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Irrigation application in upland farming to increase crop production based on runoff harvesting

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Abstract

Increased productivity of dry land farming in Indonesia is still limited by the lack of water supply, especially during the dry season; while most regions in Indonesia have high rainfall (over 1500 mm per year). The fact indicates most of the rain that falls on the land surface lost as runoff. The runoff management in dry land farming through runoff harvesting makes it possible to exploit this potential to meet the crop water requirements in the dry season. The research objective is to increase productivity and carrying capacity of dry land through appropriate runoff harvesting technology as a source of irrigation water in the area of dry land agriculture. The research method is descriptive analysis method and field observations. The result shows that the slope of the land in the catchment area with coconut and seasonal crop patterns positively correlated to runoff occurs, but not so in the land with a single or mix of seasonal crop which is more affected by the condition of the plant cover. The application of runoff harvesting technology on dry land farming is able to irrigate land planted with cultivation area of at least 44% of the total catchment area. Runoff harvesting is able to be as one of alternative appropriate technology for solving the problems in upland farming especially in dry season.

Keywords: irrigation, crop production, runoff harvesting, integrated dry land farming.

INTRODUCTION

The high annual rainfall in Indonesia is more than 1500 mm per year; it impacts on the amount of abundant runoff, especially on sloping land. Without special treatment such as runoff harvesting technology, the runoff becomes uncontrollable and cannot be used to meet the crop water requirements, especially in the dry season. Runoff harvesting technology in dry land is the technology of collecting runoff from catchment area and used it as an alternative source of irrigation water, especially during dry season (Prinz and Malik, 2002)

Dry land farming has a high potential, if it is managed properly; one of the lack of dry land farming is the water requirements of plants rely on water from rainfall (rainfed agriculture). This situation is more noticeably or more significant during the dry season; to overcome this, the management of irrigation water is needed so that plants can grow optimally.

The characteristics of dry land farming in Indonesia are: (a) low productivity because it relies on rainfall; (b) the plants grown are corn, upland rice, cassava, sweet potatoes, beans with corn as a major crop; (c) mixed cropping as a strategy in anticipation of crop failure; (d) technology is based on a traditional low input farming; (e) the limitation of land use due to the labour constraints (Nurpilihan, et al., 2013).

Reviewing of dry land farmers in Jatinangor that depending their life on dry land farming but it has low productivity, it is need technological breakthroughs, especially to meet the crop water requirements, especially in the dry season. One of the alternatives that can be studied is the application of appropriate runoff harvesting technology to meet the

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crop water requirements, especially in the dry season. This research objective is to increase productivity and land use of dry land through appropriate runoff harvesting technology as a source of irrigation water in the area of dry land agriculture.

MATERIALS AND METHODS

The research was conducted with survey and descriptive analytic method for analyzing the potential precipitation on the location of research and field observation method for calculating the potential runoff. Runoff measurements in the field is done by using the runoff plots on four with the different cropping pattern and land slope as can be seen in Table 1. Plot runoff made with dimensions of 3 m x 12 m except for crop pattern between coconuts with seasonal crop (CSC) uses the dimension (4 m x 12 m due to soil conditions). Boundary plot using ridges around the plot to prevent runoff from outside the boundary into the plot.

Table 1. Cropping patterns, slope and catchment area of runoff plots were used.

Crop Pattern	Slope (%)	Catchment area (m^2)
Coconut + seasonal crop (CSC)	21 %	88
Coconut + seasonal crop (CSC)	23 %	66
Single Seasonal crop (SSC)	18 %	66
Mix Seasonal crop (MSC)	22 %	66

The parameters observed in the field are volume of runoff on plots and high rainfall that occurs every runoff measurement. Runoff coefficient values calculated by the equation below (Crithley, 1991).

$$C = RO/P \quad (1)$$

Where; C is the runoff coefficient values; RO is the runoff (mm) and P is the depth of rainfall occurred (mm). To calculate the potential for runoff that can be harvested in the catchment area, this study used the equation below (Lancaster, 2006).

$$V = R \times C \times A \quad (2)$$

Where; V = the volume of runoff could be harvested (m3); R is the annual rainfall (m) and A is the catchment area (m2)

RESULTS AND DISCUSSION

Analysis of Regional Rainfall

The pattern and distribution of rainfall in the location of research became the basis for determining the required supplementary irrigation period is also the basic in determining the potential of runoff that can be harvested in an agricultural area. Analysis of the rainfall region was calculated by the method of Thiessen. Figure 1 below shows the rainfall in the research location 97% is determined by rainfall data from Pedca station and 3 percent was determined by rainfall data from Jatiroke Station.

