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Study of Water Management on Rainfed Land in Downstream of *Renggung* Watershed

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Abstract: *Downstream area of Renggung Watershed is a water conservative zone which is also dominated by rainfed land with vertisol soil clay fraction dominated. Watershed downstream reaches 40% and 30% from the total area of Renggung Watershed. Rainfed farming is part of dry land farming, but the presence of rainfed land in downstream of Renggung watershed does not receive intensification treatment as water becomes a limiting factor of plant growth. About 87-90% rainfall events in downstream of Renggung watershed are happened during the rainy season from November to April with 3-4 wet months, while about 10-13% happen during the dry season from May to October. It means that water is abundant in wet months, but there is a shortage of water during the dry period. Based on zone group, 72% of potential water from rainfall occurs in downstream zone, 18.3% occurs in middle zone, and 10.4% is in upstream zone. If the number of ¾ potential water of rainfall occurred in downstream So water management on rainfed land in downstream of Renggung watershed is still not optimum which is caused by (a) dependence on supply of water downstream from HLD BR, but discharge declines in last 6 months; (b) poorly water management at farming level, because plants are not cultivated in right season; and (c) poorly institutional of management and water user group, so forum to facilitate and mediate issue in terms of management and use of irrigation water is not optimal.*

Keywords: *Rainfed, Renggung watershed, water management*

I. Introduction

Some of the area, like on rain-fed lands in the province of West-Nusa Tenggara (NTB), Indonesia, particularly at Lombok Island still rely on rainwater for agricultural/farming cultivation. The productivity of rainfed land depends on the existence of rainwater as agricultural inputs. The Rainfed land has a potential to replace irrigated-technical area which is converted its land use in last few decades with the growth in population and economy. If water management for irrigation in this area is conducted optimally, so this potential can be developed to support local and national food security.Central Lombok is regency which has the largest rainfed among other regencies/cities in Lombok Island. Central Lombok Regency has 13.642 ha rainfed area; West Lombok reaches 3.328 ha; East Lombok reaches 1.724 ha; and North Lombok reaches 211 ha (BPS, 2014). About 80% agricultural area in downstream of *Renggung* Watershed use crop rotation technique. It is planted by paddy in the rainy season then replaced by *palawija* (soybeans and green beans) as a second crop in a dry season. The soil in downstream of *Renggung* watershed has a high content of clay (40 – 70%) (Idris et al., 2014). This soil is vertisols with the decisive shrink-swell potential characteristic. It is relatively difficult to cultivate because it is high plasticity soil in wet conditions but very hard in dry condition. Nevertheless, this soil is naturally suitable for farming because it has the ability to store water in large quantities for a long time even low annual rainfall ranges from 1200 mm/year.Cultivation of crops, *palawija* and some types of horticulture (tomatoes, peppers, watermelon, etc.) for the farming communities in central Lombok is an inseparable culture from agricultural activity. Lack of water availability is the main problem in some subdistricts in downstream of *Renggung* watershed. It is caused by main irrigation water supply is from rainfall which is relatively short and often erratic *(erratic rainfall)*. It will cause decreasing of plant productivity and failure crops. In other words, the level of land productivity is controlled by water supply from *Renggung* watershed especially during dry season. Based on previous research, several problems in the rainfed area of downstream of *Renggung* watershed was identified and one of them is terms problem of water resources (Markum et al., 2014). Water management aspect has an important role determining plant productivity, so the study of water management on rainfed area in downstream of *Renggung* watershed is important to be studied.

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II. Materials And Methods

A method in this study was a descriptive study by using quantitative and qualitative approach (Nazir, 2005). The quantitative descriptive research was to determine needs of irrigation water on the rainfed area in downstream of *Renggung* watershed. Whereas qualitative description was to describe implemented management in *Renggung* watershed.

