AGRICULTURAL & BIOSYSTEMS ENGINEERING
UNIVERSITAS GADJAH MADA

Guidance of Community Empowerment for Water Resources Development

[Case Studies in the Tropics]

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Preface

This guidance was arranged based on case studies in tropical country of Indonesia. Some water resources development programs were developed as a cooperation partnership between the Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada, Indonesia and the Main Office of Serayu Opak Rivers (BBWS.SO), Ministry of Public Works, Indonesia as the fund provider. Various approach methods were used by considering local conditions. We hope this guidance provides some useful references for society to support water resources development programs.

Introduction

Water scarcity is one of the most critical problems, faced by the number of countries because of climate and geographical factors. This problem has also been found in tropical countries such Indonesia, particularly in the areas with low rainfall and shallow soil layer or area with bad conservation practices. Land degradation in the form of soil erosion play an important role in decreasing of water resources which come from ground water storage. Land conversion from forest land to agricultural land and others increases soil erosion and surface runoff, whereas water infiltrations are significantly decreased. In long-term without a good control, land conversion could reduce water availability which is needed for many purposes. Water resources development are required as the way to solve the problem by increasing ground water recharge through soil conservation practices.

Mostly, land degradation problems particularly in tropical developing countries had a strong relation with social and economic factor, indicated from high occupancy of the local inhabitant on land for farming. Excessive farming by reducing vegetation cover without applying good conservation principles increase soil erosion as indicated in some studies such as Andriyanto et al. (2015), Pupim et al. (2015) and Tekwa et al. (2016). Hence, water resources development strategies are important to consider social economic factor as we applied in some programs. Generally, the program consisted of some stages such as preliminary study, field survey, action plan and implementation. As a complex problem, water resources development requires an advance approach to achieve desirable goal. In preliminary study, feasibility assessment was performed based on literature review and secondary data. Furthermore, field study was implemented to assess the worthiness of the program from side of physical condition and social economic factor. Action plan and implementation was arranged by considering the finding during field survey.

Preliminary study

This guidance is focusing on water resources development through engineering and vegetative approach. The present stage is required as a response to present issues of water resources problem. Preliminary study aims to find the main problem and solving strategies based on information, which are collected from various sources. Literature review and secondary data are used to determine preliminary strategy (Figure 1).

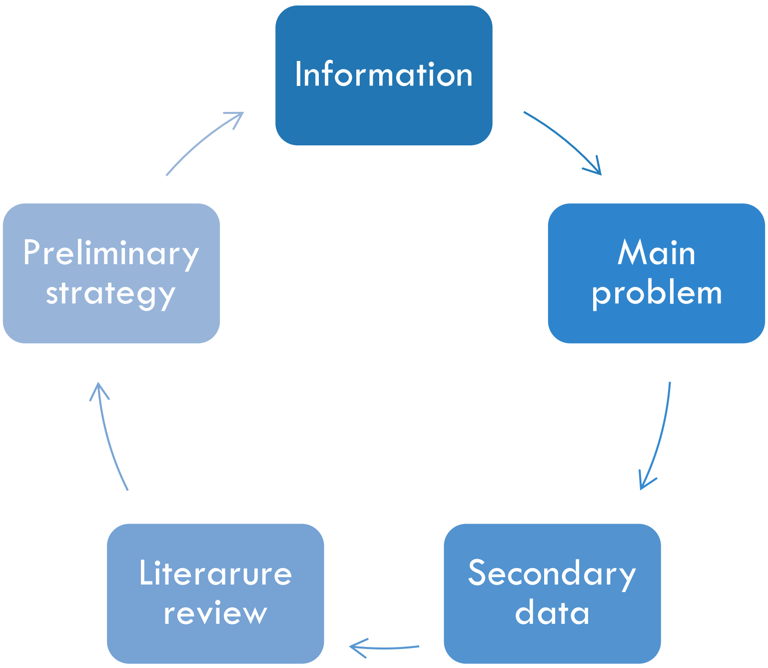

Figure 1. Stages of preliminary study

Secondary data such as statistical data (population density, education back ground, social economic status etc.), soil type map, land use map, land slope map, water springs distribution, rivers density map etc. provide useful information as consideration for determine preliminary strategy. The final strategy must be completed after field survey to collect actual information including social economic survey (rapid rural assessment and rapid participatory assessment).