The analysis of rainfall at Jatinangor research centre has annual rainfall of 1879.69mm; it was included in the category of dry land with wet climates where rainfall > 1,500 mm/year (Dwiratna, 2010). Meanwhile, based on an isohyets map as shown in Figure 2, showed that most of the Jatinangor Research Center get an average precipitation of 1860-1870 mm / year.

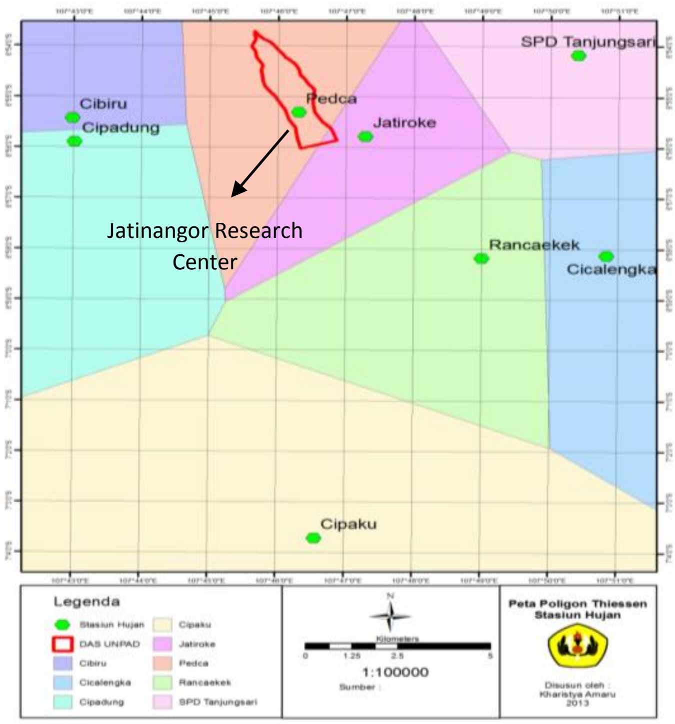

Figure 1.Thiessen polygon map of the study site.

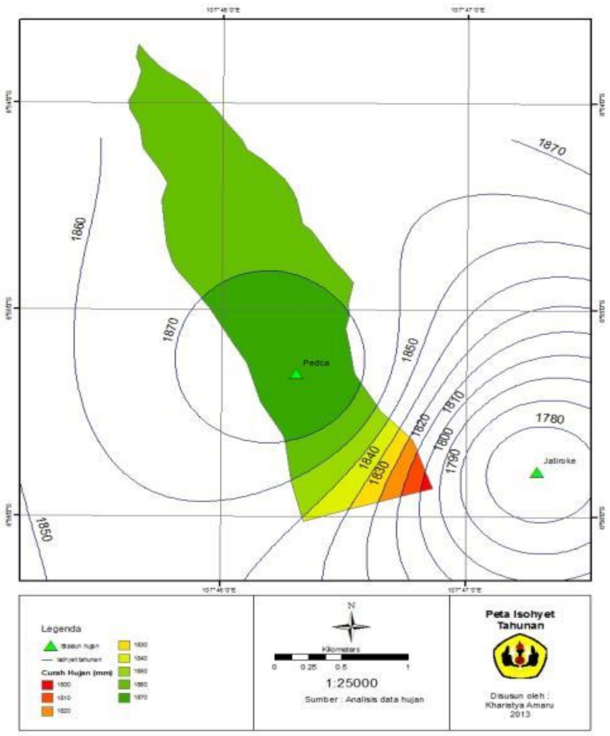

Figure 2. Isohyets map of the study site.

