

# Utilization of Small Farm Reservoir (SFR) for Upland Agriculture of Bataan, Philippines

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**Abstract:** To mitigate and adapt the climate change in the hilly areas, rainwater harvesting will solve the water supply problem in the upland. The main objective of the study was to assess and evaluate the performance of the rainwater impounding reservoir as influenced by hydrological, physical and economic factors specifically demonstrate the benefits in the upland agriculture using harvested water from runoff. There were 20 SFR sites established in the Bataan province. SFR capacity ranges from 126.0 m<sup>3</sup> to 3,134.0 m<sup>3</sup> of runoff or rainfall water. The average production area was 1.0 hectare. The production without the project was 3.25 to 3.45 tons per hectare while with the SFR were 4.05 to 4.25 tons per hectare. The net income was Php 24,777.49. The Payback Period for SFR was 1.76 years to recover the investment in establishing SFR. Some farmer had no production during the second cropping, for them it was not enough to produce crops, better to put fingerlings.

**Keywords:** Small Farm Reservoir, Climate Change, Mitigate, Rainwater Harvesting, Philippines

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## 1. Introduction

Climate change is a significant change in climate in the regions which is result of careless human activities that was observed on common measurements like rainfall, temperature, and air.

To mitigate and adapt the climate change in the hilly areas, rainwater harvesting will solve the water supply problem in the upland. Water storage was used in rainfed-growing areas to provide supplemental irrigation water during rainy season and off-season rice production [1]. Aside from irrigation, water in the small farm reservoir could also be used for small scale fish production, livestock watering and groundwater recharging [2].

Despite of abundance during rainy season, water in the mountains usually goes to rivers down to lakes and oceans when not properly stored or harvested thereby limiting the chance for farmers to store free water from rainfall at any ways when dry season's rice production will come [3].

Establishment of water impounding project in the upper reaches of watershed could be defense against floods at the same time for irrigation, soil erosion control, tapping unused water, pasture improvement for livestock, and future studies

of the same field could be possible [4]. Establishment of water impounding reservoir uses the surface runoff to conserve water for productive use and to mitigate climate change. Aside from uses, stored water on the reservoir would use of areas where normally crop production not feasible [5].

The objectives of this study were to analyze the benefits of small farm reservoir in rice production, to demonstrate the benefit of small farm reservoir in crop diversification and fish production, and to analyze the benefit of utilizing the existing small farm reservoir.

The existing small farm reservoir used by common farmers was dugout ponds without any material in the bed of reservoir that reduces stored water losses. A common loss that reduces the volume of stored water was percolation, seepage and evaporation [6]. These water losses might be saved to increase the efficiency of SFR and it would increase the production.

The study was focused on runoff water harvesting and storage for crop production specifically rice and fish production. Included in the study was sedimentation and water management strategies using small farm reservoir.

## 2. Methodology

### 2.1. Conceptual Framework

The study would document the performance and benefit of small farm reservoir in rice, diversification and fish production. Project starts from communication to proper authority regarding the concept. Instrumentation to the SFR

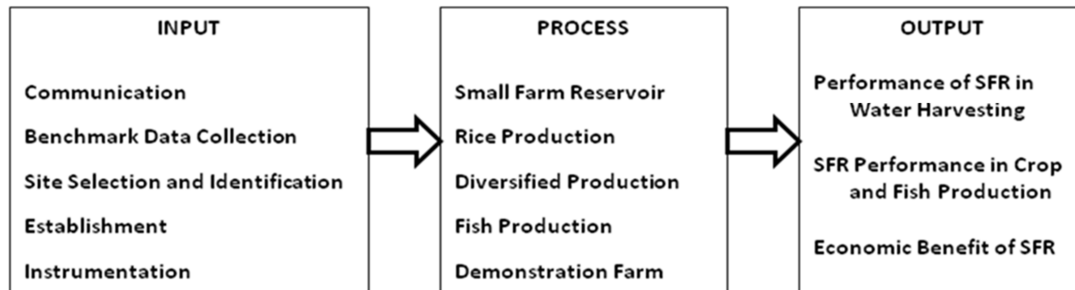


Figure 1. Conceptual framework of the study.

### 2.2. Communication, Consultation and Coordination

Preparation of communication regarding the objectives of the project address to local authority this was start from the province down to barangay level in which the beneficiary was farmers in the upland areas. Together with the DA-LGU and the local authority in the barangay, the farmer cooperator was identified in the barangay level.

