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The water balance of Tunggaoen Boa water catchment area, Rote Island, East Nusa Tenggara

Paul G. Tamelan[1], Zaenal Kusuma[2], Mochamad Bisri[3], Luchman Hakim[4]
[1]*Civil Techniques Education Department, FKIP University of Nusa Cendana and Graduate Program in Environmental Science, Brawijaya University, Malang, Indonesia*
[2]*Soil Department, Faculty of Agriculture, Brawijaya University, Malang, East Java,*
[3]*Water Engineering Department, Faculty of Engineering, Brawijaya University, Malang, East Java*
[4]*Biology Department, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang, East Java*

Abstract: *The aim of the research is to determine the water balance of Tunggaoen Boa water catchment area in Rote Island, East Nusa Tenggara. The rain falls as an important factor in water balance to supply water for domestic consumptions and farm-agricultural sectors were calculated and recommendations to develop proper water management and conservation to countermeasure water scarcity were proposed. Field survey was done in Tunggaoen Boa water catchment area. Field survey was done to generate data related to population distribution, livestock, and agricultural lands inside the modeled water catchment area. These data was calculated and analyzed to identify the standard of minimum water requirement. The mathematical model was performed to identify waterfall input, output and storages. Geographical Information System was employ to map modeled water catchment area, describes land uses, and calculate volume of water input. Research shows that input water was calculated about 25,593,278 m^3/year, higher than total water needs of domestic water requirements, livestock and agriculture (totally c.a. 12,304,940 m^3/year). The water deposit as a water storage was calculated about 13,288,338 m^3/year. Climatic condition, however, influence the water availability. In study area, climatic condition was recorded not stable, rain water fluctuate, and spatially unbalanced. In rainy season, there is often 1-2 weeks without rain during 3-4 rainy months. Dry season occurs very long, about 8-9 months and cause water scarcity in dry season. Solution to countermeasure of water scarcity is promoting proper water management, developing infrastructure such as small reservoir surface (locally called embung) to collect and store water, and infiltration wells.*
Keywords: *rain water harvesting, water conservation, semi arid regions, infiltration wells About five key*

I. Introduction

Water resources are important for all area in the globe. It is especially important in semi arid to arid environment where water often limited. Water has been identified as an important factor in living systems. Water supports numerous metabolism function of living creature. In agricultural sectors, water is crucial resources for cultivation crop yield productivity. Scholars point out that agricultural and crops productivity are determined by water availability. Therefore, it is important among governments to manage water resources to enhance agricultural and crops productivity [1] [2] [3].

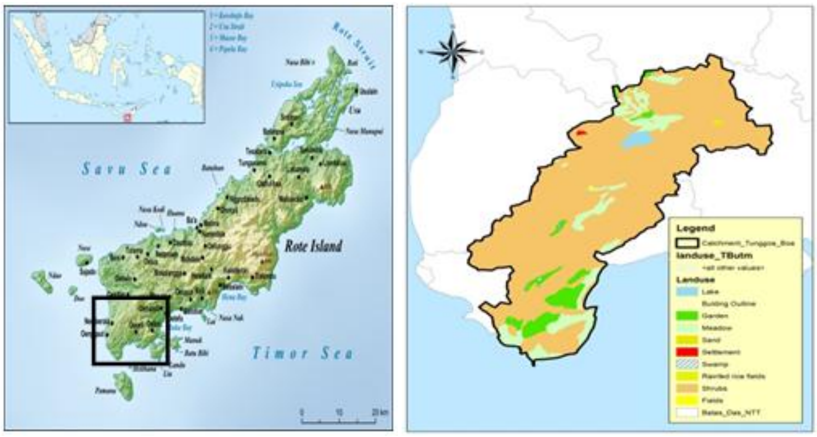
Rain fall is an important aspect to determine the water availability. It is also important to support the sustainability of living creature and community live in an area. Impact of global warming recently has been identified contribute to the pattern of rainfalls. In the wet season, there are numerous flooding was reported. Water scarcity was reported widely during dry seasons. Scholars point out that global climate changes lead to the numerous impact such as changes of rain pattern, increase of temperature and increase of sea water levels [4] [5] [6] [7].

