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The Citanduy project in Java: Toward a new approach to watershed stabilization and development

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The watersheds of Java, Bali, and Madura are densely populated. Densities of 600 to 1,000 persons/km^2 are common within the major watersheds in Java, and less than 25 percent of the land is under forest or other permanent cover. Precipitation in this tropical environment ranges from 1,500 mm to well over 3,000 mm year. The land is intensely cultivated and soil and water conservation is poor. All these factors combine to cause rapid degradation of base resources such as soil and water. Other consequences of poor soil and water conservation practices include flooding, low water for irrigation during the dry season, and sedimentation of irrigation systems and hydroelectric dams.

In 1982, Java imported about 3.4 million metric tons of foodstuffs to feed the present population of 91 million. Within the next 35 years, population of the islands will double. Therefore, conservation of soil and water resources is imperative.

Problem identification

Source of soil erosion and water runoff. In the tropical climate of Java, Bali, and Madura, erosion and runoff from clearcut forest harvesting is minimal. After the first showers, the ground is soon covered with grasses, weeds, and shrubs that stabilize the slopes. With estate crops such as rubber, clove, and coffee, the land is usually well protected from erosion by legumes or grass/weed cover among the trees.

The major source of sediments and runoff is dryland farms on mod-

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erate to steep slopes. Gentle slopes, if the land is bare, can also be major sources. Road cuts and steep embankments bordering roads and narrow valley paddy fields are also significant sources of soil erosion.

The dryland farms. Characteristic problems on the dryland farms are (a) erosion, caused by poor conservation practices; (b) low productivity, which forces the farmers to expand their operation and neglect soil conservation; (c) poor land use and farm planning; (d) lack of technical advice and programs to help the dryland farmers; and (e) lack of off-farm job opportunities for the growing labor force and, therefore, increasing population pressures on the land.

Farmer constraints

Bench terraces with the proper water outlets, waterways, and vegetative stabilization of terrace risers could reduce soil erosion to a minimum, but several factors inhibit their adoption by farmers. The main constraint to development of farm resources is lack of capital. Most of the farmers, especially on dryland farms, live at subsistence levels. But credit for these farmers can only be effective when income not only covers their minimum living standards but also provides some savings.

Irrigated versus dryland terraces. When water is available for irrigation, regardless of how steep the slopes, farmers do not hesitate to build magnificent terraces throughout the mountain side. These irrigated terraces provide a very stable slope with minimum soil erosion. Farmers build these terraces without any subsidy, technical advice, aerial photo maps, topographic maps, or any soil surveying equipment. However, the dryland terraces, many situated immediately above the irrigated terraces, are nearly always failures, for the following reasons:

1. They do not follow the contour line of the slope.
2. When they slope downhill, the water cascades from terrace to terrace.
3. When they slope toward the hillside, water accumulates in the lower points, cascading downhill and cutting gullies.
4. Runoff is excessive because nothing slows the water flow to allow maximum infiltration.

In many cases, the same farmer who builds the good irrigated terrace also builds the poor dryland terrace. Why is this so? Paddy farming is an old practice in Indonesia. The farmer knows that if he has water to irrigate his terraces, he can produce at least 2.5 to 3 t/ha of rice. But he also knows that his dryland rice yields will only be about 0.5 t/ha. There is no economic return for the effort required to build good dryland terraces.

Economic conditions at the farm level. Under irrigated conditions, the farmer is sure of at least one and a half crops of rice per year. If the water comes from a technical irrigation system, a farmer can usually get two to two and a half crops per year. At a very low production level of 3 t/ha, this means a yearly crop production value of 652,500 (U.S. $653) to 1,087,500 Rupiahs (U.S. $1,088)/ha.

On the paddy fields, the landholding is about 0.3 ha/family. Since 3 t/ha rice yield requires minimum inputs, the income from a 0.3-ha farm averages 16,300 (U.S. $16) to 27,100 Rupiahs (U.S. $27)/month.

Under dryland farming, only one crop of upland rice (dryland rice) can be harvested per year. The time from seeding to maturity for local upland rice varieties is about 150 days. For irrigated rice, the time is 90 to 135 days, depending on the variety planted. Also, irrigated rice can be started in a seedbed.

The average production of upland rice is about 0.5 t/ha when intercropped with cassava and corn, as is traditional in most parts of Java. The cassava production is about 2 t/ha (wet weight) and the corn about 0.5 t/ha (wet weight with cob).

The second crop in the dryland farms consists of peanuts intercropped with the corn and the cassava planted with the first cropping system. However, only 30 percent to 40 percent of the dryland farmers plant a second crop. Average farm monthly incomes are roughly 21,700 Rupiahs (U.S. $22) for irrigated farms (0.3 ha) and 13,853 Rupiahs (U.S. $14) for dryland farms.