### 2.3. Benchmark Data Collection

Site or area selected for the project implementation was rented by means of agricultural supplies given to the farmer cooperator. The identified site was assessed gathering the necessary information that would be use in the analysis such as name of barangay and its local official, location, elevation, soil type and properties, catchment area and service area of the small farm reservoir.

With the use of Geographic Positioning System (GPS), location, elevation, catchment and service area was measured and recorded.

### 2.4. Site Selection and Identification

*Farmer Selection* – The most farmers selected was the owner of land or the production area and some were tenants for long period that they were allowed to decide on the agricultural development of the area. Most cooperator were at their late ages but capable to do and manage agricultural activities.

*Identification of Study Sites* – In the province of Bataan, study site was identified depending on the land configuration and status of production. The selected site was rainfed rice-based [7] and that would be the representative of the community both hydrologically, physically and socially. Any strategy developed from this study site was also appropriate for the entire municipality and the province. Site identified has catchment basin areas where runoff flow down to established SFR upon saturation [8].

*Topographic Survey* – To delineate the catchment area of each study site, topographic survey was conducted. Baseline

that monitor the input water and discharge (INPUT).

The established reservoir with stored water will optimized in rice and diversified production while raising fish (PROCESS). Development of intervention strategies in optimizing SFR using performance of small farm reservoir and its economic benefits will be the output.

physical information was gathered from this catchment site. Parameters that were gathered include topography, drainage pattern and slope with the use of GPS including the land use of the selected area [9].

*Benchmark Soil Sampling* – Benchmark soil samples was collected from each sites and analyzed by the Bureau of Soils for complete physical properties and other necessary data for soil classification purposes following the USDA Soil Taxonomy.

*Catchment Area Measurement* – The catchment area of every study sites selected were measured using the Geographic Positioning System (GPS). The waterway slope was also measure gathering the elevation of the uppermost area and the lowest portion of the catchment area.

*Small Farm Reservoir* – Existing SFR was rehabilitated and established instrumentation such as sediment traps and staff gage for monitoring the volume of water stored for any changes in depth.

Downstream of catchment area was established small farm reservoir that contains and store the runoff water. One site was demonstration reservoir for rice, diversification and fish production [10].

### 2.5. Establishment of Small Farm Reservoir (SFR)

Small farm reservoirs were established at the identified site. The existing SFR was evaluated and renovate if there is. Hired heavy equipment was used in the establishment of SFR that might come from the provincial government or from private properties. The SFR depth and area were depending on the catchment area and the land configuration.

### 2.6. Instrumentation

*Raingage and Class A Evaporation Pan* – To measure rainfall, an automatic raingage with data logger were install at different sites. To monitor the rate of evaporation, a Class A evaporation pan was also installed. The monitoring and measurement was from the start till end of study period.

*Sediment Traps* – One sediment trap was constructed. The sediment traps was positioned or installed upstream of the reservoir.

*Installation of Staff Gage* – Established reservoirs were installed with staff gage to monitor the volume of water stored in the reservoir [11].

## 2.7. Data gathering and Collection

Data gathering, collection and uploading were done once in two weeks for hydrological parameters. Physical factors were observed and recorded before and after the season. Economic parameters such as yield and inputs were collected before and after the production seasons.

*Inputs* – Cost of materials in the reservoir establishment, rice production expenses, crop diversification inputs including fish production were recorded and monitored.

*Gross Income* – Total income generated from rice production and crop diversification after harvesting and fish production gross income from the SFR after total harvest were computed.

*Net Income* – Gross income generated minus the total

expenses occurred during establishment and management of small farm reservoir.

*Benefit Cost Ratio* – The ratio of net income generated in the production to the total expenses occurred during production including services and postharvest operation was estimated.

*Internal Rate of Return (IRR)* – The number of crop production and fish production season to cope up the expenses in the establishment of small farm reservoir in the upland areas.

## 3. Results and Discussion

### 3.1. Farmer Cooperators

Farmer cooperator were selected based on the following criteria: a) has a rainfed rice production area [12], b) without production after the main crop c) has an space where to established SFR, d) should be land owner or long period tenant and d) willing to be a farmer cooperator of the project (Table 1).

Table 1. Farmer Cooperators information.

