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SMALL FARM RESERVOIR AS A SUPPLEMENTAL IRRIGATION SOURCE FOR CROPS PLANTED ON MARGINAL LAND

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ABSTRACT

Rainwater harvesting is a water conservation measures. Water is harvested in addition to reducing runoff, and erosion control can be used as a supplemental source of irrigation for crops on marginal land. A study was conducted to test the effectiveness of a small pool of rainwater harvesting usually termed as a small farm reservoir (SFRs) as a complementary source of irrigation water in improving the productivity of farming on marginal land. The experiment was conducted from December 2005 to August 2007 in Buanasakti, East Lampung, Indonesia. Three SFRs with a volume of 7 x 3 x 2.5 m (50 m^3 were made on upland at sloping area (8-15%) of 1.5 ha. Further rain was deposited to be used by farmers for crop watering, especially in the early dry season. Extensive planting of crops that can be irrigated with SFRs, based on consideration of the farmers themselves. Observation result indicated that the SFRs were used by the farmers to water the vegetables and tobacco plants with different extents. However, on average, the presence of SFRs increased the planting area of vegetables such as beans and cucumbers in the dry season to 650%. Increased intensity of cultivation of vegetables and tobacco cultivation also increase farmers' income of 1.5 ha of marginal land as much as 37.49%.

Keywords: small farm reservoir, supplemental irrigation, vegetables, marginal land

INTRODUCTION

Rainwater harvesting can be defined as the process of collecting surface runoff and storing it for the future beneficial use or agricultural purposes (Hachum and Mohammad 2007). The storage of water has become a key strategy against water scarcity under changing climate conditions. In addition, water management efficiency is a key issue for sustainable agriculture development (Pandey *et al.,* 2003; Quezada *et al.,* 2011). On marginal land, where soil water holding capacity is low due to erosion and low soil organic matter, the crop growth and production were hampered by water stress (Irianto and Surmaini 2002). Plants experiencing water stress can also occur due to uneven rainfall although the average annual rainfall is in normal condition.

The productivity of upland crops can be increased by improving soil quality (Medina and Azcón, 2010), and it can also be done with sufficient water availability for crop needs. According to Ghosh *et al.,* (2010) the most efficient and least expensive way to meet crop water needs is to harvest rainwater. Harvesting rainwater with a small pond and the water used to irrigate crops such as vegetables and tobacco can increase the real income of farmers on degraded hilly land in Bantul and Kulonprogo regency, Yogyakarta Province (Maswar *et al.,* 1995; Hafif and Irawan 1999). Building lots of small pools of rain water harvesting in the planting area as adopted by the farmers in the village Nawungan, Yogyakarta effectively increased the productivity of dry land (Hafif and Irawan, 1999).

Most of the irrigation projects on a large scale has proved to be very costly and sometimes environmentally unfriendly (Ngigi, 2003). In the last 10–20 years, small farm reservoirs (SFRs) received high attention, as their role in alleviating poverty has been recognized (Sawunyama, 2005). Wisser *et al.,* (2009) assessed that the supplemental irrigation for existing cropland areas could increase cereal production by 35% for a medium variant of

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reservoir capacity, with large potential increases in Africa and Asia. The annual growth rate in the number of small reservoirs could be as much as 60% in dry regions of India (Downing *et al.,* 2006).

The research objective was to study the effectiveness of the SFRs as a complementary source of irrigation water in improving the productivity of farming on marginal land.

MATERIALS AND METHODS

Research was conducted from December 2005 to August 2007 at Buanasakti village, East Lampung (Lat. 5º 08' S and 105 24' E; Elevation 44 m). The area was about 30 km from Sukadana town, central city of East Lampung regency and ± 10 km from Metro municipality.

Three small farm reservoirs (SFRs) with volume 7 x 3 x 2.5 m (50 m^2) were constructed on sloping land of 8-15%. Each placed on 0.5 ha of land owned by farmers. The SFR wall and floor were covered with plastic to control seepage and percolation. The SFRs were placed on a slightly sunken area with a distance of approximately 1-2 m from the main drainage channel.