The climates changes which are potentially lead to water scarcity has been empirically identified in Tunggaoen Boa, West Rote sub-regency. This area located at the south tips of Rote Island, the southern island on Indonesia archipelago, with semi arid climate. Water has been identified crucial for agriculture, but the amount of water was limited. These conditions lead to the low productivity of agricultural productions. There are rainfalls in some seasons, but waters poor managed properly. There are lack of water resources management and approach. This situation seems common in East Nusa Tenggara [8] [9]. The aims of the research is to determine the water balance of Tunggaoen Boa water catchment area in Rote Islands, East Nusa Tenggara. The rain fall as important factor in water balance to supply water for domestic consumptions and farm-agricultural sectors were calculated and recommendations to develop proper water management and conservation to countermeasure water scarcity were proposed.

II. Methodology

Study area

Field survey was conducted at Rote Island in East Lesser Sunda (Nusa Tenggara Timur Province). Rote Island has similar climates with other island in Lesser Sunda. It is characterized by limited number of rain month. The number of rainfall season occurs along 3-4 months while the dry season occurs at 8-9 months. Within rainy season there are often strong winds and storm. Wind velocity was calculated about 14 knot/hour with the averages of air pressure about 966.7 millibar and rain fall was about 800-1200 mm. The air temperature was about 23.6 – 27ºC. Within the last three year air temperature was increase with minimum temperature was recorded about 17.0º C and maximum was about 33.7º C. The area of Rote Ndao regency was classified as semi-arid regions which are influenced by monsoon. Rainy season was short, occurs between December to March with air humidity was about 85% [8] [9] [10] [11]. Field survey was done from January to December 2015 in water catchment area of Tunggaoen Boa with area about 2,559.32 Ha. Administratively, it is located at West Rote sub-regency. This area was famous for nature—based tourism attractions in Rote Ndao Regency (Fig.1).



Rote Island Tunggaoen Boa Cacthment Area

Fig. The geographic position of Rote Ndao and the land use types on Tunggaoen Boa water catchment area in Rote Ndao.

Methods

The study area and the border were mapped using Geographic Information System (GIS) techniques. Through this approach, the land use and habitat types of water catchment were mapped and identified. The climates data of the study area was generated from local meteorological office (BMG, *Badan Metereologi dan Geofisika*) [11]. The Rote Ndao climates data during 2005 to 2014 were collected and evaluated. The daily rainfall was analyzed to identify the level of monthly rainfall. From the calculation, there are data related to both monthly and yearly water input. The next step was water output calculation to identify water storage of the water catchment area. The water output calculation was done by calculating water loss, involving infiltration, run off and evapotranspiration. The next step was the water balance calculation to identify storage. Water balance was calculated using formula: Storage = input – output. The water storage data was compared to the domestic and agricultural water needs. When value of storage minus, the water management was describes to countermeasure water scarcity.

Data analysis

Water balance was analyzed to get input, output and storage volume of water to provides water for domestic, farm and agricultural purposes. Data analysis was based on mathematical equations to determines (1) the water balance, (2) domestic fresh water requirement, (3) number of water requirement for plant and vegetations, and (4) number livestock.

Area water balance calculations

The equation to calculate area water balance was done following Clarke (1973) [12], as:

$I = O + \Delta S$, --------------- (1)

In which, I = water inflow in systems, precipitation (rain fall), underground-sub subterranean water, irrigation and other resources with equations I = (V = d A), in which V= inflow water, d = rainfall, A= catchment area size. In this calculation, O = outflow water, includes evapotranspiration, run off and underground-sub subterranean water, evapotranspiration, ΔS = changes of water storage, includes surface water storage and sub subterranean water such as lake, dam, underground water and soil moisture [13].