Field survey

In water resources development program, field surveys are required to verify actual condition of area. Commonly, there are three types of survey as follows:

1. Water resources potency survey
2. Topographical survey
3. Social economic survey

In survey of water resources potency, field investigation must include assessment of river discharge, water springs, river network and river profile. This survey is required for small scale dam construction where the river profile will affect the capacity of dam. Figure 2 shows water resources survey activity for water resources development.

Figure 2. Survey of water resources potency

Topographical surveys are required for engineering and vegetative approach. Small dam construction needs information of elevation and land slope to determine the location of structures. Small scale dams are good for sedimentation control and increasing ground water recharge in the area with high slope and small rivers. Small dam which constructs in high elevation area increases water level, so that water retrieval can be applied for completing water needs in downstream area.

Meanwhile, vegetative approach by increasing vegetation cover needs land slope elevation for determining priority scale of the program, where are with high slope and low vegetation cover are priority area. Increasing vegetation cover will increase infiltration, reduce surface runoff and increase ground water storage.

Social economic survey is important part of the program to understand the social economic background of local inhabitant. Social economic factor is mainly related to local cultural, educational background and livelihood. Studies by Setyawan et al. (2013) and Susanto et al. (2013) indicated people with low education have a high dependency of land which is mostly used for farming. There are four main activities of this survey:

1. Program introduction
2. Rapid rural appraisal (RRA)
3. Participatory rural appraisal (PRA)
4. In-depth interview

Program introduction introduces the program to community through a meeting or discussion forum. People can get all required information and give suggestions about the program. Meanwhile, rapid rural appraisal is a survey to collect information about social economic background of the inhabitant and participatory rural appraisal is a survey to collect aspiration of the inhabitant. These two surveys could be done in the meeting.

The RRA and PRA are time consuming, hence, a good scheduling is helpful to achieve the target of surveys. In case a very huge number of population, sampling method by considering sampling ratio toward total population could be the better way for implementing the RRA and PRA. Figure 3 shows activities during the RRA and PRA. For in-depth interview, it is collecting information from key persons of the community by interview. This way enables data collecting in a shorter time.

Figure 3. RRA and PRA activities

The finding of social economic survey provides important information for consideration the water resources development program. Hence, the program's goals could be reached as planned. Continuously, community involvement could be realized with appropriates strategy of the program.

Feasibility assessment

Feasibility assessment aims to evaluate the suitability of the program by considering local circumstances and the purposes of the water resources development program. Commonly, local circumstances are included some factors such as:

1. Hydrological condition
2. Erosion and sedimentation
3. Land use types
4. Vegetation cover
5. Land slope
6. Soil characteristics
7. Social economic

Areas with low water availability, high erosion and sedimentation, high farm land, low vegetation cover, high land slope and high population density are feasible for the program. Assessment of local condition could be conducted by field assessment and in-depth interview with the local inhabitant.

Figure 4 shows an example of erosion field observation in an agricultural land. Those pictures indicate a high soil loss due to low vegetation cover and high land cultivation. Area with high population density must involve the local inhabitant to participate the program. Hence, program sustainability could be reached.

Figure 4. Field observation of soil loss (Erosion)

Action plan and Implementation

Feasibility assessment is followed up by action plan and implementation of water resources development program. Stages of program implementation are consisted of some activities as follows:

1. Determining specific location of the program
2. Scheduling
3. Designing
4. Implementation

Short-term and long-term water resources development programs for increasing water availability in the future use various approach such as regreening deforested land, constructing small farm reservoir, constructing dam, terracing etc. The selected approach must be clearly determining a specific location of the program. Figure 5 shows an example of program locations (points with number of 1 to 4) for gully plug construction and clean water storage in a mountainous village.