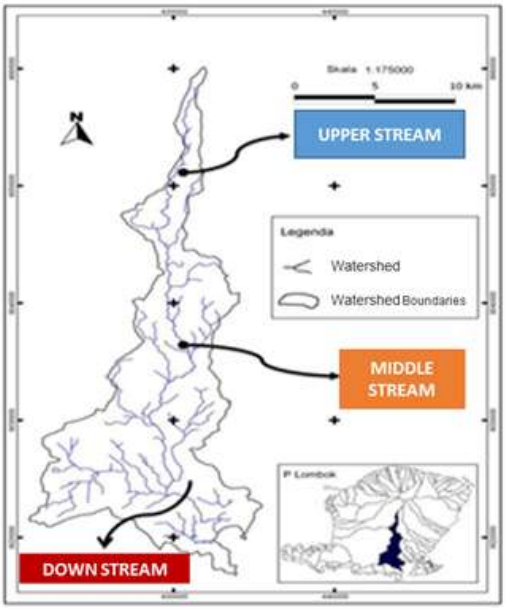


Figure 1. Location of research observation in

Renggung Watershed Location of research was in upstream (*Aik Bual* Village, *Kopang* Subdistrict), middle-stream (*Selebung* Village, *Janapria* Subdistrict), and downstream (*Sukaraja* Village, *Praya Timur* Subdistrict) of *Renggung* watershed that was administratively located in Central Lombok Regency (Figure 1). Data (width, use, and productivity of land area) will be analyzed descriptively to get description about the study of management on rainfed, and semi irrigation land in downstream of *Renggung* watershed.

III. Results And Discussion

3.1 General description of *Renggung* watershed downstream

The geographical position of *Renggung* watershed was in 8°38'4"SL and 116°21'31" EL and about 95.7% is located in Central Lombok, while about 4.3% is in East Lombok. The width of *Renggung* watershed is about 215.99 km^2. Downstream of *Renggung* watershed area belongs to 29 villages in six subdistricts (Table 1).

Table 1. Total area in downstream of *Renggung* Watershed

Administrative area (Regency/Subdistrict)	**Σ Villages**	**Area**	
		Ha	**% Watershed Area**
Central Lombok			
- Central Praya Subdistrict	5	1567.11	7.3
- East Praya Subdistrict	9	5182.41	24
- Pujut Subdistrict	11	7226.01	33.5
Total of Central Lombok	25	13975.53	64.8
East Lombok			
- Montong Gading Subdistrict	1	48.97	0.2
- Terara Subdistrict	2	396.20	1.8
- Jerowaru Subdistrict	1	478.60	2.2
Total of East Lombok	4	923.77	4.3
Total of downstream of Renggung Watershed	**29**	**14889.30**	**69.1**

Source: International of Fauna & Flora 2012 (Data processed; area is village/subdistrict in *Renggung* Watershed)

Table 1 explains that about 64.8% downstream area of *Renggung* watershed is located in Central Lombok regency, while about 4.3% is in East Lombok Regency. So this study is focused in Central Lombok regency, especially in the Praya Timur, Central Praya and Pujut Sub-District (Table 1). Upstream of *Renggung* Watershed is water productive zone but downstream is water conservative zone. Downstream of *Renggung* watershed is the center of rainfed agricultural and upland/moor. In this region, rainfall is relatively low, so there are many water reservoir buildings for water management in downstream of *Renggung* watershed.

3.2 Physical condition and climate of rainfed land in downstream of *Renggung* watershed

3.2.1 Physical condition of rainfed land

Rainfed zone in downstream of *Renggung* watershed is dominated by vertisol soil type (Figure 2). Soil profile shows that vertisol soil type has a high content of clay, so it is difficult in processing (Figure 3).

Physically vertisol soil is dark gray colored and clay textured (clay; heavy texture) with a relatively deep solum (> 1 m). This soil is composed of *montmorillonite* clay mineral. It causes that shrink/swell potential of soil depends on moisture condition. It is very sticky and slippery in wet condition (rainy season), but it is very cracked in dry (dry season). Soil texture is classified as high clay with level of clay fraction is greater than 50%, so it has high ability to store water (water holding capacity) (Idris et al.,2012)

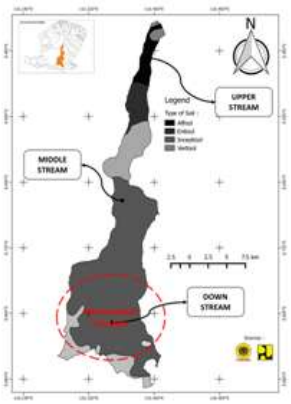


Figure 2. Map of Renggung Watershed Renggung Watershed

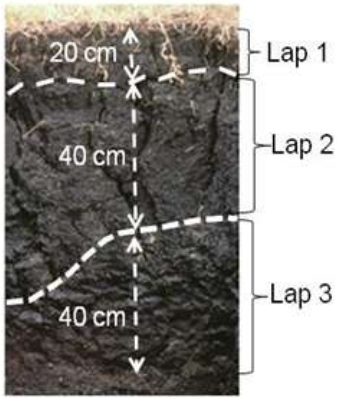


Figure 3. Soil profile in downstream of soil type

Vertisol soil has high pH, cation exchange capacity (CEC), and alkali saturation. Nevertheless, organic matter content of vertisol soil is generally low because of lack of organic materials recovering. Soil fertility is classified to moderate with high content of potassium (K) but nitrogen (N) and phosfor (P) content are generally low to moderate (Ma'shum, 2005).