Domestic fresh water requirement

The domestic water requirements were calculated following Indonesian National Standard Methods SNI [14], in which it is generated by calculation of recent population and increasing number of population in the future within ten years based on the percentages of population rate increase in study area. It is calculated using formula:

$Pn = Po\ (1+ r\ )^{n}$,----------------- (2)

In which, Pn = projection of pollution increase in year n, Po = number of recent population, r = rate of population growth, and n = number of year projection. Result of calculation was used for assessment of domestic water requirement, in which the minimum amount was stated 100 l/individual/days [14]. These multiply with number of community to generate minimum water requirement.

Number of water requirement for plant and vegetations

Calculation was based on types of soil and land uses area of water catchment. In order to identify the minimum water requirement for plant and vegetation, the size area of vegetation was multiplied by water need of each crops types.

Number of water requirement for livestock

The calculation of water requirement for livestock was given by Indonesian National Standard [14] as shown in Table 1:

Table 1. Water requirement for livestock

Types of livestock	Water requirement (liter/ head/days)
Cow/buffalo/horse	40
Goat	5
Pigs	6
Poultry	0.6

Sources: Technical Report National Water Resources Policy 1992 in SNI, 2002 [14].

The water requirement calculation for livestock was calculated as follow [14]:

Q(L) = 365x[q(c/b)xP(c/b +q(s/g)xP(s/g)+q(pi)xP(pi)+q(po)xP(po)] ---- (3)

In which: Q(L) = water requirement for livestock (m^3/years), q(c/b) = cow/buffalo (l/ head /day), q(s/g) = goat (l/ head /day), q(pi) = pigs (l/head /day), q(po) = poultry (l/head /day), P(c/b) = cow/buffalo, P(s/g) = goat, P(pi) = pigs, P(po) = Poultry. The total of water requirement (m^3/year) was calculated using livestock growth in the future ten years.

Amount of additional water storage

Methods for additional water storage or risk potential lose was done by extracting 20% of total available water. It is especially important to maintain water quality and water infrastructure stability. The calculation of additional water storage amount was calculated as Aws = 0,20 output, in which Aws = Amount of additional water storage (m^3).

III. Result and Discussion

The Tunggaoen Boa catchment area.

The Tunggaoen Boa water catchment area located at the west part of Rote Ndao regency. In the perspective of climates, this area located at dry area with semi arid environment. The area was influenced by strong monsoon with wind velocity of 14 knot/hours. The averages of air pressure about 966.7 millibar. Rainy season in this region relatively short, started from December to March with averages of rainfall about 500-1000 mm. The data of climatic situation within past ten years in Rote Ndao Regency was about 1,557.83 mm/year, with monthly rainfall of 129.81 mm, number of rain days 97.2 with duration calculated about 40 minutes. In the past ten years, the maximum rainfall was recorded about 139.1 mm at January 24, 2008. Temperature was ranging from 23.6 ºC to 27 ºC. Within the past three years, air temperatures continuously increase with minimum temperature was 17 ºC and maximum temperature was 33.7 ºC. This climates situation was similar with climates description by climates office records and as reported by scholars [9] [10] [11].

The rainfall of Tunggaoen Boa catchment area in west Rote was given in Table 2.

Table 2. Rain fall records in Rote Ndao area at 2005-2014.

Year	Yearly rain fall (mm)	Averages (monthly) (mm)	Max. Rain fall (mm)
2005	1026.6	85.55	85.1
2006	1524.5	127.04	116.3
2007	1369.2	114.10	77.9
2008	1921.7	160.14	139.1
2009	1239.3	103.28	90.8
2010	1820.1	151.68	87.1
2011	2167.5	180.63	74.0
2012	1402.7	116.89	101.2
2013	1849.2	154.10	106.0
2014	1257.5	104.79	65.6
Averages	1557.83	129.82	R max = 139.1

Sources : BMG Kabupaten Rote Ndao, 2015 [11].

Based on the national data related to the climates situation (Table 2), the averages of rain fall in study area within past ten years was calculated about 1557.83 mm/years. It can be classified as moderates. The highest rainfall was occurs in 2011 (2,167.5 mm), while the lower rainfall was occurs in 2009 (1,239.3 mm/year). These data shows that profiles of rain fall in study area was fluctuate and occurs uneven yearly. The average of monthly rainfall were about 129.82 mm/month. It was classified as moderates [15].