Seed sources and credit availability. Dryland rice seed sources are extremely limited. Only irrigated rice varieties of fairly good quality can be purchased at the village level, and some improved corn varieties are available in provincial capitals or Jakarta. Most dryland farmers use impure, traditional seeds of local varieties that germinate and perform poorly.

Credit is available to very few dryland farmers. Subsidized loans are time-consuming and difficult to obtain; high-interest loans are easy to obtain but difficult to repay.

Urea and triple superphosphate fertilizers are available at reasonable prices because of government subsidy. Seeds and other fertilizers needed in the dryland farms should also be made available at subsidized prices.

Technology and experience on dryland cultivation. The National Food Crop Extension System reaches only those farmers engaged in paddy rice cultivation. Dryland rice farming systems are more complex and difficult. In irrigated rice production a single package of technology can be used throughout the country; however, in dryland farming, cultural practices

of each crop must fit specific soil type, precipitation, level of nutrients, and other factors.

Government constraints

Traditionally, rice has been the staple food of Indonesians. Even in areas where other crops, such as corn, are more abundant, as in certain kabupatens (districts) of Sulawesi, the wealthier population consumed rice. Corn was labeled a poor people's diet. Today, special campaigns organized by the Governor of South Sulawesi are directed at increasing the corn consumption as a staple food of that province. Other upland crops normally grown under dryland conditions have been ignored. The government is now trying to increase their production, but our level of knowledge of dryland (palawija) crops is in its infancy. The production of rice is reaching a plateau, but the population is increasing; thus, the staple food needs to be diversified to provide an adequate, more balanced diet. This also may help to decrease rice imports; therefore, the emphasis is on diversifying the agricultural system.

Research on farming systems. Research on crop breedings, adaptation and cropping systems is conducted by the Agency for Agricultural Research and Development, under the Ministry of Agriculture (MOA). Their task, however, is monumental. To achieve full production potential and increase farm income, research is needed to determine the most appropriate technology for each environmental condition. Recommendations can be extrapolated only after enough trials have been conducted under different conditions and soil types.

Dryland farms averaging 0.5 ha produce many different commodities; therefore, if the production of only one commodity is improved, the impact on farmers' income will be minimal. A demonstration project must be preceded by enough data on each of those crops under different levels of inputs and choices of varieties best adapted to the site type.

Soil and water conservation. The rapid deterioration of the watersheds is due not only to population pressures and land use change from permanent vegetation to agriculture but also land use change without proper conservation practices. However, if land use planning is done properly, each farmer can use his land to its maximum potential under well managed conservation practices. When better sources of alternative income are made available to the farmers, marginal lands can be changed to permanent vegetation. Until that time, however, compromises are needed to help farmers obtain adequate income while keeping land deterioration to a minimum. Low production from the dryland farms makes conservation unprofitable. Until this fact is understood and addressed by the government agencies, soil and water erosion problems will continue.

Extension. When farmers on the dryland farms have diversified operations (crops, forage livestock, fish, estate crops, timber, fuel wood, and fruit trees), it is impossible to supply an extension specialist for each of these activities at the farm or farmers' group level. The polyvalent concept (multidisciplinary) of extension field workers appears to be the only alternative. The polyvalent extension system requires subject matter specialists to meet periodically with the extension workers. This is taking place in some Rural Extension Centers, especially in rice paddy field cultivation. The ratio of extension workers to area of paddy land is, in most cases, one for every 800 ha. However, the ratio is smaller for dryland. Although 30 percent to 40 percent of the extension workers may have attended the 1½-month training course in the polyvalent concept, the subject matter specialists come only from the Directorate General of Food Crops. Thus the polyvalent extension system is only food crop related. This is part of a confusion between an extension program and a commodity-oriented program. The system might be more efficient if the Agency for Extension brought farmers the latest technology and methods to upgrade the rural community rather than the Food Crop commodity-oriented program. The Rural Extension Centers could then become centers for disseminating techniques in rural development, such as crops, livestock, fisheries, health, and home economics.

Rather than assign fixed numbers of extension workers per area of land, it is more appropriate to concentrate manpower where project goals can be reached. The extension workers can then move to spread the new techniques to other areas. The best extension is that promoted by farmers themselves.

Grasses for forage and for stabilizing terraces

Grasses and legumes are extremely difficult to find in Java, and available varieties are limited and in very small quantities. In a tropical environment, however, forage has tremendous potential and can serve as well to stabilize terrace risers and other critical lands. Large grass nurseries are essential for distribution to the farmers.

Knowledge of forage for feeding livestock and for soil stabilization purposes is lacking within the technical government agencies. The only grass they currently use is elephant grass (*Pennisetum purpureum*).

