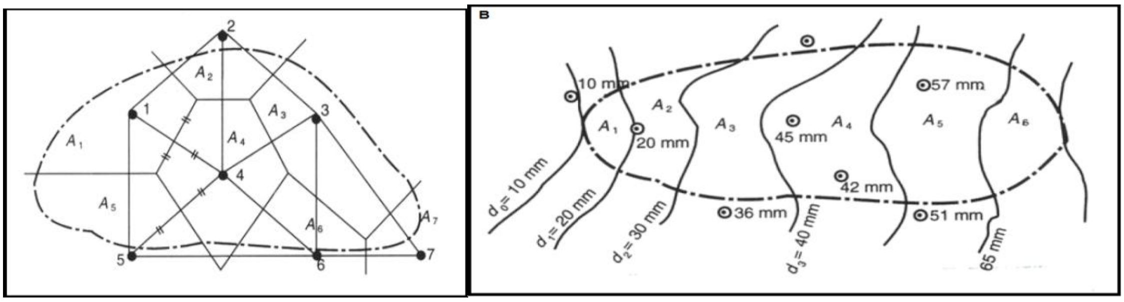

Fig. 1. A. Method of Polygon Thiessen dan B. Method *Isohyet Line* (Soemarto, 1999)

a) Method of Average Algebra

Average rainfall area average method algebra can be calculated by the following equation (Soemarto, 1999):

$$d = \frac{d_1 + d_2 + d_3 + \ldots + d_n}{n} = \sum_{i=1}^{n} \frac{d_i}{n}$$ with

d = high average rainfall
d1,d2,. dn = high rainfall on location data 1,2,…n
n = numbers of location data

b) Methof of Polygon Thiessen

Average rainfall areas Thiessen polygon method can be calculated by the following equation(Soemarto, 1999:11):

$$d = \frac{A_1 d_1 + A_2 d_2 + \ldots + A_n d_n}{A_1 + A_2 + \ldots + A_n} = \sum_{i=l}^{n} \frac{A_i d_i}{A_i} = \sum_{i=l}^{n} \frac{A_i d_i}{A}$$ with :

A = acreage d = high average rainfall
d1,d2,…dn = high rainfal in locatio data1,2,…n
A1, A2, A3,An = area of influence of the location data 1, 2, 3, , n

c) Method of Isohyet Line

This way, it must be drawn first contour with the same high rainfall(Isohyets), as in figure1. Then the widest part of the Isohyets-Isohyets adjacent measured, and the average value was calculated as the average value calculated to weigh the value of the contour, as follows :

$$d = \frac{\frac{d_0 + d_1}{2} A_1 + \frac{d_1 + d_2}{2} A_2 + \ldots + \frac{d_{n-1} + d_n}{2} A_n}{A_1 + A_2 + \ldots + A_n}$$ dengan :

A = total acreage d = high average rainfall area
d0, d1, …dn = rainfall on *isohyet*0,1,2, …,n
A1, A2, A3,.An = largeparts of the region bounded by *isohyet-isohyet*.

2.2.2. Availability of River Water

The availability of river water is done by measuring the direct debit on the existing river channel in the study area, but because the island is no river that was not done.

2.2.3. Availability of Existence Spring

The existence of this spring is influenced by the condition of the land and vegetation(plants) in the catchment area, but since the areaof the island has no water springs,so that this condition was also ignored.

2.2.4. Availability Storage of Surface Water

Water reservoir is meant here is the storage of surface water both natural and artificial. Which includes natural reservoirs are lakes, ponds or swamps, while the artificial reservoirs, a reservoir ordam. But the island is also the location does not exist, there is only a small basin which aimspervasive rain water or surface water or residual water that has been used in this area.

2.2.5. Availability of Groundwater

Ground water is the water that moves in the soil contained in the spaces between soil grains(layers) are for medin cracks of rocks(*fissure water)* (Sosrodarsono, 1999). In the Water Resources Act, water shed land called ground water basin(CAT), which is defined as an area bounded by the limit shydrogeological, where all events such hydrogeological pengimbuhan process, drainage, and ground water discharge takes place(Kodoatie, 2005). According Danaryantoet al, 2004, in Kodoatie2005CATin Indonesia are generally divided into two CAT Free(unconfined aquifer) and CATD epressed(confined aquifer). CAT is spread across Indonesia with a total magnitude of the potential of each CATis:

a. CATUnconfined: Potential1,165,971millionm^3/year
b. CATConfined: Potential35,325millionm^3/year