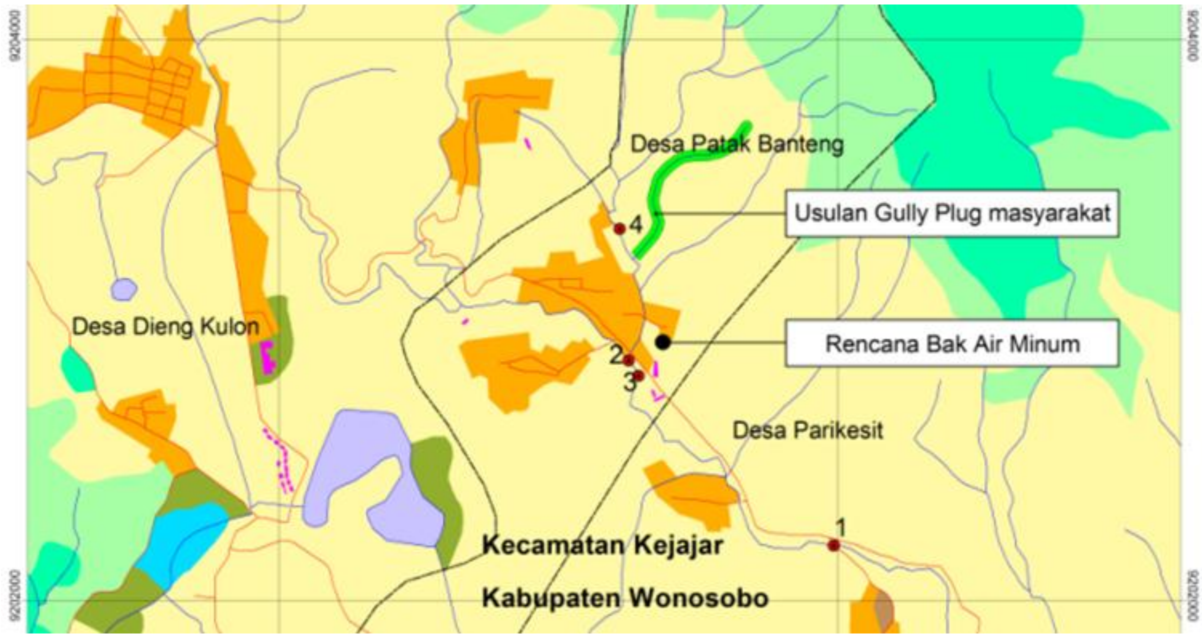

Figure 5. Specific locations of water resources development program

Another important thing before designing is scheduling. It must be in detail describe all stages of the program. After scheduling, the program starts a detail design of construction which is clearly describing all aspects of the construction (dimension, location etc.), hence it provides a good information for program implementation. Figure 6 shows an example of gully plug design for reducing river bottom degradation and increasing water storage. A design accelerates the progress of program implementation by providing a good guidance.