	COOPERATOR	PROJECT LOCATION/ADDRESS	PRODUCTION AREA (Ha.)
1	Maximo Guzon	Mabatang, Abucay	3.0
2	Anthony S. Villanueva	Four Lanes, Tuyo, Balanga City	0.5
3	Salvacion Soria	Baseco, Country, Mariveles	1.25
4	Juanito Payao	Baseco, Country, Mariveles	0.3
5	Nilo Pajaro	Parang II, Samal	2.5
6	Rafael G. Izon	Parang III Ibaba, Samal	2.5
7	Enrique Maneclang	Sitio Ibayo, Sabang, Morong	0.75
8	Silverio C. Rubiano	Mabatang, Abucay	0.75
9	Sammy B. Rubiano	Mabatang, Abucay	1.25
10	Virgilio DR. Manrique	Mabatang, Abucay	1.4
11	BPSU Abucay	Bangkal, Abucay, Bataan	0.2
12	Michael T. Bugay	Adamson Gugo, Samal	1.25
13	Juanito E. Garcia	Adamson Gugo, Samal	1.0
14	Angelito H. Ortiguerra	Pugad Lawin, San Juan, Samal	0.75
15	Narciso DR. Bugay	Adamson Gugo, Samal	0.6
16	Ricardo V. Suarez	Mambog, Capitangan, Abucay	0.7
17	Armando B. Tamayo	Olipang Liputan, Mabatang, Abucay	0.3
18	Nicanor O. Oliveria	Olipang Liputan, Mabatang, Abucay	1.5
19	Arjel M. Manrique	Olipang Liputan, Mabatang, Abucay	2.0
20	Venancio C. Del Rosario	Barao Daang Bakuran, Mabatang, Abucay	1.0

### 3.2. SFR Location and Characteristics

Table 2 shows the location, elevation and surface area of established Small Farm Reservoir (SFR). Surface area was ranges from 42.0 m<sup>2</sup> to 500.0 m<sup>2</sup>. Elevation of established small farm reservoir from the sea level ranged from 15.0 m to 347.0 m. The location of established SFR is within Bataan Province (N 14°26' E 120°31').

### 3.3. SFR Physical Characteristics and Capacity

Table 3 shows the dimensions of the established SFR. Top

length ranges from 10.0 m to 55.0 m and top width ranges from 4.2 m to 30.0 m. Bottom length ranges from 10.0 m to 53.0 m and bottom width ranges from 4.2 m to 28.0 m.

Based on the dimension of the constructed SFR, it can store rainfall or runoff water ranging from 126.0 m<sup>3</sup> to 3,134.0 m<sup>3</sup> capacity.

Watershed of the established SFR was measured for the effectiveness to store runoff or rainfall [13]. Table 3 showed the measured dimension of the SFR watershed area.

Table 2. SFR Location and Physical Characteristics.

	COOPERATOR	SFR Surface Area (m <sup>2</sup> )	Location		Elevation (masl)
			North	East	
1	Maximo Guzon	500.0	14°44'57.2"	120°31'09.7"	33.0
2	Anthony S. Villanueva	144.0	14°26'08.9"	120°31'27.9"	15.0
3	Salvacion Soria	284.0	14°26'18.6"	120°31'24.2"	88.0
4	Juanito Payao	400.0	14°26'07.4"	120°31'26.6"	87.0
5	Nilo Pajaroha	420.0	14°45'45.9"	120°31'29.5"	15.0
6	Rafael G. Izon	500.0	14°45'43.2"	120°30'42.5"	56.0
7	Enrique Maneclang	500.0	14°41'12.0"	120°15'55.3"	15.0
8	Silverio C. Rubiano	500.0	14°44'56.5"	120°31'05.8"	21.0
9	Sammy B. Rubiano	420.0	14°44'25.7"	120°26'44.4"	19.0
10	Virgilio DR. Manrique	520.0	14°44'38.7"	120°30'46.5"	55.0
11	BPSU Abucay	42.0	14°46'11.6"	120°30'01.0"	347.0
12	Michael T. Bugay	375.0	14°45'54.2"	120°30'03.6"	69.0
13	Juanito E. Garcia	330.0	14°45'54.6"	120°30'00.02"	73.0
14	Angelito H. Ortiguerra	400.0	14°46'39.6"	120°30'50.6"	44.0
15	Narciso DR. Bugay	200.0	14°45'40.5"	120°30'07.0"	83.0
16	Ricardo V. Suarez	120.0	14°42'20.7"	120°30'34.3"	86.0
17	Armando B. Tamayo	210.0	14°44'37.6"	120°31'11.3"	32.0
18	Nicanor O. Oliveria	690.0	14°44'36.4"	120°31'11.5"	32.0
19	Arjel M. Manrique	225.0	14°44'36.9"	120°31'06.7"	34.0
20	Venancio C. Del Rosario	500.0	14°44'14.4"	120°31'17.6"	20.0

### 3.4. Sedimentation

Soil sediments deposited from the SFR bottom was monitored using sediments traps. It was recorded that 11 cm to 15 cm depth of sediments every year. The result was 13 years up to 25 years of useful life for the established SFR.