The rainwater was harvested with each SFRs to irrigate vegetables or other crops planting area of approximately 1000 m^2. This consideration was based on the characteristics of farmers, namely that in the dry season, farmers will not be able to irrigate crops over 1000 m^2 manually. To be more effective in controlling erosion and run-off, bench was made in the field parallel to contour lines and reinforced with bulrush. Water usage, plant selection and planting area were carried out by the farmers. However, to enhance the effectiveness of water use, farmers were advised to plant vegetables and other high value crops such as tobacco in the early dry season.

The data collected were the physical and chemical properties of soil, such as texture (pipette method), pH (pH meter), Total N (Kjeldahl method), C-organic (Walkley and Black method), P_2O_5 (Bray method) exchangeable K, CEC, and BS (NH_4-Acetat 1N pH7 method). The other data collected were daily rainfall, cropping patterns, crop production, production costs and returns.

RESULTS AND DISCUSSION

Land charactieristics

The research location was categorized as an agro-ecological zone IIIax2, i.e. upland area with slope 8 to 15%, less than 750 m from sea level, humid, and well drainage (Sudaryanto *et al.,* 2002). The physical and chemical characteristics of *Inceptisols* (*Dystrudept*) are presented in Table 1.

Table 1. Some physical-chemical characteristics of Dystrudept in Buanasakti, East Lampung

Soil Characteristics	Value	Category (Landon 1991)
Textur:		
a. Sand (%)	64.50	Sandy loam
b. Silt (%)	21.50	
c. Clay (%)	14.00	
pH (H_2O)	5.10	Low
C-organic (%)	1.40	Low
Total N (%)	0.05	Very low
C/N	28.00	
P_2O_5 (Bray I) (ppm)	3.84	Very low
K (cmol(+)/kg)	0.57	high
KTK (Cmol(+)/kg)	16.23	Low
KB (%)	24.60	Low

Study sites were categorized as marginal land because of low soil nutrient content except for potassium (0.57 cmol(+)/kg). Plants with low soil CEC (16.23 cmol(+)/kg) would be difficult to absorb nutrients. In addition, the land would look heavily degraded due to erosion. Phenomenon was indicated by so many coarse particles found on the ground.

Climate

According to Oldeman *et al.,* (1979) and BMG (2005), the Climate of the study area was categorized as D2 zone with 4-5 wet months (> 200 mm) and 2-3 dry months (<100 mm) within a year. Especially in 2006, there was an extreme drought condition for 4 months i.e. from August to November, but the total annual rainfall remained in the normal condition which was about 1750 mm (Hafif *et al*., 2011).

According to the daily rainfall data (Figure 1), the rainfall distribution was uneven, where it sometimes did not rain for two weeks as in late January to mid February 2007 where the growth of upland rice in generative was very sensitive to water shortage. Hamim *et al.* (2008) reported without watering for 14 days, relative water content of soybean plants decreased to 43%, causing production to decline by 50%. Water stored in the SFRs was used as irrigation supplement to cope with water stress under such a rainfall condition.

Upland Cropping Pattern

In general, farmers grow upland rice and sometimes maize in the first planting season. They used to grow more than one type of crops in the first growing season, which sometimes included vegetables such as long beans as hedgerows. When the rice or corn reached 1 month old in the first growing season, farmers grew cassava among the rows of corn or rice with cassava planting distance of 2 x 0.8 m. In the second planting season after rice and corn, farmers re-planted corn or peanuts or peas planted on the sidelines of cassava.

After the SFRs were made, the cropping pattern changed, especially at the end of cropping season 2. Farmers grew vegetables such as cucumbers, eggplants, green beans and/or tobacco in the early dry season. As reported by Hafif *et al*. (2011), the existence of the SFRs increased cropping intensity through the expansion of planting area of vegetables and tobacco. In the 2006 growing season, widespread planting of these commodities increased 100-400%, and in the 2007 growing season, it increased to 650%. Cropping scenario was applied by farmers in the study area before and after the existence of the SFRs shown in Figure 2.

Once SFRs exist, vegetables will be one of the major commodities grown by farmers in addition to rice, maize and cassava on marginal land. The results were consistent with the Maswar *et al.* (1995) in which SFRs significantly increased cropping intensity when introduced in the degraded hilly area in Kulonprogo, Yogyakarta.