2.3. Water Requirement

According to the observations, the amount of discharge main stay taken for completion of the optimumuse of water in some kinds of jobstailored to the needs of the next, is used in the calculation of the availability of discharge is Weilbull method. as follows :

$$P(Xm) = \frac{m}{N+1} \quad \text{atau} \quad T(Xm) = \frac{N+1}{m}$$, with :

XM = set value (discharge).
P (XMC) = Opportunity occurrence of set value
N = Number of observations from variat X (data flow)
m = Number sequence of events, or ranking events.
T (Xm) = Period anniversary of the incident Xm

Water resources requirementsdivided into3 groups, among others:

1) The need for waterfor domestic include drinking water, clean water, offices, worship, shopping malls, hospitals, hospitality, flushing.
2) The need for water for agriculture, among others, rice fields, plantations, animal husbandry, fisheries.

3) The need for water for industrial, among others, heavy industry, the industry is, light industry, mining, hydroelectricity.

2.3.1. Domestic Water Needs

Water requirement per person per day, adjusted for which the person lived. In each category a particular city people have needs for water are different from each other.Meanwhile, to conduct a needs assessment of water with population projections carried out by the approximate formula is:Growth geometry (Geometric Rate of Growth) The formula of the ratio of geometric growth is: $P_n = P_0. (1 + r)$ n Where:

P_n = total population in year n
P_0 = the total population at the beginning of the year
r = rate of population growth (%)
n = interval of time (years)

Exponential Rate of Growth,the calculation using the following formula:P_n = Pn= P0. ern Where: P_n = total population in year n

P_0 = the total population at the beginning of the year
r = rate of population growth (%)
n = interval of time (years)
e = natural logarithm (2.718281828)

2.3.2. Agricultural Water Needs

Agricultural water requirements include:

a. Irrigation Water Needs

Irrigation water demand is the amount of water that flows through irrigation systems, in order to maintain the balance of the amount of water in agriculture. The balance of the amount of water in and out of a farm is as follows:

o The amount of water that enters in the form of irrigation water (IR) and rainwater (R)

o The water coming out of water needed for plant growth (ET), seedbed and tillage (Pd), and the amount of water that seeps due to percolation and infiltration (P and I).

In addition to the rainfall factor (R) and other factors (Pd, P, and I), crop water requirements (ET) is an important factor affecting the amount of irrigation water requirements (IR). The greater the greater the IR ET. So that one of the efforts to minimize the need for irrigation water is to reduce the water needs of plants.

b. Fishing Water Needs

The water needs of fisheries is strongly influenced by factors such as the following:

a) The salinity optimum required b) Evapotranspiration in the area (pond) c) Seepage happened d) of rain that falls into pond

2.3.3. Industrial Water Needs

Industry is defined as activities that produce products, including mining and power generation.

2.4. Stages Analysis Calculation

Stages of the water balance calculation as follows:
1) Data collection
2) Observations on the field
3) The calculation of the potential availability of water

a. Groundwater Availability Calculation

Potential water availability can be obtained by the sum total availability water of various designation: $Q_{Avaliable}=Q_{Rivers\ Flow}+Q_{Groundwater}$, where:

$Q_{Avaliable}$=potentialtotalwater availability(million m^3/year)
$Q_{Rivers\ Flow}$=availability ofriver flow(million m^3/year)
$Q_{Groundwater}$=availability ofgroundwater(million m^3/year)

III. METHODOLOGY

Studies conducted by several approaches include literature and secondary data, field work portion of primary data that will be tested in laboratory and studio activities. Field activities undertaken include the measurement of surface conditions on the ground water resident dug wells on the Satando island is totaling 19 wells during the rainy season, the condition of transition season from the rainy season to the dry season and during the dry season. Information geological conditions, structure and hidrology, climatic conditions and socio-economic conditions of island population. Laboratory analysis of water samples taken from the field with an emphasis on the major elements such as Ca, Na, K, etc. bicarbonate. While the studio activities include the analysis of topographic maps by using TIN (Trianguled Irregular Network) as well as a compilation of all the data obtained.Based on data from ground water level changes are correlated with conditions and intensity of rainfall that occurred on the island, then analyzed how far the influence of rainfall on unconfined groundwater potential on a coral sand layer of the Satando island, Pangkep Regency, South Sulawesi.

