Soil Conservation Technology for Farming Systems in the upper Watersheds of Indonesia

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INTRODUCTION

Farmers' livelihood in the watershed areas of Indonesia are generally marginal. Their main income, which can rarely support the family needs, depends on the natural resources available in the area. Consequently, these farmers do not have any choice but to exploit these resources. This in turn proves to be a major factor in aggravating the causes of soil erosion and landslides and land degradation in general.

Land degradation affects 600 watersheds in Indonesia, covering an estimated 11 to 13.5 million ha. About 9 million ha of this area is categorized as critical and needs immediate attention (Notohadiprawiro, 1999). To address the problem, the government has launched several programmes, such as land rehabilitation and conservation. However, these programmes lack farmers' involvement in planning and decision making.

The Assessment Institute for Agricultural Technology (AIAT) in Ungaran recognizes this situation and therefore evaluates agricultural technologies for dissemination with farmer participation. This paper presents AIAT's approach to assess and disseminate agricultural technologies. Likewise, it describes some conservation farming technologies that can be adopted by farmers in the watershed area.

TECHNOLOGY ASSESSMENT AND DISSEMINATION

Human being have always utilized natural resources. The relationship between mankind and nature could be the basis for evolving a conservation farming system (Suharjo and Patong, 1973; Makeham and Malcolm, 1986). The farming system is composed of, *inter alia*, several components that include land, water, climate, fertilizer, seed, livestock, farm equipment, and the farm manager. Shaner (1982) suggested that the farming system as a whole should be regarded as a part of the bigger system, such as the village system, or a regional system.

The farming system in dryland areas as illustrated in Figure 1, consists of several subsystems such as natural resources, external input, internal input, and marketing. This concept has been implemented in Nepal through a research and agricultural extension network to develop farming operations on every agroecosystem (Davendra and Yokohama, 1999).

One obligation of the AIAT in Ungaran is to assess and develop a technology or technologies suitable for the ecosystem in Central Java. The technology should not only be practical and easily adopted by farmers, but also safe for the environment. Several studies of the farming systems in Kaligarang Watershed include growing oranges, increasing farmers' income by growing maize in the agroforestry area, peanut production under young teak forest, and developing an 'embung' (small reservoir) for plant and livestock in the Sindoro Sumbing mountain area.

Approaches and methodology

Although the strategy and approaches of farming operation differ, the principle remains the same, that is, using the **participatory approach and technical services**. Initially, farmers have to be

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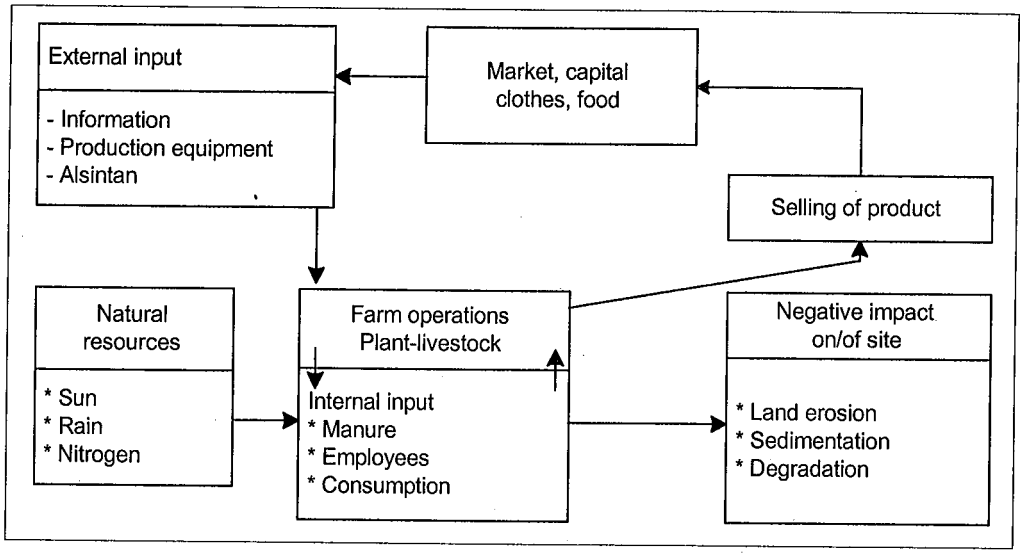

Figure 1. The interconnection among subsystems on a dryland farming system (Prasetyo and Setiani, 2000).

encouraged to make their own plan, prioritize, and solve their own problems. The potential solutions discussed with the farmers are based on preliminary observation on the physical, biological, and socioeconomic conditions on the farm. The linkages among these factors determine the nature of the farming operation. This method is commonly known as participatory rural appraisal (PRA). The alternatives (topdown), farmers' aspiration (bottom up), natural and human resources, together, determine the participation of farmers as illustrated in Figure 2.