Table 3. Watershed area of SFR.

	NAME	Area (ha)	Small Farm Reservoir					Capacity (m³)	WATERSHED AREA (m²)
			Length (m)		Width (m)		Depth (m)		
			Top	Bottom	Top	Bottom			
1	Maximo Guzon	3.0	16	14	12	10	3.20	354.1	30 x 10
2	Anthony S. Villanueva	0.5	20	18	12	10	3.20	448.0	20 X 10
3	Salvacion Soria	1.25	10	9	15	14	2.5	230.0	creek diverted
4	Juanito Payao	0.3	20	18	20	18	2.25	543.0	25 x 20
5	Nilo Pajaroha	2.5	21	19	21	19	3.25	868.7	21 x 70
6	Rafael G. Izon	2.5	34.4	31.4	19.4	16.4	3.80	1497.6	12 x 34.4
7	Enrique Maneclang	0.75	18		14		1.5	126.0	18 x 95
8	Silverio C. Rubiano	0.75	15	13	15	13	3.40	446.5	15 x 13
9	Sammy B. Rubiano	1.25	24	20	14	10	3.5	625.3	35 x 50
10	Virgilio DR. Manrique	1.4	10	8.5	20	18	3.5	411.8	4. 75 ha
11	BPSU Abucay	0.2	10		4.2		3.0	126.0	creek diverted
12	Michael T. Bugay	1.25	25	23	15	13	3.5	786.3	creek diverted
13	Juanito E. Garcia	2.0	22	20	12	10	2.5	386.7	22 x 95
14	Angelito H. Ortiguerra	0.75	20	18	20	18	4.2	1013.6	surface flow from highway
15	Narciso DR. Bugay	0.6	17	15	11	9	2.8	300.5	17 x 10
16	Ricardo V. Suarez	0.7	10	8	16	14	3	272.0	16 x 10
17	Armando B. Tamayo	0.3	15	13	15	13	2.5	328.3	15 x 72
18	Nicanor O. Oliveria	1.5	40	38	30	28	2	1509.3	40 x 72
19	Arjel M. Manrique	2.0	18	15	18	15	3.5	640.5	65 x 80
20	Venancio Del Rosario	1.0	30	30	8	8	4	960	30 x 30

### 3.5. Rice Production (Tons) Per Cropping with the Project

Table 4 showed the seasonal production per area planted by cooperators. It was presented the production without the SFR project and with the established small farm reservoir.

Without the small farm reservoir during the rainy season, 80 percent of the cooperators were produce rice with an average of 3.96 tons per hectare and only three (3) of them had production during second crop with an average production of 3.47 tons per hectare, because they have shallow tube well to supplement irrigation water. Some of

them do diversification after the main crop.

The investment cost in the establishment of small farm reservoir was Php 42,755.50 (average). And the average production cost was Php 25, 355.65 per hectare.

With small farm reservoir during the rainy season or the main crop, the average production was 4.16 tons per hectare and 4.30 tons per hectare during the second cropping. The increase in production was due to the availability of water during the time when the crop needs irrigation water.

The gross income per hectare with the SFR was Php 49,633.00 and net income was Php 24,277.49. In the establishment of SFR, the payback period takes 1.76 years or around 2 years to recover the SFR establishment cost (Table 5).