The maximum daily rainfall was found at January 4th, 2008. In which it is recorded about 139.1 mm. This data was used as to calculate surface run off for management safety and stability of water infrastructure. East Java, Bali, and Nusa Tenggara can be classified as dry area because such regions have water deficit more than six months [16]. Sumatera, Kalimantan, and Papua can be considered as wet regions with water surplus, in which rainy season occurs mostly beyond 5 months yearly. Within last 100 years, however, there increase average temperature about 0.72-3.92°C. This was followed by decrease of precipitation about 2-3%. In the southern Indonesia, it was reported changes of rainy season patterns. In many cases, the intensity of rain fall increases by 10% and decrease about 75% in dry season [17].

Therefore, the information management system related to rainfall was needed, especially in the decision making aspect in sustainable development. The development of information system related to the ground water availability based on computer system was important to provide rapid and accurate information [18**]**. Plant productivity is the main component in the model development related to the relationship between vegetation and climates. Using geographic information system as a tool of evaluation, it is clear that air temperature and pressure contribute significantly in changing of secondary crops, while rainfall and global radiation are important factors in vegetation and its seasonality [18] [19].

Based on the analysis, the number of rainfall Tunggaoen Boa catchment area was lower than available data from Rote Ndao climate office. According to national map of climate conditions, the rain fall of west Rote about 1.000-1.500 mm/years. This situation was supported by information gathered from local community, in which rain usually lower than other area.

Water Input

The yearly total input of water in Tunggaoen Boa catchment area was shown in Table 3.

Table 3. Monthly rainfall and rainfall water input in Tunggaoen Boa catchment area in West Rote sub regency.

Months	Monthly average rainfall	Number of rainy days	Input volume (BMG data)	Input volume in study area*
January	335.79	19.1	8,593,967	5,516,467
February	292.7	16.5	7,491,152	4,808,570
March	274.45	16.3	7,024,075	4,508,754
April	115.92	10.3	2,966,773	1,904,372
May	58.14	4.8	1,487,993	955,143
June	31.19	2.6	798,254	512,399
July	7.76	1.3	198,604	127,484
August	6.73	0.8	172,243	110,563
September	12.06	1	308,655	198,126
October	22.03	1.8	563,820	361,916
November	67.14	4.7	1,718,333	1,102,998
December	333.92	18	8,546,107	5,485,746
Total	1557.83	97.2	39,869,976	25,593,278

Sources : Data from BMG and analysis. *the real input in field was estimated about 64.19 % of BMG data

Based on the data, number of normal rain month with rainfall > 100 mm/month was about 4-5 months, from December, January, March and April. Based on the official climatic data in Rote Ndao 2015, it was recorded that rainfall in April was fluctuate yearly. In 2009, the rainfall in April was recorded 18.5 mm while in 2011 it was recorded about 316.8 mm. This phenomena basically related to the regional climates and wind flow in Pacific oceans. The highest rainfall was recorded at four month continuously, from December to March. It was recorded about 333.92mm, 335.79mm, 292.7 and 274.45mm respectively. The distribution, however, uneven and there are often without rain days along 1-2 weeks. During May to December, the rainfall water was were less than 100 mm/month. There often no rainfall between June to October. According to meteorological data, there are no rainfall from June-October. The average duration rain was about 40 minutes and number of rain days was about 97.2 days a years. The rainfall duration and days was less compared to the Kupang city. This situation influence water deficit, especially when input water was limited and consumption and output is high. In Merauke, water deficit period occurs 4 to 7 months yearly, in which is often common in Kuprik sub Regency (deficit water occurs in 7 months), and short water deficit (4 months) found in sub district Jagebob, Kimaan and Muting [20]. In order to sustain the water supply in such area, the technology of water resources management was needed. Rainfall water harvesting technology has been reported important to promote in area with dry season more than four months, in which the rainfall often recorded less than 100 mm per month. These techniques can be done by collecting and storing water during periods of wet month, and distributed properly [21].