Upland Productivity

The yields of the various crops grown in the cropping season 2006/2007 (Tabel 2) showed that the production of rice and corn as reported by farmers was similar to the results of the previous year. While the production of cassava is planted with a spacing of 2x0.8 m was very low, approximately only 600 kg / ha (150 kg/0.25 ha) mainly due to the extreme dry climatic conditions that occurred in August and September 2006, low water holding capacity and no fertilizers applied. Wargiono (2003) found that cassava planted with a spacing of 1 x 0.8 m with no fertilizer only reached the production of approximately 7 ton/ha.

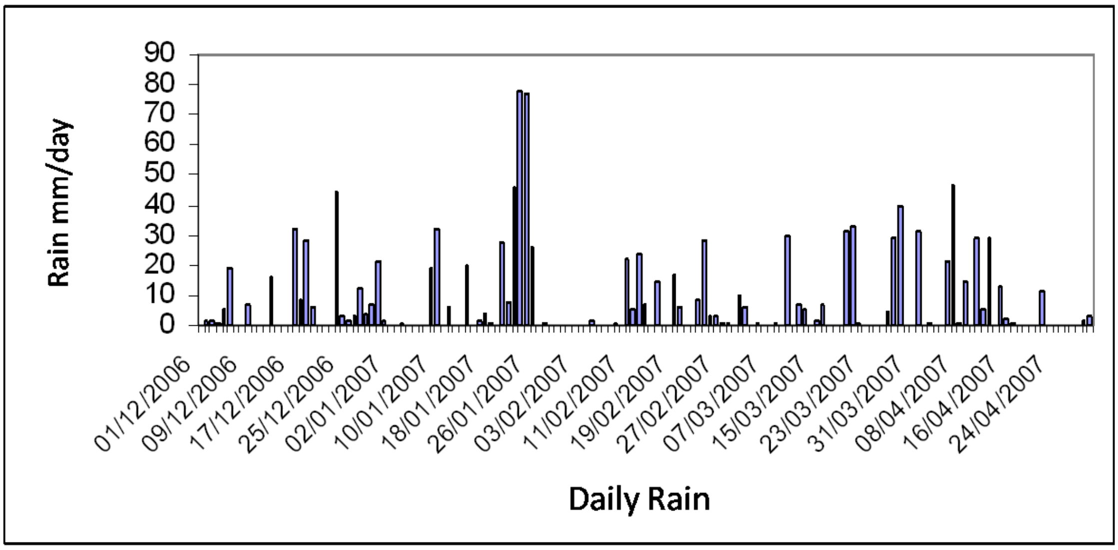
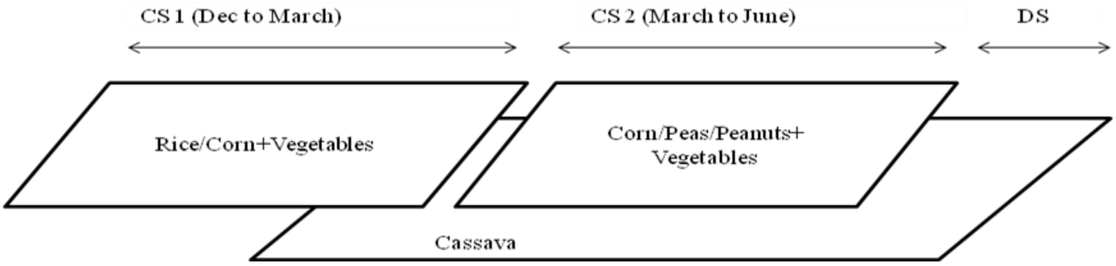
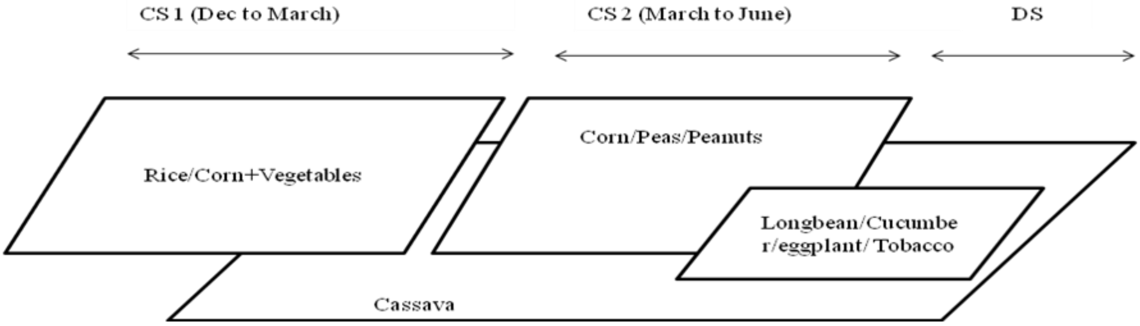