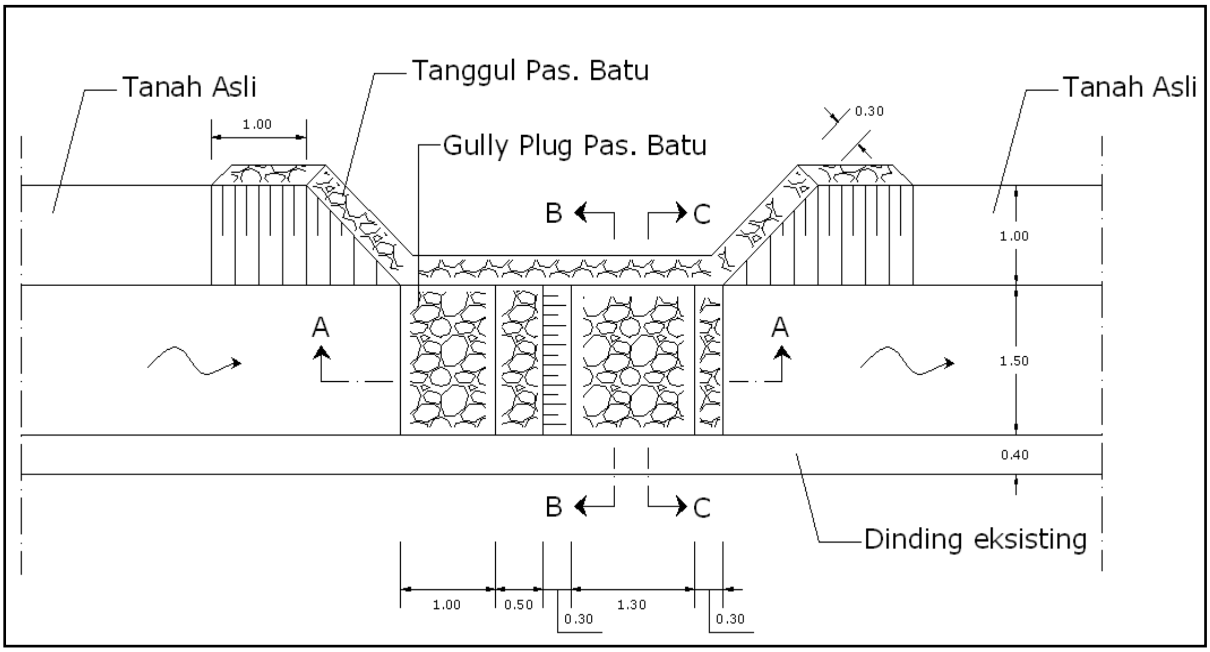

Figure 6. Design of gully plug structure

After designing, program implementation will be conducted as scheduled. For program in the scheme of community empowerment, while must involve community participation, material of construction can also be collected from local source (e.g. stones, sand, wood etc.) as shown in the Figure 7.

Figure 7. Construction of gully plug by using gabion

Case studies

This part describes some case studies of community empowerment for water resources development in some approach and for some different purposes.

1. Development of fish farming in swamp water

This program aimed to optimize water resources potency in the estuary area between lereng and jati rivers, southern Purworejo, Central Java Province, Indonesia (Figure 8). These rivers are located on the border of saltwater and freshwater, but, generally dominated by fresh water. The program was held by involving local community (farmer) and local government which was represented by Fisheries Agency of Puworejo Regency. Local community has a role as an implementer of the program, while fisheries agency provides guidance for the program.

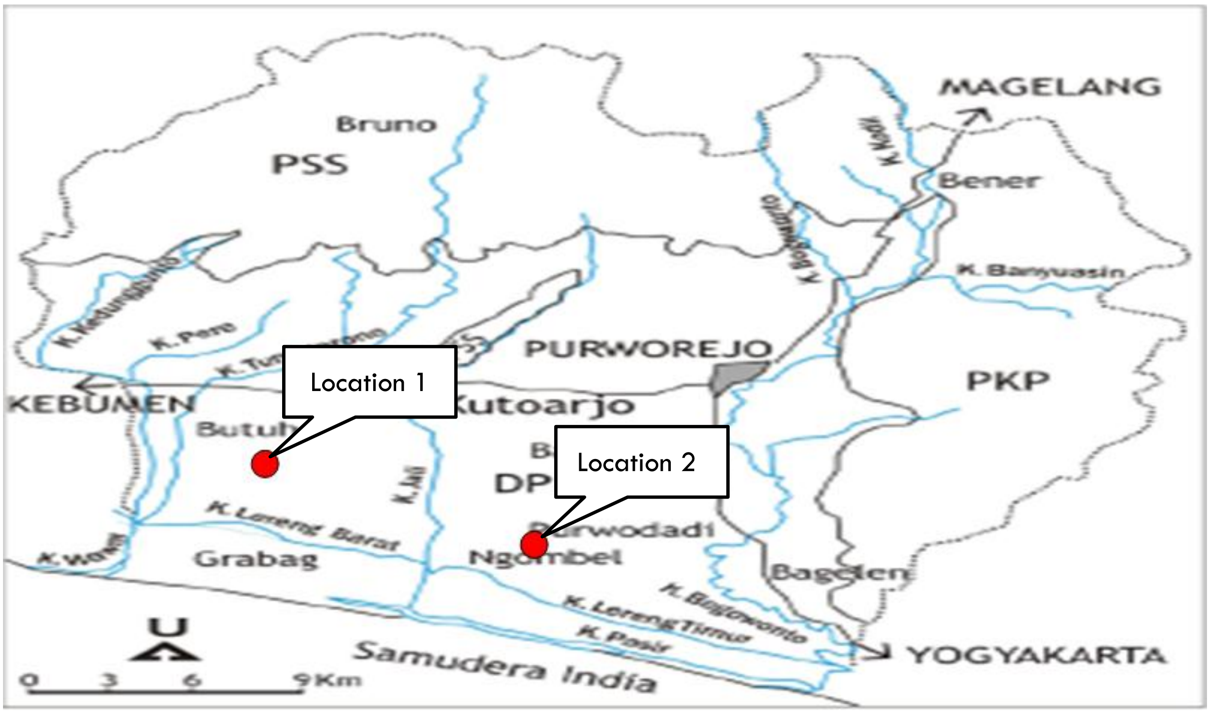

Figure 8. Location of development of fish farming in swamp water program

Development fish farming of in the swamp water between lereng and jati rivers was a water resources program to support agricultural sector especially for increasing fishery production of local farmers. The program was feasible in this area due to some reasons such as huge number of water availability along of the seasons, easy road access and the feeds are much enough. Figure 9 shows algae plant in the place of the program.