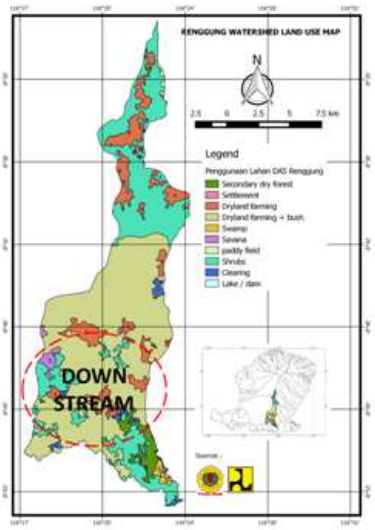


Figure 4. Renggung watershed land use map

Figure 4 shows that land use in *Renggung* watershed largely is dryland agriculture and paddy fields; and about 30-40% located in the downstream of the watershed. Dryland farming consists of rainfed land, moor, and gardens. The presence of rainfed land in downstream of *Renggung* Watershed barely get intensification treatment because intensive agricultural management will show its effect when water does not become a limiting factor of plant growth. Meanwhile, secondary dry forest and forest plantations in upstream of watersheds only cover 1.7% of the total watershed area (Idris et al., 2012).

3.2.2 Climate condition of rainfed land

Based on Oldeman Climate Classification, downstream of *Renggung* watershed has D3 till D4 climate type (Figure 5) with 4-6 dry months (rainfall <100 mm per month) and 3-4 wet months (Oldeman et al., 1980). Annual rainfall in the rainfed area in downstream of *Renggung* Watershed is ranged from 1200 mm/year .

Figure 5. Lombok Island climate classification

Water scarcity greatly inhibits process of agricultural production, especially in a dry land with dry climates. Rain is the main source of water for plants in most parts of Indonesia. Approximately 1% of 183 million hectares land in Indonesia has annual rainfall > 1.000 mm. In arid and semi-arid areas, rainfall >1.000 mm can support agriculture with the implementation of water-saving technology. Rainfall of 1,000 mm/year will be able to support production process of seasonal crops for two seasons with the assumption that water needs for seasonal crops on dryland is 120 mm/month (Oldeman et al., 1980).

About 87-90% and 10-13% potential water from precipitation in dry land areas will occur in the rainy season (November-April) and in the dry season. It means that availability of water is abundant in wet months, but it will decrease in dry months. In the upstream zone, 78% and 22% rainfall occur in wet months and dry months. In middle zone, about 84-87% and 13-16% rainfall occur in wet months and dry months.

3.3 The condition of water resources in downstream of *Renggung* watershed

South side of Rinjani mountain is upstream of *Renggung* Watershed which is a supplier of agricultural irrigation water in downstream, wherein water supply is also added from High-Level Diversion (HLD) *Babak Renggung* (BRG). In addition, *Renggung* watershed also gets water supply from suppletion of *Gule Liat* (Figure 6). About 48.7% of 53.4 million m^3 water of *Renggung* river comes from upstream and middle stream catchment area along the river until *Ponggong* (observation point), 39.4% from HLD-*Babak Renggung*, and 11.8% from *Gile Liat* (Figure 6) (*Pusat Penelitian Sumber Daya Air dan Agroklimat*, 2014). Water in downstream of *Renggung* watershed is overused. It can be said that level of water usage in *Renggung* watershed is very high and this makes dependence on suppletion water source from other watersheds such as suppletion of HLD *Babak-Renggung*.