Figure 1. Daily rainfall from December 2006 to April 2007 in Buanasakti, East Lampung

Cropping scenario applied by farmers prior to the SFRs



Cropping scenario applied by the farmers after the SFRs



Remarks: CS = cropping season, DS = dry season

Figure 2. Cropping scenario applied by farmers before and after the introduction of SFRs on Marginal Land in Buanasakti, East Lampung.

Table 2. Crops and production planted in cropping season 2006/2007on marginal land in Buanasakti, East Lampung

No.	Farmers	Land area (ha)	Cropping season			Planting area (m^2)	Production (kg)
			RS1 (Dec- March)	RS2 (March-June)	DR1 (June-August)		
1.	Tukirin	0.5	Rice			2000	320
			Corn			2000	420
			Cassava*	Cassava	Cassava	2500	150
				Peanuts		400	50
				Long bean	Long bean	800	40
					Tobacco	200	60
2.	Seno	0.5	Rice			2000	390
			Peanuts			800	120
				Long bean	Long bean	1500	80
				Cucumber	Cucumber	200	400
3.	Kemat	0.5	Rice			2500	480
			Corn			2500	660
				Peanuts	Peanuts	1200	240
				Long bean	Long bean	800	50

Remarks: RS1= rainy season 1, RS2= rainy season 2, DS1= dry season 1, *planting distance of cassava 0,8x2 m (cassava as intercrop)

Table 3. Comparison of farmers' income before and after the SFRs made at 1.5 ha of marginal land

Farmers	Crops	Before SFRs			After SFRs		
		Gross return (RP)	Cost (Rp)	Net return (Rp)	Gross return (Rp)	Cost (Rp)	Net return (Rp)
Tukirin	Rice	480,000	197,500	282,500	480,000	197,500	282,500
	Corn	420,000	280,500	139,500	420,000	280,500	139,500
	Peanuts	125,000	36,000	89,000	125,000	36,000	89,000
	Long bean	80,000	25,000	55,000	160,000	41,500	118,500
	Tobacco	-	-	-	210,000	32,500	177,500
	Cassava	30,000	20,000	10,000	30,000	20,000	10,000
Seno	Rice	585,000	197,500	387,500	585,000	197,500	387,500
	Peanuts	360,000	196,000	164,000	360,000	196,000	164,000
	Long bean	80,000	25,000	55,000	320,000	80,000	240,000
	Cucumber	-	-	-	300,000	80,000	220,000
Kemat	Rice	870,000	246,000	624,000	870,000	246,000	624,000
	Corn	660,000	350,000	310,000	660,000	350,000	310,000
	Peanuts	400,000	75,000	325,000	600,000	90,000	510,000
	Long bean	80,000	25,000	55,000	200,000	40,000	160,000
Total				2,496,500			3,432,500
Total of increasing farmers' income (Rp) 3,432,500 – 2,496,500							936,000
The average percentage of increase in farmers' income (%)							37.49

Simple economic analysis performed to determine the impact of the presence of SFRs on the income of the farmers. The economic analysis used production data from the three farmers. Farmers' incomes were compared before and after the existence of SFRs (Table 3). The increased cropping intensity by SFRs at 1.5 ha of marginal land was able to increase farmers' income as much as 37.49%, from an average of Rp. 2,496,500,- to Rp. 3,432,500,- (Table 3).

CONCLUSIONS

Meeting the water needs for plants is one way to increase crop production on marginal land. SFRs in Buanasakti was not only useful to meet the water needs of crops in the dry season, but it also functioned as a source of supplemental irrigation when the rainfall was uncertain during rainy season. The existence of SFRs increased cropping intensity, especially for vegetables and tobacco. Growing cropping intensity increased the farmers' income of 1.5 ha marginal land as much as 37.49%.

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