Based of Oldeman climate classification that Jatinangor region has five of wet months (NDJFM) where monthly rainfall > 200mm; four dry month (JJAS) where monthly rainfalll < 100 mm and three humid months (monthly rainfall between 100-200 mm per month), as can be seen in Figure 3. The condition of rainfall in research centre of Jatinangor caused farmers to only cultivate once a year with intercropping pattern between sweet potato + corn + cassava.

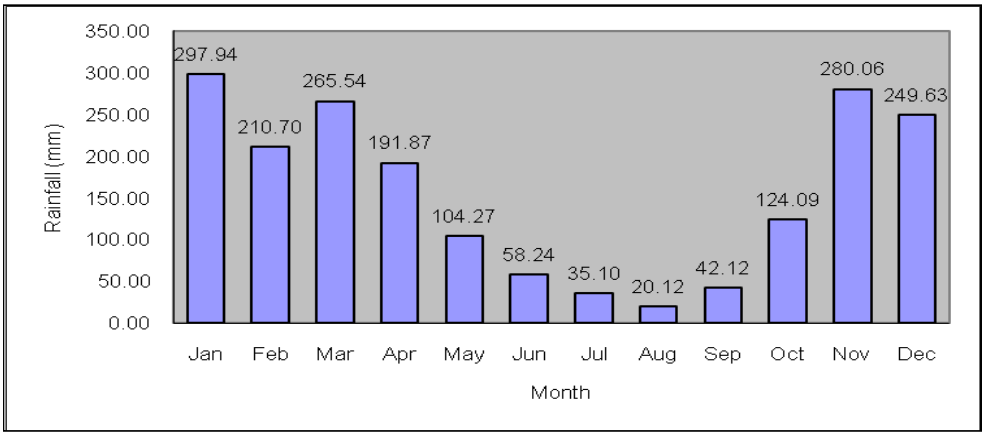

Figure 3. Distribution of monthly rainfall in Jatinangor.

Figure 3 shows that January until May had heavy rainfall and decrease in June to September. Peak rainfalls were occurring in January; February; March; November and December.

Rainfall-Runoff Analysis of the Several Crop Patterns and Slope

Actual rainfall and runoff in the field measured during the growing season. Results of field observations indicate that the surface runoff is strongly influenced by rainfall. Figure 4 below the surface runoff that occurs in all the plots were tested increased along with the high rainfall that occurred.