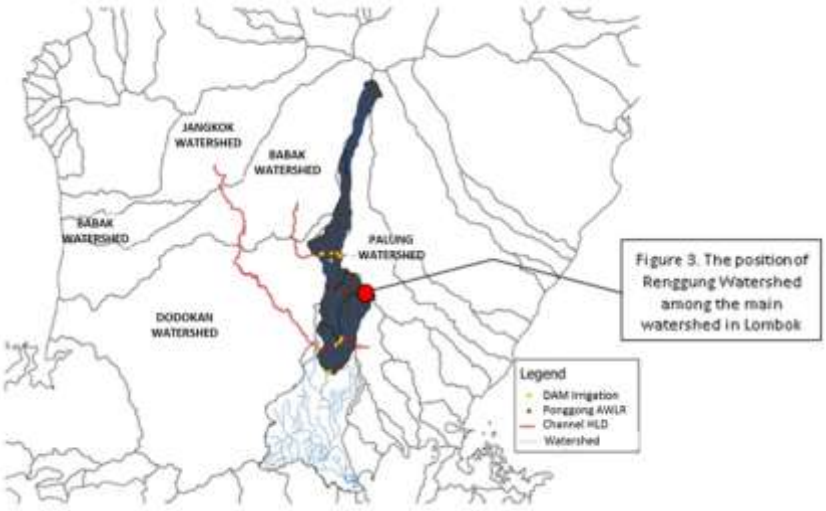
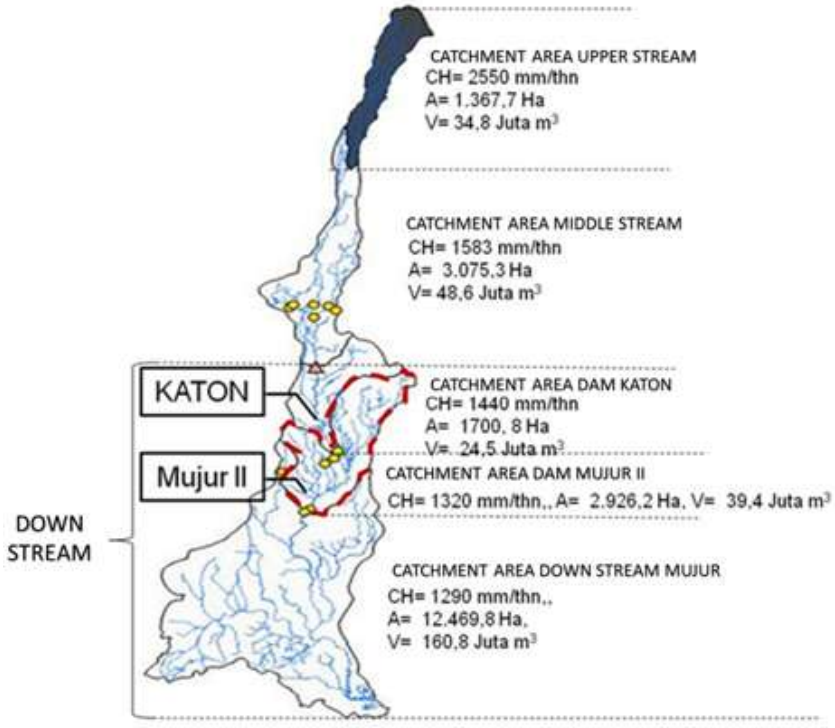


Figure 6. Position of Renggung Watershed among main watershed in Lombok Island (*RCWRA*, 2014)



Source: *Reserch Centre for Water Resources and Agroklimate (RCWRA) 2014*

Figure 7. Position of Renggung Watershed among main watershed in Lombok Island (Research Centre for Water Resources and Agroklimate, 2014)

Portions of water in upstream catchment (*Nyeredet*) are 34.9 million m^3 (10.4%); middle catchment area is 61.4 million m^3 (18.3%), *Katon* are 28.99 million m^3 (8.7%), *Mujur* are 48.67 million m^3 (14.5%) and downstream catchment *Mujur* are 160.8 million m^3 (48%) (Figure 7). Based on the zone (upstream, midstream and downstream), about 72% of potential water is from rainfall in downstream zone, 18.3% occurs in the middle zone, and 10.4 % in upstream zone (Table 2).

Table 2. Water availability and needs in each catchment of *Renggung* watershed

No	Catchment Segment	Area (ha)	Water Needs (Million m3/year)	Water availability (million m3/year)	IPA/ water use Index (per basin)	Category
1	Nyeredet	1367.8	17.1	34.88	0.49	GOOD
2	AWLR Ponggong	3075.3	86.2	59.17	1.46	WORSE
3	Bendung Katon	1700.8	23.0	77.77	0.30	GOOD
4	Mujur	2986.2	41.1	75.92	0.54	GOOD
5	Hilir Mujur	12469.9	192.6	172.16	1.12	WORSE
	Total	21600.0	360.0	410.94	0.88	MEDIUM