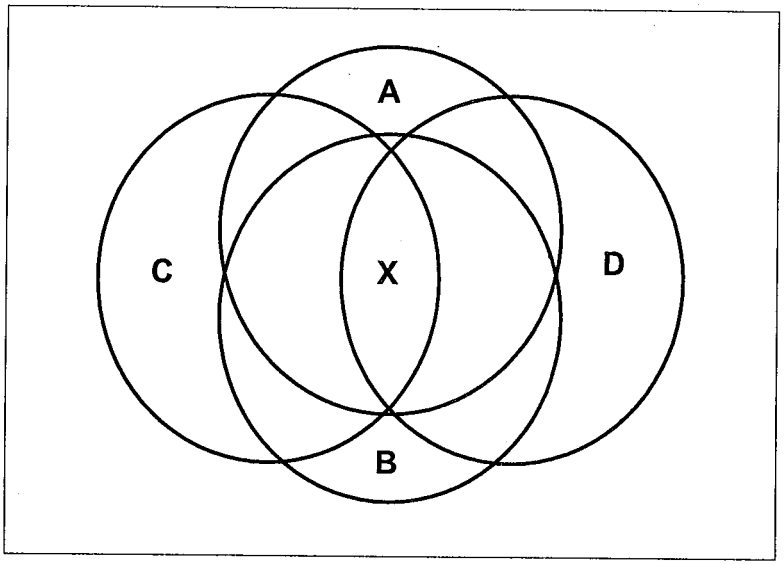

Figure 2. Diagram of the participatory approach (Setiani and Prasetyo, 2000)
Note: A : Topdown approach
B : Bottom up approach
C : Natural resources
D : Human resource
X : Participatory approach

Technology dissemination

Findings or recommendations derived from studies conducted in several watershed areas are being disseminated through extension workers and farmers' group leaders. The field laboratory in Sidomulyo village, Ungaran, representing Kaligarang Watershed is an ideal place for farmers or students to learn how such a study was set up. The site of the field laboratory was first developed in the late 1980s under the Upland Agriculture and Conservation Project (UACP). It now has a weather station and automatic water level recorders, perennial trees, fishponds, and buildings for general purposes.

AIAT Ungaran has a mandate to deliver technologies developed at the Research Institute to stakeholders. The strategy is to bring the technologies as close as possible to farmers' needs and farming conditions. Dissemination approaches include discussion with farmers, publications or electronic media.

ALTERNATIVE CONSERVATION FARMING SYSTEMS TECHNOLOGIES

Conservation is an effort to preserve natural resources and to protect them from damage, loss, and extinction. Fagi *et.al.* (1988) define a conservation farming system as the optimum utilization of land and water for an unlimited time. The utilization of land and water beyond its capacity would result in a damaged ecosystem. Farming operations in upper watersheds require technology that suits the agroecological principles. The following are alternative technologies that have been developed based on several studies in Central Java.

Vegetables and livestock farming systems

Farmers who live in the mountains such as in the Sindoro-Sumbing area (Serayu-Luk Ulo Watershed) and Ungaran (Jratunsenula and Kaligarang watersheds) usually engage in intensive farming. They always grow crops by tumpang-sisip (intercropping) on every inch of available land.For example, farmers usually practice a cropping pattern of carrot-maize-cabbage-fallow. On one hectare, this pattern could produce 12.8 tons of carrot, 1.8 tons of maize, and 6.8 tons of cabbage (Prasetyo *et al*, 2000). The water table is shallow and therefore embung can be built to collect water. Farmers then can grow grasses, legumes, and raise cattle.

In the Sindoro-Sumbing conservation area, various crops are grown all year round. In planting potato, farmers establish a 'bedengan' (flat bed) which is arranged vertically across the contour to avoid excess water that would lead to wilting disease. However, this practice could accelerate erosion. When the furrow is arranged diagonally, it can minimize land erosion by 17 to 65%, while the yield of potato remains the same.