This grass, when planted in the proper place and if adequately fertilized, will produce excellent forage. But farmers seldom fertilize it, and it shades out food crops when it is planted on the terrace risers. On the other hand, if the grass is not allowed to grow to 1.5 m tall, at which height it

starts flowering, it will eventually die. If cut at the flowering stage, it has enough stored energy to grow again. Also, elephant grass requires high soil fertility, whereas in most cases the terrace risers are mainly subsoil of low fertility.

Grass must form a solid ground cover if it is to stabilize the soil. Thus, only rhizomatous or stoloniferous grasses should be used, and many of them also have excellent palatability and nutritive value for livestock.

With the present level of income from the dryland farms, it is impossible for farmers to expand their herds. The formation of farmer groups and cooperative associations could give the farmers a better bargaining position to purchase and obtain inputs as well as to market their products.

Most farmers have little knowledge of animal health, nutrition, weight gain, or breeding; thus, their livestock are at the lowest level of performance. The low degree of livestock fecundity and the high mortality of offspring are mainly due to poor diet.

Government assistance in basic livestock management problems would have a greater impact on farmers' income than the present push for artificial insemination. A particular example of mismanagement of livestock is in Kabupaten Boyolali. In this village the government at one time provided milk cows. The farmers owned eight milk cows, which produced 7 liters of milk per day and were "dry" 4 months per year—an extremely low production level. They also had problems getting the refrigerated semen for artificial insemination and, in practice, few of the cows gave birth to live, healthy calves. The farmers were feeding mainly local grass, which was coarse, fibrous, and low in palatability and nutritional value. They brought water in a bucket twice a day rather than allowing the cows to drink as much as they wanted when they needed it.

Possible solutions to the watershed problems in Java

Research is needed to develop the appropriate technology for maximum farm productivity in each environment. The technology needs to have proven economic advantages. A system of model farms, together with training and extension, must be established to make that technology available to the farmers. Rapid multiplication of seeds, plant materials, and livestock must take place. Credit programs need to be established. Credit and other incentives should be given only to those farmers willing to participate in soil and water conservation programs. The conservation program should be conducted on the basis of a group of farmers in a mini-watershed or hydrologic unit. For example, terraces could then be built along the contour of the hillside regardless of property boundaries. For credit purposes, it is also better to deal with groups than with individual farmers because there is a sense of responsibility and moral obligation within the group.

The conservation and agriculture development project should be the people's project and not the central government's project. It is the responsibility of the central government to provide the technology and resources not available locally. Our experience in Citanduy and the Solo River Basin is that the farmers are always willing to cooperate if the government is willing to provide them with technical assistance, seeds, plant materials, fertilizers, and credit.

Farm system technology package. Dryland farmers live at subsistence levels, with landholdings of about 0.5 ha. A comprehensive farm development program is required to provide a significant contribution to their farming income. This farm development program should consist of the following:

1. Crops. (a) Improved cropping systems adapted to the specific environmental conditions of the specific site. (b) When feasible, introduction of a third crop, such as sorghum or legumes, that is drought resistant, and can make use of the residual moisture at the end of the rainy season. (c) Introduction of improved high yielding varieties of seeds that are responsive to fertilizers and resistant to pests and diseases. (d) Consistent multiplication and distribution of pure seed lines. (e) Economic use of fertilizer to provide the best return for the level of inputs. (f) The best plant density for the level of inputs. (g) Comprehensive crop protection against pests and diseases.

2. Forage. (a) Proper grasses and/or legumes best suited for the specific site for terrace riser stabilization and livestock feed. (b) The use of *Leucaena* to supplement protein in the livestock diet, and as a source of fuel wood. It can be planted as a hedge to mark property boundaries or in areas over 50 percent slope. In shallow soils where bench terraces cannot be built, thick hedges of *Leucaena* can act as vegetative barriers to stop soil erosion.

3. Livestock. (a) Small ruminants such as sheep and goats, which are usually more appropriate and more easily marketed than larger livestock. Also, a portion of the herd can be sold when funds are needed, and the death of an animal is less disastrous. (b) Cows and buffaloes in areas where they are used as draft animals. (c) Dairy cows in areas where milk industry facilities are available.

4. Trees. (a) Cash crop trees, such as clove or coffee, to provide a source of income. (b) Fruit trees to provide food and income. (c) Timber trees, such as the fast-growing and nitrogen-fixing *Albizia falcata*. (d) Fuel wood and animal feed trees such as *Calliandra* and *Leucaena*. A combination of these trees should be planted in areas with over 50 percent slope or other marginal lands. Adapted, shade-tolerant forage grasses and legumes for soil stabilization and animal feed as an alternative source of income should be planted.

5. Fish ponds. If a suitable water source is available, fish ponds should be built and stocked with different noncompetitive varieties of fresh water fingerlings. An 8- by 10-m fish pond can produce an income of about 600,000 Rupiahs (U.S. $600)/year.