Source: *Research Centre for Water Resources and Agroklimate* 2014

Information: Availability of water is calculated from rainfall on watershed segments added with the river discharge from watershed segment above it, water requirements are calculated using estimated water use in a variety of land use (Perdirjen RHL and Perhutanan No.: P.4/V-Set/2009, Date : March 05 th 2009)

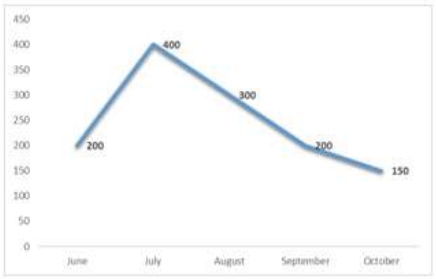
Based on Water Use Index (IPA), only three from five catchment areas along *Renggung* watershed who were in good condition such as *Nyeredet* (IPA=0.49), Katon (0.3), and *Mujur* (0.54). Two others catchment area was in a worse condition such as *Ponggong* (IPA=1.46) and *Hilir Mujur* (IPA=1.12). It means that amount of water in two catchment areas is overused. IPA < 1 shows that amount of water available from rainfall is not fully used. In the upstream area (IPA < 0.5), the water is only used less than half of water available. It is caused by rarely population density and nonintensive agricultural activity. Catchment area with IPA > 1 indicates that water demand in the area is exceeded the amount of water provided through rainfall. This is caused by intensive agricultural activity in the region, especially in areas that apply rice-rice-*palawija* cropping pattern. This condition may be exacerbated by the tendency of rice cropping pattern throughout the year (Idris et al., 2014).

3.4 Rainfed land water management in downstream of *Renggung* watershed

Rainfed land water management in downstream of *Renggung* Watershed basically is intended for realization of optimal conditions from vegetation resources, soil, and water so it can give the maximum and sustainable benefits. Rainfed land water management in downstream of watershed continually decrease. It is understood as a process of formulation and implementation of natural and human resources manipulation activities or programs in *Renggung* watershed. It is the benefit of production and services without causing damage to soil and water resources; included identification of linkages between land use, soil and water, and linkages between upstream and downstream areas of a watershed (Asdak, 2002). There are several factors that cause not optimally water management in rainfed land of downstream of *Renggung* watershed, as follows:

3.4.1 Irrigation water management in the downstream of *Renggung* watershed

Water resources in downstream of *Renggung* Watershed were used to irrigate rainfed land and it depended on water supply from HLD-BR. Data were obtained from water supply from HLD-BR in last 6 months (Figure 8 and Figure 9).



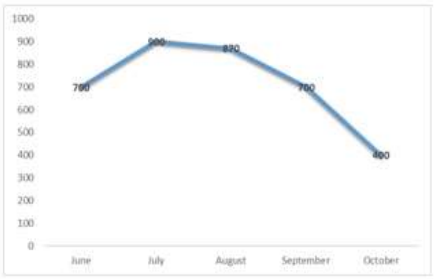


Figure 8 Discharge of DAM Mujur I (L/sec) in last 6 montFigure 9. Discharge of DAM Mujur II (L/sec) in last 6 months

Figures 8 and 9 explains that water supply data of HLD BR to DAM *Mujur* I and *Mujur* II had a deficit to meet irrigation needs on second and third crop season (MT-2 and MT-3). Bad management of some water facilities and infrastructures also causes DAM and ponds shallowing, so that DAM and ponds can not collect water in large quantities. This causes lack of water supply for irrigation in second and third crops season (dry season). It will cause a decrease of plant production and crop failure (Pusat Penelitian Sumber Daya Air dan Agroklimat, 2014).

3.4.2 Water management at farming level

Water doorman at DAM *Mujur* I and DAM *Mujur* II stated that not all of rainfed land in downstream of *Renggung* watershed was recommended to plant by paddy on MT-2, even more on MT-3. It is caused by deficit water supply from the HLD *Babak Renggung*.