The water input of Tunggaoen Boa water catchment area (an area about 2,559.32 Ha) mainly comes from rainfall water, with totally input calculated about 39,869,976 m^3/year. Actually, the water input was only 25,593,278 m^3/year, or equal to 64.19% of the released data from BMG of Rote Ndao Regency. Based on the ATLAS map of rainfall, the average of rainfall in water catchment area was about 1.000 mm/year, lower than data recorded from climate station (1,557.83 mm/years). The highest monthly rainfall occurs in January, calculated about 5,516,467 m^3, and the lowest input was found in August (110,563 m^3). The amount of rainfall in particular area is the potential water for local community. The size of area therefore important factor to define the water stock [22].

The output water resources

Domestic requirement

The minimal water requirement for domestic aspect was estimated below (Table 4).

Table 4. Number of population and water requirement in Tunggaoen Boa water catchment area.

No	Sex	Sedeoen	Nemberala	Oenggaut	Boa	Number in 2015	Estimated number in 2025	Water requirement l/day
1	Male	36	108	0	400	544	647	64,700
2	Female	42	120	0	424	586	697	69,700
Total		78	228	0	824	1130	1,344	134,400

Sources: Village monograph of West Rote sub regency(2015) [23].

Not all communities in four villages leave in water catchment area, but many of them do farming activities in water catchment area. Based on the calculation of population projection growth by 0.29% within 10 years, it is estimated that in 2025 the number of population will be 1,344 people. The need of water was estimated about 134,400 liter/day or 49.056 m^3/year, in which it was withdrawal from wells. In dry season, however, these water intruded by sea water an lead water become brackish. Scholar point out that fresh water from shallow wells was limited, and in dry season there are salt water intrusion to the wells [24].

In study area, water resources from caves spring with debit of 3 liter/second is especially important and sufficient to support basic population domestic needs, but there are no proper management for the spring. The location of spring is far from local settlements and there are no infrastructure that allow water flows to the settlement area. Water usually collected in truck water collection and transferred to the local community. In remotes area, this phenomenon was reported common and becomes significant limitation for community development and prosperity. There are often absent of water resources management when water surplus in wet months. Therefore, there are needs proper water management by involving community participation [25].

In order to manage the abundance water resources in rainy season, it is important to perform several basic strategies including 1) developing infrastructure to collect water and its distribution, 2) establishing authority to manage fresh water by involving community participation, and 3) establishing infiltration wells. Scholars point out that that rainwater harvesting is one of the efficient approach to provides water in arid environments with limited water. It is especially important because water is the basic resources for human life [26].

Water for agricultural

The calculation of water requirement for agriculture purposes was calculated and shown in Table 5.

Table 5. The calculation of water requirements in each land uses types.

No	Land uses types	Area (Ha)	Water requirement volume (m^3/year)
1	Gardens and plantations	163	1,222,500
2	Settlement with coconut threes	209	3,553,000
3	Rainfed Lowland Rice	2.3286	18,628.8
4	Shrubs with Lontar palm	102	1,734,000
5	Dry fields	486,672	3,650,040
	Total		10,178,168.8

Sources : Village monograph of West Rote sub regency (2015) [23].

Based in the Table 5, the water needed by plants was about 10,178,168.8 m^3/year. The calculation of water for agricultural system was important because agriculture cannot be separated from human life. Agricultural productivity supports human life, and therefore the avaibility of food is important. From Table 5, there are about 1,222,500 m^3/year needed for 163 ha agricultural technical irrigation. Based on the data from Rote Ndao climatology station, the available of water from rainfall during December to March was calculated about 1.236.86 mm, However, in fact there is 794 mm water available (64.19% of the estimated water area). This means, the available of water was sufficient to support agricultural farming (750 mm). In the study site, however, there often water scarcity which area contributes to the less of seedling and young crops individual survival. It is often related to the absent of rainfall 1-2 weeks. Scholars point out that agricultural production in arid and semi arid environment often depend on the water and rainfall [27]. These pressure able to modify ground water level and its temporal pattern. These situation are threats to important natural environmental service such as irrigation for agricultural lands, especially in dry season.