Palawija (secondary crop) and livestock farming systems

One of the activities of the UACP is to introduce high yielding varieties of maize, soybean, and mung bean, with the application of appropriate fertilizers. Fagi *et al.* (1988), Sulaeman *et al.* (1991), and Husein *et al.* (1992) reported an increase in the production of secondary crops by up to 40%. The project included studies on livestock, woody plants, and food crops that were managed in an integrated manner. After the project was terminated, farmers who benefited from the project found it difficult to obtain seeds (Prasetyo *et al.*, 1992). Thus, AIAT Ungaran developed maize seed growers when BISMA variety was introduced into the farming system (Setiani *et al.*, 1999). Likewise, a seed distribution system was developed along with the introduction of technologies to increase peanut production (Prasetyo *et al.*,1999). An innovation or introduction of technology should not only benefit the farmers, but also improve the quality of the environment. The disappointment of a farmer with regard to the introduction of a technology is when his need was neglected.

Crop-fish-livestock farming systems

Integrating crops, livestock, and fish on farmland in the watershed on the upper reaches of river had an ecological and economic impact. It is a conservation measure that improved habitat stability and increased the variety of animals and plants. Such a farming system for crops, livestock, and fish will optimize the resources in the field and surrounding area. This approach has been practiced at Kaligarang Watershed by using surface flow (runoff) collected in an embung. A volume of 30 m^3 could be stocked with 750 fish. In this system, maize was planted in rows alternated with ginger in the first season, and peanut in the second season. Meanwhile, grasses were planted along the dike.

Fish survival was 88% and during harvest (after four months), the weight of each fish ranged from 250–310 g. The yield of maize, ginger, and peanut was 3.6, 6.7, and 1.4 tons, respectively. The production of fresh grasses (harvested seven times) is presented in Table 1.

Table 1. Fresh leaf production of several grasses, planted on a dike at Kaligarang Watershed, 1999–2000

Harvest period	Fresh leaves (kg 6 m^{-1})			
	Pennisetum purpoides	***Pennisetum purpurium***	***Setaria sphacelata***	***Brachiaria brizantha***
April 19, 1999	20.8	23.1	13.5	13.5
May 20, 1999	22.8	16.7	12.4	13.1
July 10, 1999	9.7	12.8	6.3	7.8
August 30, 1999	6.8	4.7	4.1	5.2
October 20, 1999	17.2	11.3	10.4	11.3
November 30, 1999	29.4	18.9	12.3	14.1
January 10, 2000	36.2	24.3	14.3	13.2
March 4, 2000	34.2	24.4	13.5	13.4
Total	**184.3**	**136.2**	**86.9**	**92.5**

Land with 15–30% slopes has 2,000-m-long terraces and the fresh grasses produced from the terraces could amount to 65 tons or about 8.3 tons dry weight. Total harvest on a dry weight basis can be used to estimate the number of livestock that can be raised. This is done by dividing the dry weight by the amount consumed by the livestock in one year. According to Reksohadiprojo *et al.* (1984) and Kearl (1982) the amount of dried grasses consumed by one goat varies from 42.8–78.5 g for every kg of goat having a weight of 20 kg, or a total of 312 to 537 kg dry matter consumed per year. Planting grasses could conserve terraces and the watershed. As reported by Haryati *et al.* (1991), erosion from a slope of 20–40% could be reduced from 25.6 t ha^{-1} y^{-1} to 2.6 to 3.3 t ha^{-1} y^{-1} with the provision of bench terracing.

Crops-trees-livestock farming system

Crop, tree, and livestock farming systems have been adopted by many farmers on drylands. Farmers in Kopeng, Central Java, within the catchment area of Rawapening, practiced growing vegetable and maize, while raising cattle. Cattle fattening is a common farmer's practice. AIAT Ungaran learned that in the past, farmers in this area used to grow oranges. It was reintroduced as a tree intercrop. After three years, the canopy of orange trees covered approximately 1.5 m^2. Although a seasonal crop cannot be grown any longer, orange trees with a minimum production of 40 kg y^{-1} in the first three years, are promising.

SUMMARY

The Assessment Institute for Agricultural Technology (AIAT) in Ungaran is given the mandate to develop and assess technologies suitable for the ecosystem in Central Java. In the hilly areas of Kali Garang Watershed, a number of technologies and farming systems have been identified to give a better income for the farmers. These technologies are based on the past results of researches in Central Java and from the actual assessment and evaluation by AIAT.

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