Gambar 9. Algae plant in the swamp area of lereng and jati rivers

The program was started with in-depth interview and socialization which was attended by local farmer and is continued by constructing program's plot. Guidance and monitoring were conducted during the program. Figure 10 shows handover of fish seeds and discussion with farmers in the field.

Figure 10. Handover of fish seeds and discussion with local farmers during the program

The program was completed after about 2,5 months. Fish seeds which is cultivated in the program site has economic value around of IDR. 5,000,000,- and increase to IDR. 13,000,000 after harvesting. Hence, the farmers were receiving IDR. 3,200,000 for a month. This program provides an alternative way to reduce excessive fish farming in some reservoirs in Java Island. This program results useful references to solve problems about water resources management particularly related to social economic factors. Activity during fish harvesting process is shown in the Figure 11.

Figure 11. Fish harvesting process

2. System of rice intensification (SRI)

System of rice intensification (SRI) is the set of practices to increase the productivity of irrigated rice by changing the management of water. In SRI system, rice grow by low water demand, so that, many water could be used for other purposes. SRI offers a new form of water resources development and enable increasing rice production in dry areas. We introduced SRI to farmers in the downstream area of Sempor reservoir, Kebumen Regency, Central Java Province, Indonesia in 2009. The plot of SRI was selected by considering the existence of irrigation system canal and road access (Figure 12.)

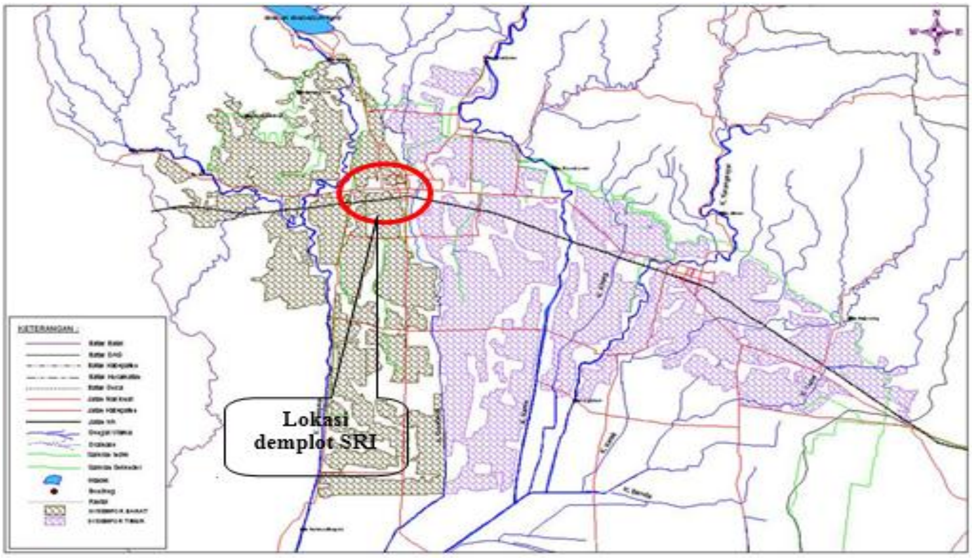

Figure 12. Location of SRI program in Kebumen Regency

The program was started by program introduction (socialization) and training which was followed by local farmer, water user farmer association member, village government officer and field irrigation observer. Some types of training were given to participants such as:

1. Organic fertilizer production
2. Natural pesticide production
3. SRI: nurseries, planting method, irrigation operation, plant monitoring
4. Pests and plant diseases control

Three plots of experiment were used in this program i.e. plot of SRI 1:1 (1:1 comparison of organic and chemical fertilizer), plot of SRI 1:3 (1:3 comparison of organic and chemical fertilizer) and plot of conventional rice plantation.

Nursery was begun a few days after training by involving local farmers. Nursery plot was located near the SRI program location. Nursery for conventional method was implemented by spreading rice seed in the field. Whereas, for SRI, it was grown in small growing box (Figure 13), hence, it was easy to move into field for planting.

Figure 13. Rice nursery for SRI

Rice seeds was planted after 10-14 days nursery. For conventional method, commonly it was planted around of 21 days after nursery. Plant interval, seed requirement and operation of irrigation between SRI and conventional method weren't same as described in Table 1. Generally, SRI had a longer plant interval, less seed requirement and low water need.