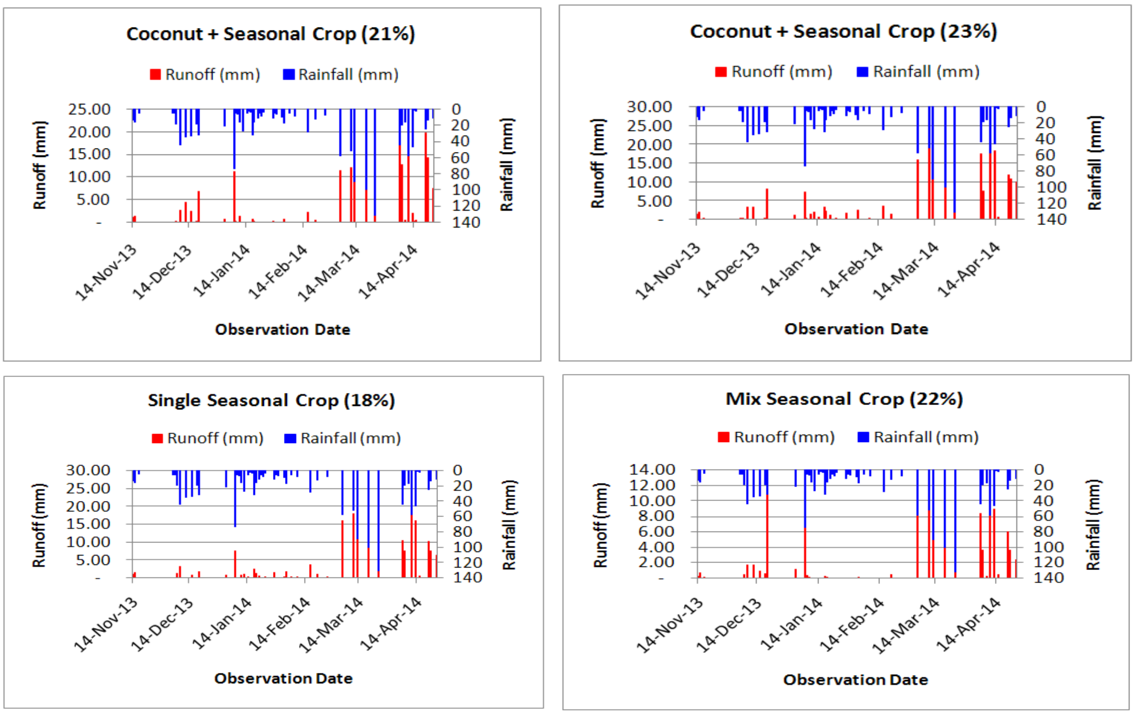

Figure 4. The actual of rainfall and runoff surface in the field.

Influenced rainfall and the amount of runoff occurred on farms was also affected by the slope and cropping patterns. Table 2 shows the surface runoff in some the cropping pattern and land slope as a result of field observations.

Crop Pattern	Slope (%)	Runoff (mm)	Runoff coefficient
Coconut + seasonal crop (CSC)	21 %	195.89	0.129

Coconut + seasonal crop (CSC)	23 %	223.26	0.120
Single Seasonal crop (SSC)	18 %	251.18	0.152
Mix Seasonal crop (MSC)	22 %	138.26	0.093

Table 2. Surface runoff in Several the cropping patterns and slope.

Table 2 show that in dry land farming with cropping patterns coconut + seasonal crop (CSC), surface runoff is affected by the land slope. The greater slope getting greater the runoff. But it is different with the runoff on single seasonal crop patterns (SSC) and the mix seasonal crop (MSC). Runoff on the single seasonal crop is greater than the mix seasonal crop despite of having values lower slope. This proves that the runoff is also determined by the crop canopy, which is in the dense crop canopy (MSC) less runoff that occurs.

Observations of the rainfall and runoff actual in the field were done to calculate the coefficient of runoff from the catchment area. Runoff coefficient value calculated each time during the field observations using Equation 1. Table 2 also shows that the smallest runoff coefficient value occurs in mix seasonal cropping pattern, while on a land with a single seasonal crop pattern was the largest coefficient value.

Estimated Potential Runoff Harvest from the Catchment

Potential runoff was calculated after the runoff coefficient known. The amount of water that could be harvested was calculated using the Equation2. Table 3 below shows the results of the calculation of the potential runoff in plots that were attempted.

Table 3. Potential runoff that can be harvested.

Crop Pattern	Catchment Area (m^2)	Runoff coefficient	Annual Rainfall (mm)	Runoffharvested (m^3)	Irrigatedland (m^2)*)
Coconut + seasonal crop (CSC)	88	0.129		21.34	53.35 (60%)
Coconut + seasonal crop (CSC)	66	0.120	1879.69	14.89	37.23 (56%)
Single Seasonal crop (SSC)	66	0.152		18.86	47.15 (71%)
Mix Seasonal crop (MSC)	66	0.093		11.54	28.85 (44%)

*) assumed to land planted with crop and crop water requirements are 400 mm over the period of plant growth

If it is assumed the crop water requirements amount of corn during the growth period is 400mm (120 days cultivate of corn + 4mm/day potential evapotranspiration and corn Kc is 0.83), then at least runoff harvested on a plot with a mix of seasonal crop can be used to irrigate 28.85m^2 of land that planted with corn. The larger catchment area, the greater area that can be irrigated. Therefore, the runoff water harvesting technology can be used as an effective technology in increasing the productivity of dry land farming.

CONCLUSIONS

The following conclusions can be drawn from the study:

- The slope of the land in the catchment area with coconut + seasonal crop patterns positively correlated to runoff that occurs, but not in the land with a single or mix of seasonal crop were more affected by the condition canopy of the plant.
- The appropriate runoff harvesting technology in dry land farming be able to irrigate the land at least 44% of the catchment area.
- Runoff harvesting can use as one of alternative the appropriate technology for solve the problem lack of water in dry land farming.
- The farmers in the research field could able to growth of three time a year, so make increasing farmer welfare.

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