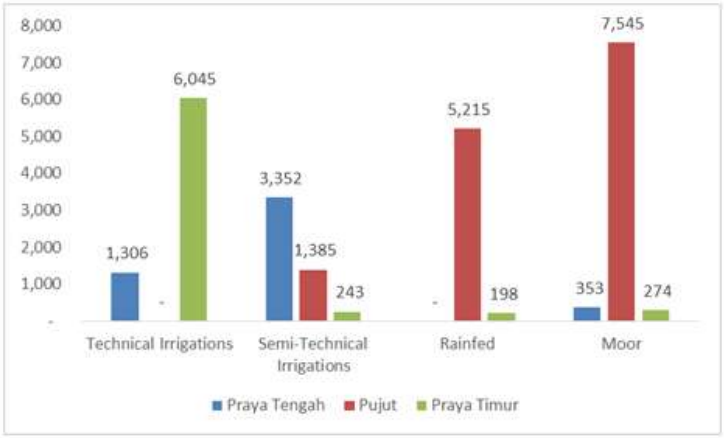


Figure 10 Land use in downstream of Renggung Watershed (Ha)

Figure 10 shows domination of rainfed land and moor in several subdistrict in downstream of *Renggung* watershed. Selection of plants is needed to be conducted on a regional basis to get much benefit and suitable for water resources availability. Based on observation, plant selection was conducted randomly by farmers and they did not heed appeals of DAM officials from Department of Public Works/Dinas Pekerjaan

Umum (PU). Most of the farmers did not plant paddy in the right season, so it caused wastefully and lack of water resources in the middle of cropping season. Development of linear program model is very useful to allocate plants in observation location and it will avoid waste and lack of water resources.

3.4.3 Institutional of management and water user group

The success of management at downstream of *Renggung* watershed was not inseparable from the role of community groups in watershed preserving. There were several groups of water farmer-users in downstream of *Renggung* watershed, but their presence was a vacuum. It had no an optimal role as a forum to facilitate and mediate some problems in the community.

Many conflicts happened in the community at downstream of *Renggung* watershed that was caused by lack of proper management and water utilization, an especially deficit of water irrigation at MT2. This proved that management and water user groups were still poor.

Some techniques needed to be applied by manager and water user groups of water management at rainfed land (vertisol), such as:

a. Raised Beds System
   Plant techniques using *Raised Beds System* has more advantages in water use efficiency than a system of *gora* and paddy field, especially at MT2 and MT3. Surplus water can be accommodated at ponds to be used when experiencing water deficit. (Ma'shum et al., 2002).
b. Manufacture of ponds
   The practice of water management in rainfed land in downstream of *Renggung* watershed needs to be conducted in a surplus month (rainfall > evaporation) by utilizing ponds resources. The water reservoir is used at critical periods during the rainy and dry season.
c. Determination of proper cropping time
   The timing of cropping and water management in a rainfed land entirely depends on dynamics of rainfall. Rainy season is from November to April, so the determination of appropriate cropping time is better to follow the pattern of rain.
d. Land management for effectiveness of water usage
   Mulsa; some studies show that use of mulch/*mulsa* from crop residues, cover crop, and hedge plant can suppress evaporation, especially at rainfed which has a relatively short of a wet month. In addition, application of mulch/*mulsa* can improve soil physical properties such as volume weight, aeration pore, and aggregate stability.

IV. Conclusion

- Downstream of *Renggung* watershed is mostly included in Central Lombok Regency, which reached 64.8% from total area in downstream of *Renggung* Watershed whereas 4.3% include in East Lombok Regency that is the rainfed agricultural center, moor and also water conservative area.
- The downstream rainfed land is dominated by vertisol soil which has *montmorillonite* mineral. It causes the soil shrink in wet condition and hard in dry conditions. The Rainfed land is categorized to D3-D4 climate type with 4-6 dry months and wet months 3-4 months with rainfall ranges about 1200 mm/year.
- Water supply in the downstream of *Renggung* watershed comes from three sources, ie from the upstream catchment draining to the downstream reaches 48,7%, from HLD Babak *Renggung* 39,4% and Embung/ Ponds of Gule Liat 11,8%. In the downstream of *Renggung* watershed, the water has been fully used even exceeding the capability to be provided in the catchment area because most farmers apply the cropping pattern rice-rice-*palawija*.
- Water irrigation discharge decreased continuously in downstream of DAM *Mujur* I and DAM *Mujur* II. About 40% and > 20% of water are used to irrigate in second (MT-2) and third (MT-3) crop season. The total area of standard irrigation reaches 665 Ha for DAM *Mujur* I and 3.508 Ha for DAM *Mujur* II.
- Water management at a farming level in downstream is not fully reflected suitability of cropping patterns and amount of water availability.
- Role of management and water user groups in water management is not optimal, so applying some techniques such as (a) Raised beds system; (b) Manufacture of ponds; (c) Determination of proper cropping time; and (d) Land management for effectiveness of water usage need to be improved.

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