Table 1. Comparison of SRI and conventional rice cultivation method

Aspect	SRI	Conventional
Planting days	10-14 days	21-23 days
Plant interval	30 cm x 30 cm	25 cm x 25 cm
Seed requirement	8-10 kg/ha	20-30 kg/ha
Seed per planting hole	1 seed	3-5 seeds
Irrigation system	interrupted flooding	full flooding

Seed planting one seed for each planting hole after 10-14 days nursery in SRI, produced higher seedlings than conventional method, hence in SRI, plant interval must be longer. Figure 14 showed planting activities of SRI.

Figure 14. Planting activities of SRI

For irrigation, in SRI, irrigation (to achieve 2 cm water level of flooding) was given when the soil indicates wet dry condition, indicated from the appearance of smooth crack in soil surface. Interrupted flooding system in SRI enables lower water use compared with conventional system. Application of control system for determining soil moisture content and irrigation offer a better control system for SRI. Weeds plant control was conducted from nursery until pre-harvesting period.

In this program, farmers were encouraged to use organic fertilizer due to environmental security consideration. The other reason was due to economic consideration where organic agriculture product has a higher price than conventional product. Comparison of three type of plots were described in Table 2. Full organic farming in a large scale is costly, hence, this program started to introduce semi organic farming.

Table 2. Components of SRI and conventional rice plantation

Aspect	Semi organic 1:1	Semi organic 1:3	Conventional
Organic fer.	5 ton/ha	2.5 ton/ha	-
Urea	125 kg/ha	187.5 kg/ha	250 kg/ha
TSP	-	-	100 kg/ha
KCl	-	-	100 kg/ha
Ponska	125 kg/ha	150 kg/ha	-
ZA	62 kg/ha	62 kg/ha	-

Some findings were found from this program. Number of seedlings among of three plots showed that plot semi organic 1:3 produced the highest number (about 45 seedlings for a planting hole) followed by semi organic 1:1 (about 30 seedlings for a planting hole) and conventional method (about 20 seedlings for a planting hole) as described in Figure 15. The differences of seedlings number were clearly found in day 30 to 70 after planting. Meanwhile, for irrigation, semi organic 1:1 reduced about 20.9% of water need, while semi organic 1:3 reduced about 26.4% of water need compared with conventional system.