IV. ANALYSIS ANDDISCUSSION

4.1. Calculation ofPotentialWater Availability

Analysis of the potential availability of water in this study included two categories: availability of rain water and ground water will be studied further on the relationship of rainfall to the water potential in coral sand layer on Satando island.

4.1.1. Availability ofRainwater

Calculation of the average rainfall and the month-daily rainfall for various reliability of the water basin on the island Satando presented in Table 1

Table 1. Calculationof RainfallMeanFor VariousReliability

No	chance (%)	Monthly Rainfall Satando Island Pangkep Regency												Annual Rainfall (mm)
		Jan	Feb	March	Apr	May	June	July	Ags	Sep	Oct	Nov	Des	
1	9,09	682	481	215	116	143	78	49	5	0	0	192	582	**211.917**
2	18,18	524	488	294	109	162	73	42	4	5	8	176	230	**176.250**
3	27,27	530	242	289	122	201	151	0	2	3	37	250	1051	**239.833**
4	36,36	457	490	392	102	163	67	40	7	0	221	229	748	**243.000**
5	45,45	945	426	116	218	73	27	54	0	0	37	14	166	**173.000**
6	54,55	1183	301	156	262	406	145	172	103	290	283	347	755	**366.917**
7	63,64	854	513	538	421	284	3	0	11	16	155	371	777	**328.583**
8	72,73	561	230	188	97	172	101	46	0	42	140	270	547	**199.500**
9	81,82	947	342	394	430	206	244	127	8	0	67	247	704	**309.667**
10	90,91	943	236	379	130	106	112	62	1	0	0	99	907	**247.917**
Average		**762.60**	**374.90**	**296.10**	**200.70**	**191.60**	**100.10**	**59.20**	**14.10**	**35.60**	**94.80**	**219.50**	**646.70**	**249.658**
$R_{70\%}$		625.33	307.42	242.8	164.57	157.11	82.082	0.000	0.000	0.000	77.736	179.99	530.29	204.720
$R_{80\%}$		648.210	318.665	251.685	170.595	162.860	85.085	0.000	0.000	0.000	80.580	186.575	549.695	212.210
$R_{90\%}$		388.93	191.2	151.01	102.36	97.716	51.051	0.000	0.000	0.000	0.000	111.95	329.82	127.326

4.1.2. Groundwater Availability Tabulation of available ground water contained in the island Satando taken from the data pumping is done on 4 wells in he rainy season, the transition and the dry season duringea chnasing5x 24hours later correlate with dug wells other areas of the island so that its potential(table2)

Table 2. Availability of Groundwater

Date month	Discharge Pumping	Potensial Water of Resident Dug Wells							Number Well	Long Pumping	Stop pump	Rainfall Day	Total Day Potential
		S.01	S.02	S.03	S.04	S.05	S.06	S.07					
14-Jan	0.5 lt/s	7	7	7	7	2	2	2	19	0.62 h	0	16 mm	**54 M^3**
15-Jan	0.5 lt/s	9	9	9	9	2	2	2	19	0.62 h	0	61 mm	**62 M^3**
16-Jan	0.5 lt/s	8	8	8	8	2	2	2	19	0.62 h	0	43 mm	**58 M^3**
17-Jan	0.5 lt/s	12	12	12	12	2	2	2	19	0.62 h	0	143 mm	**74 M^3**
18-Jan	0.5 lt/s	7	7	7	7	2	2	2	19	0.62 h	0	16 mm	**54 M^3**
28-May	0.4 lt/s	5.5	5.5	5.5	5.5	1	1	1	17	0.83 h	3.0 h	4	**35 M^3**
29-May	0.4 lt/s	5.5	5.5	5.5	5.5	1	1	1	17	0.83 h	3.0 h	4	**54 M^3**
30-May	0.4 lt/s	5.5	5.5	5.5	5.5	1	1	1	17	0.83 h	3.0 h	4	**35 M^3**
31-May	0.4 lt/s	5.5	5.5	5.5	5.5	1	1	1	17	0.83 h	3.0 h	4	**35 M^3**
01-June	0.4 lt/s	5.5	5.5	5.5	5.5	1	1	1	17	0.83 h	3.0 h	4	**35 M^3**
25-Sept.	0.3 lt/s	3.5	3.5	3.5	3.5	0.5	0.5	0.5	11	0.50 h	4.0 h	0	**17.9 M^3**
26-Sept.	0.3 lt/s	3.5	3.5	3.5	3.5	0.5	0.5	0.5	11	0.50 h	4.0 h	0	**17.9 M^3**
27-Sept.	0.3 lt/s	3.5	3.5	3.5	3.5	0.5	0.5	0.5	11	0.50 h	4.0 h	0	**17.9 M^3**
28-Sept.	0.3 lt/s	3.5	3.5	3.5	3.5	0.5	0.5	0.5	11	0.50 h	4.0 h	0	**17.9 M^3**
29-Sept.	0.3 lt/s	3.5	3.5	3.5	3.5	0.5	0.5	0.5	11	0.50 h	4.0 h	0	**17.9 M^3**