**Table 4.** Rice Production (tons) per cropping.

	COOPERATOR/Actual Prod'n Area	2013		2014		2015							
		1st	Var	2nd	Var	1st	Var	2 <sup>nd</sup>	Var	1st	2nd	Var	
1	Maximo Guzon (0.75)	3.6 *	Rc18	None*		4.05	R40/R42/F	None	F	2.3**	C130/F	D*	F
2	Anthony S. Villanueva (0.50)	1.0 *		None*		1.6	Rc216	None		1.5	Line Variety	2.3	C130/ Rc218
3	Salvacion Soria (0.75)	2.0 *		None*		2.9	Rc128	1.1 + D*	RC128	3.4	Upland Rice	1.8	Rc298
4	Juanito Payao (0.30)	1.15 *		D*		1.25	Rc128	D*	Rc128	1.4	Rc128	D*	
5	Nilo Pajaroha (2.0)	9.5 *		9.2*		10.0	Rc18/F	9.6	Rc218/F		Rc218		Rc218
6	Rafael G. Izon (1.50)	4.5*		None*		7.0	C130, Rc216	None		3.0	C130	None	
7	Enrique Maneclang (0.5)	2.7*		None*		3.0	Rc218/F	1.05	Rc146/F	2.2	Bigante/F	3.0	Bigante/F
8	Silverio C. Rubiano (0.5)	2.7*		None*		0.9**		None		2.1	C130	None	
9	Sammy B. Rubiano (0.75)	3.4*		None*		None		None		None		None	
10	Virgilio DR. Manrique (1.0)	None*		None*		None	w/1,300 fingerlings	F	None	F	F	F	None
11	BPSU Abucay (0.10)	None*		None*		7.125 kg + D	Rc23	D*		10.2 kg +D	Rc23	None	
12	Michael T. Bugay (1.0)	-		-		2.2*	Rc218	0.25*	Rc218	2.2	Rc122	None	
13	Juanito E. Garcia (1.0)	-		-		6.5*	Rc218	None		3.0**	Rc218	0.75	Rc218
14	Angelito H. Ortiguerra (0.75)	-		-		3.0*	Rc218	None		2.9	Rc18	D	Sweet F16
15	Narciso DR. Bugay (0.50)	-		-		2.5*	Rc218	2.0*	Rc218	2.5	Rc218	1.9	Rc218
16	Ricardo V. Suarez (0.50)	-		-		None*	None	None*	None	None	None	None	None
17	Armando B. Tamayo (0.30)	-		-		-		-		1.25*	Rc218	None	
18	Nicanor O. Oliveria (1.0)	-		-		-		-		4.9*	Rc18, Rc218	None	
19	Arjel M. Manrique (1.0)	-		-		-		-		4.55*	Rc218	None	
20	Venancio C. Del Rosario (0.50)	-		-		-		-		None*		None	

Var – Variety \*without project \*\* reduced area D - diversification

**Table 5.** Economics of SFR.

Basic Computation	AMOUNT
Initial Cost	43765.00
II. Fixed Cost	
a. Depreciation Cost (10%)	4,376.50
b. Interest on Investment (10%)	4,376.50
c. Repair and Maintenance (2%)	875.3
d. Tax and Insurance (2%)	875.3
Total Annual Fixed Cost	10,503.60
III. Variable Cost	
a. Fuel	1,000.00
Total Investment Cost	55,268.60
IV. Gross Income	49,633.04
V. Net Income	24,277.39
VI. Return of Investment	56.81%
VII. Payback Period	1.76 yrs

## 4. Summary

There were 20 SFR sites established in the Bataan province: 6 sites in the Municipality of Samal, 10 sites in the Municipality of Abucay, 1 site in the City of Balanga, 2 sites in the Municipality of Mariveles, and 1 site in the Municipality of Morong. SFR capacity ranges from 126.0 m<sup>3</sup> to 3,134.0 m<sup>3</sup> of runoff or rainfall water. The average production area was 1.0 hectare. The

production without the project was 3.25 to 3.45 tons per hectare while with the SFR was 4.05 to 4.25 tons per hectare. Ten (10) of the famer cooperator were doing the rice-rice cropping pattern while the others were rice-diversified or rice only without second crop. The net income was Php 24,777.49. The payback period for SFR was 1.76 years to recover the investment in establishing SFR. While the rainfall within 2013 - 2015 years was 2,122.6 mm, 2,156.8 mm, and 2,521.1 mm, respectively.

## 5. Conclusion

Some farmer cooperators do not produce rice or even diversified because of soil texture and structure that could not store water. One farmer do not produce due to personal reason. Some farmer had no production during the second cropping, for them it was not enough to produce crops, better to put fingerlings.

The benefit of SFR were to increase the production annually, rice and diversification. Moreover, utilization of SFR stored water for long period up to its life span including indirect benefit such as fish production, cooling of birds during dry season and even recreation activities.

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