There are needs of strategic solution to countermeasure water scarcity in Tunggaoen boa water catchment area. It is especially important to ensure sustainability of agricultural and farming system. Technically, there are needs of small reservoir surface (locally called *embung*) development to collect water in rainy seasons and distribute in dry season to agricultural area. The significance of small reservoir surface (*embung*) has been reported by scholars. Study found that the absent of small reservoir surface (*embung*) lead to the water deficit in August to November in Kendal Regency (Central Java). The water deficit was calculated about 108,493.75 m^3 [28]. The existence of small reservoir surface (*embung*) able to reduce water scarcity to irrigate 750 ha agricultural land due to the ability of small reservoir surface (*embung*) to water support water about 126.073,688 m^3. The calculation of evapotranspiration was given in Table 6.

Table 6. The total volume of evapotranspiration of Tunggaoen Boa water catchment area.

No	Land uses types	Area size (Ha)	Total of evapotranspiration (m^3/year)
1	Lakes	24.13	15.04
3	Gardens	116.24	126.76
4	Grasslands	350.03	436.23
5	Sands	6.05	3.77
6	Settlement /coconut trees	2.12	2.64
7	Peat	1.35	0.84
8	Rainfed Lowland Rice	2.33	3.63
9	Shrubs with lontar palm	2,055.72	2,722.10
10	Dry fields	1.35	1.47
Area size = 2,559 Ha, Rainfall 1,557.83 mm/year			3,312.48

Based on the table 6, the highest evapotranspiration found at shrubs with lontar palm category (2,722.10 m^3/year) with total area about 2,055.72 Ha. The calculation shows that total input of water in catchment area from rainfall was about 25.593.278 m^3/year. Loss of water due to the evapotranspiration was about 3,312.48 m^3/year or equal to 0.012%. This can be said that evapotranspiration has less contribution to water loss in Tunggaoen Boa water catchment area.

While loss of water due to evapotranspiration low, it is still contribute significantly in water availability. A study conducted at Merauke confirms that water deficit can be influenced by evapotranspiration [20]. The high level of evapotranspiration leads to the decrease of ground water. It is caused by few amount of ground water to support potential water amount. Lack of soil humidity in agricultural farm leads to the decrease of crop productivity. Low humidity has related to the low water availability in soils [2]. It is especially caused by long dry periods, degradation of hydrological systems and potential evapotranspiration. In order to maintain soil humidity, the water infiltration process was important. Land with vegetation able to absorb more water and therefore good for water conservation [29] [30]. In the study area, therefore, it is important to perform revegetation programs with the objective area improving vegetated area and vegetation quality. It is especially important to improve water conservation in study area.

Water requirement for livestock

The water needs to meets livestock enterprises was given in Table 7:

Table 7. The calculation of water requirement for livestock enterprises in study area.

Livestock	Number	Requirement (l/ind./day)	Water requirement (l/year)
Cow	905	40	13,213,000
Buffalo	17	40	248,200
Horse	66	40	963,600
Goat	1,521	5	2,775,825
Sheep	0	5	0
Pigs	994	6	2,176,860
Chicken	1,202	0.6	263,238
Duck	41	0.6	8,979
Total			19,649,702

Based on the Table 7, it is clear that water requirement for live stock was about 19,649,702 l/year, or equal to = 19.650 m^3/year. Within the next ten years, the prediction of water requirement using estimation 2% of livestock growth was about 23.580 m^3/year. Recently, water for live stock consumption was supplied from wells which are located far from the farm or grazing area in forest. In Rote Island, distance of local people settlement and location of livestock was far, and it is impossible to transport water to feeding ground locations. In order to increase livestock productivity, the development of water resources infrastructure was important.