4.1.3. Total PotentialWater Availability

Availability of rainwater in Table 1 above can be used if the rain becomes runoff all but partly also into the coral sand layers inflow for unconfined groundwater this island that must be corrected potential of rainwater. Based on data from wells that can be used during the rainy season 19 resident dug wells with a total potential per day is 54 metre^3, when a season of transition the number of wells that can be used only 17 resident dug wells with a total potential per day is 35 metre^3, whereas during the dry season the number of wells that can be used only 11 resident dug wells and has been unable to meet the needs of residents of the island with a total potential of only 17.9 metre^3 per day. Based on calculation capability well as a whole on the basis of daily rainfall data in 2014, the assumption discharge 54 m^3 only 30 days, discharge 35 m^3 dominant can be 172 days and discharge of 17.9 m^3 for 163 days, so the potential for water on the island Satando year only 10.557, 7 meter^3.

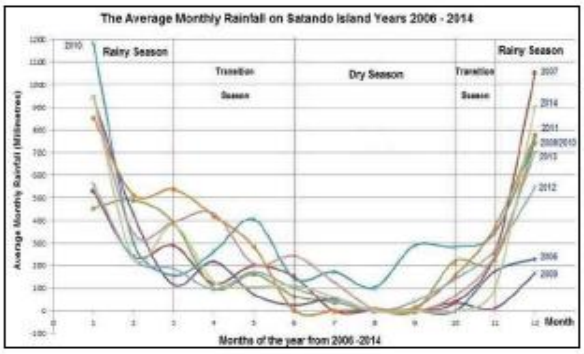

Fig. 2. The average monthly n potential water

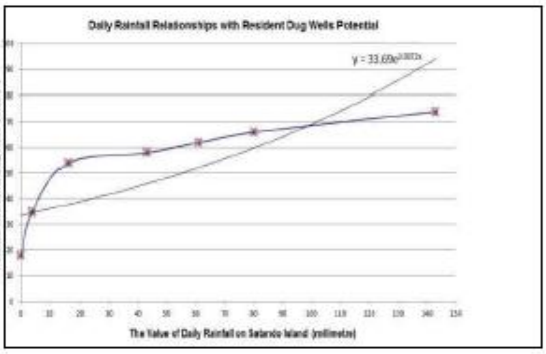

Fig. 3. Daily Rainfall Relationship potensial water

4.2. Analysis Daily Rainfall relationship with Potential Groundwater

The relationship between the intensity of rainfall with soil water potential in the coral sand layer SatandoIsland at the site in view with changes in ground water level in resident dug wells and potential are able to produce these wells in a day when the rain came down with a certain intensity. The calculation of the value of this relationship is done during the rainy season date 14 to 18 January 2014 at 4 resident dug well and 15 other wells, as a season of transition on May 28 - June 1, 2014 at 4 resident dug well and 13 other wells and drought dated September 25 to 29 2014, 4resident dug wells and 7 other wells (Fig.2). Calculation debit capabilities that can be generated by each of the wells tesebut then correlated with soil water potential in the coral sand layer containing groundwater the Satando island. During the rainy season, water availability conditions are very abundant, because in addition to a source of ground water from water wells there is also a source of water from rainwater residents of the island. As the season transitions condition of the water supply has been reduced, so that residents have been waiting for freshwater wells. At the time of the dry season, the water potential wells in total only about 17.9 meter^3 per day while it takes approximately 32.22 meter^3 per day and residents take water in inland areas Pangkep Regency.

4.3. Calculation of Water Supplies

Analysis of water demand on the Satando island only includes one category only, namely domestic water needs because the water needs of agriculture and water industry does not exist. So the main factor in the island's water usage only for the needs of clean water and sanitation. Satandoisland with a population of 2014 inhabitants is 537 so it takes about 11767.3 meter^3 per year.