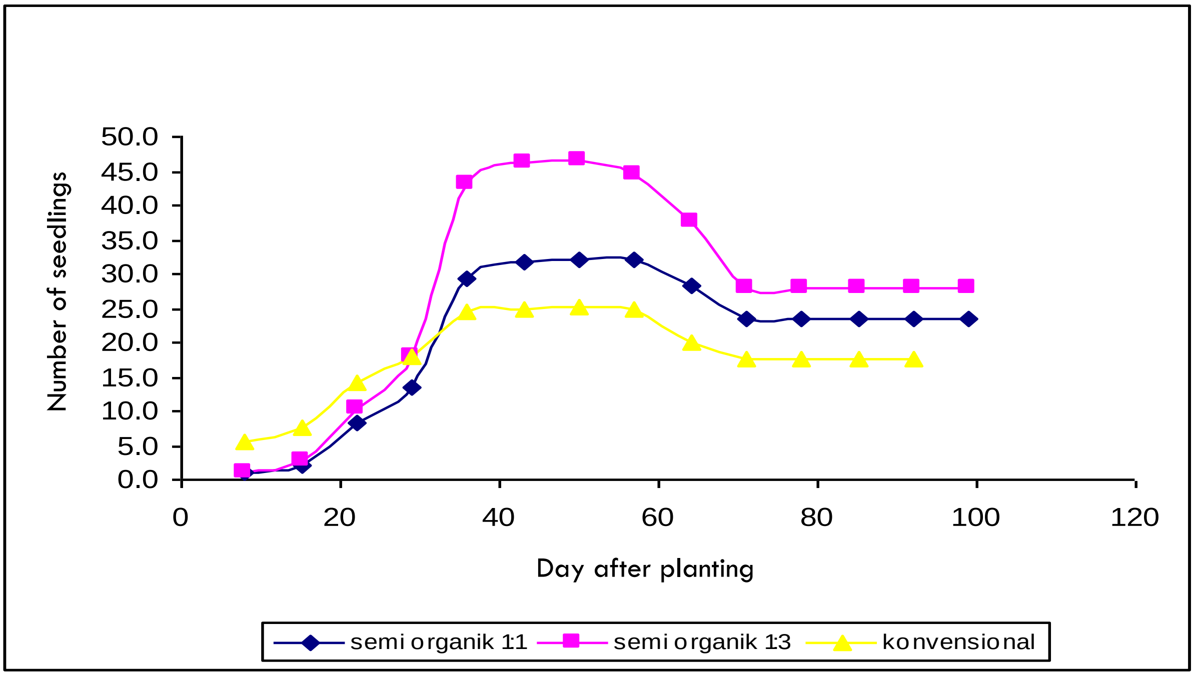

Figure 15. Number of seedlings for three types of plots

About 100 days after planting, rice of three plots were harvested. semi organic 1:1 plot produced the highest yield (Figure 16).

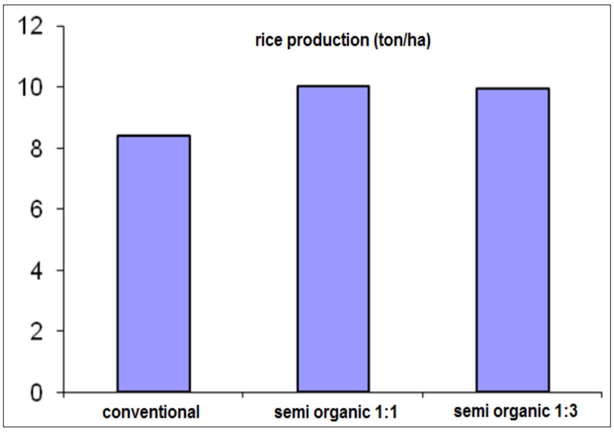

Figure 16. Rice production from three different plots

Semi organic 1:1 plot produced about 10.01 ton/ha (19.6% higher than conventional), semi organic 1:3 plot produced about 9.93 ton/ha (18.49% higher than conventional) and conventional plot produced about 8.38 ton/ha.

3. Water conservation program in mountainous area

This program aims to increase the value of water utilization and to increase ground water re-charge by constructing conservation building and re-greening critical land in mountainous area of Dieng, Wonosobo Regency, Central Java Province, Indonesia in 2010. Small dams with gabion and gully plug (Figure 17) were constructed to increase water re-charge and to control erosion and river sedimentation in upstream area.

Figure 17. Small dams and gully plug construction

Another same program was vegetation method by re-greening deforested area (Figure 18). Increasing vegetation cover could reduce land erosion and river sedimentation.

Figure 18. Re-greening deforested area

4. Fish cages cultivation in tropical river

This program aims to increase the value of water utilization in river and to reduce social economic problem by increasing local inhabitant income in downstream Serayu River, Central Java Province, Indonesia in 2011. High dependency of people on land for farming and river for sand mining were threaten the potency of water resources due to increasing surface runoff, land erosion and degradation of river bottom. The program involved local inhabitant which was mostly a farmer, local non-government organization (NGO) of Serayu river and local fishery agency in Banyumas Regency. Program location was selected based on agreement with local community and local government (fishery agency). The program was started by program introduction (Figure 19).

Figure 19. Introduction of fish cages cultivation program to local community

Fish cages was made by local community using local material (Figure 20). During cage construction, supervision was conducted by local government (fishery agency). Fish cage construction spent about 3-4 weeks effective time and produced about 16 units for tilapia fish cultivation. Fish type was determined based on agreement with local community. This type of fish can be harvested in short time (around of 3 months). River side modification was conducted to anticipate river flood during wet season about October to March in each year.

Figure 20. Fish cage construction for Serayu river

After construction, each cage was filled with 500 fish seeds (Figure 21). Banyumas fishery agency was giving a practice guidance of fish cages cultivation for local community. Program monitoring was conducted by local NGO and Banyumas fishery agency.

Figure 21. Fish seed release in cage

After about three months cultivation, fish cages were ready for harvesting (Figure 22). Total fish weight of each cage could reach 100 kg. Feed availability in downstream Serayu River increased fish grow. The result of this program provides an alternative way to solve social economy problem to reduce high dependency of local inhabitant on land and river.

Figure 22. Fish cage cultivation harvesting in Serayu River

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