Based on the calculation, the need of water for domestic consumption, livestock and agriculture in Tunggaoen Boa water catchment area was about 10,254,117.28 m^3/year. In order to provide significant water for such aspect, the development of water infrastructure was important. There are need water resources management to enhance the environmental sustainability and ensure the sustainable water support for the future [31].

The calculation of safety water

The safety water was important to conserve water quality and water infrastructure stability. In such calculation about 20% of total water requirement (2,050,823 m^3/year) includes in the calculation. In order to enhance the water infrastructure construction and condensation, the safety water allocation was important. The condensation potentially occurs due to temperature and other physical impact. Scholars point out that early design for water balance should allocate 20% of water from total water [32].

The water balance of watershed area

Based on the calculation, the water availability was higher that water needs, the storage was calculated about 13,288,338 m^3/year. The possibility use such storage for other activities which area needs water. The unequal distribution of rainfall, however, influence the number of water availability, in which water deficit in some months. These cause water scarcity in study area. Therefore, there are need water management scenarios in these area. Scholar point out that area with scare water and number of rainy month limited, it is indicated by rainfall less than 100 mm per month, need rain water harvesting technology [21]. It is especially important to collect and store rain water for further agricultural and domestic needs. In the situation where water is limited the water storage could be significant sources for human life in its agricultural activity in semi arid environment.

Water problems in some area occur due to the water deficit. This is found in Deli watershed in North Sumatera, in which number of water requirement has higher than water supply. Totally, the needs of water requirement for agriculture, domestic consumption, livestock and industry are calculated about 63,305,774.05 m^3/year. The related impact of such problems was numerous, including increase of environmental problems. This situation contributes to the carbon cycle, nutrition and vegetation. There is a need-technological approach, including establishing dam, irrigation and river water flow management [33].

Effort to countermeasure water scarcity.

Proper water management in Tunggaoen Boa water catchment area based on the local condition as was is needed to solve water scarcity in semi arid environment, especially in dry season when rainfall limited and water was rare. According to the calculation, the water resources in Tunggaoen Boa water catchment area for the next ten years are able to support domestic consumption, livestock and agricultural needs. However, without proper management it is impossible to optimize water resources in semi arid environments. In agricultural aspect, it is important to promote various planting patterns from December to April. Livestock should be manage properly, and intensive system of livestock need to be promoted. It is especially important when centralization of water resources for livestock was applied. The local community need the water with standard quality, volume and its distribution. WWF, state that one of the ten family household has fresh water problems, especially in arid environments [17]. Therefore, optimizing quantity, quality and sustainability of freshwater is important. It is especially become the responsibility off all communityies and stakeholders.

Based on the available input water volume and uneven rainwater distribution during one month, infrastructure technology to collect and store water resources is needed. It is especially important to enhance water safety, especially in long dry periods. Rain water harvesting can be done during December to March. In such a case, developing water recourses infrastructure such as *embung* is important. Rainwater harvesting is an efficient approach to provides sustainable water resources.

IV. Conclusion and Recommendation

Conclusion:

1. The climates of Tunggaoen Boa watershed in West Rote sub Regency was semi arid. Based on the water balance calculation, the amount of water enough to support water availability for four month, with averages water amount about 309.21mm monthly. In some month, the intensity of rainfall was high but the rain duration was short. The dry season was long, 8 months and it contributes to the water scarcity to support human daily life, agriculture and livestock. Based on the water balance calculation, the available water was higher than water needs and there are still storage water recorded about 13.289.214 m^3/year. In fact, however, there are water scarcities in study area. It occurs due to lack of proper management of water and poor of supporting water infrastructure.
2. The proper solution is promoting proper water management through rain water harvesting, especially in rainy season. There are also important to build infrastructure related to water management, such as water hole, *embung* and infiltration.

Recommendations:

1. It is crucial for goverment to provide infrastructure for rainfall water management, including dams and irrigation to increase water resources use efficiency.
2. Community empowerment is needed, especially in agricultural practices. The undemanding of cropping pattern based on the physical characteristics is important to increase crop productivity.

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