4.3. Water Balance Analysis

Water balance calculations that compare the total water requirement includes only the water for domestic needs with the availability of water on the Satandoisland. In 2014, the total water needs of the domestic sector is 11767.3 meter^3 per year. Potential total water available in the soil capable Satando Island in one year only so 10557.7 meter^3 and 1209.6 meter^3 deficit. Assuming that during the dry season, the island is still the potential for ground water of about 17.9 meter^3 per day then the Residents Satando Island will be a shortage of water for 67.58 days (68 days) to be met by bringing water from the mainland Pangkep Regency. Thus, in one year Satando Island residents are very short of water more than 2 months (68 days) and the rest of the water potential in the island is still capable of meeting its needs residents.

4.4. Analysis Daily Rainfall relationship with Potential Groundwater

Based on the calculation of wells and potential generated in the wells are located on coral sand layer at Satando island shows relationship daily average that in the rainy season as many as 19 wells with the ability of 54 meter^3 per day, while at a season of transition is only 17 wells Traffic debit dig with 35 meter^3 per day. During the dry season wells that can be utilized only 11 wells with the ability to discharge 17.9 meter^3 per day. In the event of rain on the island with a certain intensity, then the potential for water at wells also increased, so the graphed curve dependence potential of water in wells in coral sand layer with the condition of the intensity of rainfall on the island Satando which generate dependency relationship potential groundwater Island Satando with the intensity of rainfall is 33.69% (Figure 3).

4.5. Effect of Water Potential Against Vegetation on Satando island

Potential 4 wells were large debits in Satando Island is at the center of the island with the surrounding vegetation conditions there are some big breadfruit tree with strong roots into the sand layer reefs and rocks on the island. One resident dug well at this location is able to generate debit 7–12 meter^3 per day when the rainy season and still be able to produce about 3,5 meter^3 flow during the dry season. While other wells are no trees vegetation tribe despite being at the center of the island and the layers of sand reefs, but also the ability debitnya less where during the rainy season only about 2-4 meter^3 and when the dry season maximum of only 0,5 meter^3 and some wells be dry or contain brackish water. Thus, there is a significant correlation between the vegetation on the island Satando breadfruit tree with soil water potential.

4.6. Water Resources management policies in the island Satando

Based on several factors and parameters above, the water management policies of land on Satando island is to control the use of water and disposal of remnants channeled into absorption wells were created in the yard. Disposal of household waste such as plastics and others that can be burnt collected and then burned, while the form of liquid oil, and other harmful,Olie in particular container, then taken to a landfill on the mainland territory Pangkep. Manufacture of toilets or latrines for human waste directly connected to the sea so it does not pollute the ground water potential in the island. Every home should create a water reservoir during the rainy season and excess rain water that spilled dipenampungan flowed into the catchment wells made in the yard so that the maximum rain water is able to seep into the sand layer reefs to increase the potential of fresh water on Satandoisland. This island residents still have to control the population so that increase the need for water in this area is still controlled by controlling the birth rate and improve the level of education of children of school age. Preserving the breadfruit tree vegetation with meremajakannya and increase the population in the side yard to plant vegetables and seasonal fruits whose roots are able to increase the ability of soil layer holds fresh water on the island.

V. CONCLUSION

The results of the water balance calculation, it can be the potential availability of water in coral sand layer Satando island is 10557,7 meter^3 year, while domestic demand of water in the year amounted to 11767.3 meter^3 so happens that the deficit needs 1.209,6 meter^{3}cause residents of the island water shortages around 68 days (2 months), which must be filled with water brought from the mainland in Pangkep Regency. Dependence potential of water in wells in a layer of sand reef with the intensity of the rainfall conditions that occurred on the Satando island amounted to 33.69% of the intensity of daily rainfall that occurred.

Effect of vegetation on soil water potential in a layer of sand on the island's reefs in particular the effect of very significant breadfruit tree roots where the potential wells that nearby there is greater than the breadfruit tree that has no vegetation. Policy management of ground water on the island Satando is to control the use of water and disposal of remnants channeled into absorption wells were created in the yard of the house, arranging the disposal of household waste and toilet and each house makes rainwater and excess rain water flowed into the wells infiltration. Besides, the islanders still have to control the population by controlling the birth rate and improve the level of education of children of school age and also preserve breadfruit tree vegetation with meremajakannya and increase the population in the side yard to plant vegetables and other seasonal fruits.

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