6. Beehives. In a tropical environment where there are always some plants flowering, honey can be an easy source of income and food sweetener for a minimum effort and investment.

7. Poultry. Layer or broiler operations should be established when about 70 percent of their feed can be grown as a third crop during the dry season with such crops as sorghum or legumes.

8. Charcoal. In areas where it is not possible to grow a third crop and there is sufficient land not suitable for crops or over 50 percent slope, the manufacture of charcoal should be considered. With this type of operation, the farmer can supplement his income during the dry season by pruning trees such as *Leucaena* and *Calliandra*. Other crop residues such as corn cobs and cassava stems can also be used to make a charcoal brickette, using cassava paste as a binder.

Organization and administration. Government assistance to individuals and communities and local and provincial governments must be well designed—neither too large nor too complex. The goals and target areas should be clearly stated and scheduled.

One agency should be formed that will be responsible for all technical inputs for the stabilization and development of watersheds. This agency would operate within each province that has watershed development programs.

This agency should be similar to the present Directorate of Reforestation and Land Rehabilitation (DITSI); however, it should not be under the Directorate General of Forestry since the target areas are not the forests but the privately owned dryland farms in the watershed. This new agency should train subject matter specialists, mid-level specialists, and perhaps some extension workers, to support extension efforts in soil and water conservation techniques and coordinate activities. Thus, this agency must be the umbrella organization for coordination and integration of the program.

The watershed program should consist of the following components:

1. Research. (a) To develop appropriate technology packages. (b) To develop the most appropriate soil conservation techniques and land uses as determined by the Soil Research Institute at Bogor.

2. Extension support by government. (a) Soil and Water Conservation and Watershed Development Agency, (b) DG Agricultural Research, (c) DG Food Crops, (d) DG Animal Husbandry, (e) DG Estate Crops, (f) DG Forestry, (g) DG Fisheries, (h) DG Bangda, (i) DG Water Resources, and (j) others as program activities require.

3. Coordinating Agency. The new conservation and watershed development agency should, under the Bupatis and Governors, coordinate all technical inputs for the watershed program. Since most of the activities would be within the Department of Agriculture (DOA), a central coordinating headquarters facility should be established at the basin level.

Since the watershed development targets are the dryland farmers and their community, local governments must be brought fully into the program. Their participation is essential for motivating, organizing, providing support and serving as a channel to express the people's desires. To ensure local government participation and encourage cooperation of the technical agencies with the local government, the budgets for implementation (other than research) should go directly to the local governments. The Bupatis, however, should appoint a watershed coordinator as the liaison between the local government (Bupati) and the technical agencies (the Director of the Agriculture Watershed Development Basin Headquarters, AWDBHQ). That director should then allocate the budgets to each sector within his headquarters and be responsible to the Bupati for the final end-product. Auditors from BAPPENAS should periodically ensure that budgets are properly spent and targets reached. Thus, the Bupatis and Directors of AWDBHQ should be held responsible for the success or failure of the watershed development projects. Authorities at the basin and national level will provide guidance on policies.

Citanduy II case study

The Citanduy River Basin Development Project covers two watersheds, the Citanduy with 350,000 ha and the Segara Anakan with 96,000 ha. The average population density of the Citanduy basin was 640/km^2 in 1979.

Land use in the Citanduy watershed includes lowland rice (25%); upland crop (34%); plantation (13%); forest (13%); home and gardens (8%); pond, rivers, etc. (1%); others (6%). About 59,000 ha or 17 percent of the upper watershed is classified as a critical area.

The goal of the project is to sustain the productive capacity of the basin, by using better soil and water conservation techniques while enhancing the capacity to produce food through better use of soil and water resources.

The Citanduy II project has three main components: (a) upper watershed development to provide a package of upland conservation and production technology to upland farmers, (b) development of irrigation systems to rehabilitate upper Citanduy irrigation systems and their management, and (c) local development planning and management to help district government personnel.

The Citanduy II watershed component of the project is based on con-

servation technology developed in Solo and farming system technology developed in Panawangan (Citanduy Basin) pilot watershed projects. A farming system approach was used with components to increase upland agriculture and livestock production and reduce erosion with bench terraces, waterways, and vegetative stabilization of the terrace risers.

Organization. A basin coordinating committee was established by decree of the Ministries of Agriculture, Home Affairs, and Public Works to coordinate the project implementation under the national level steering committee established by presidential decree.

At the project level the Ministry of Agriculture established a multidisciplinary team of technical personnel from various agencies led by a project manager. Field staff is composed of personnel drawn from the various director generals and agencies of the DOA.

The watershed project consists of the following components:

1. Agricultural research. Applied research by the Agency for Agricultural Research and Development (AARD) covers cropping systems, livestock, agroforestry, freshwater fisheries, soil erosion, and other concerns.
2. Model farms. The size of a model farm is approximately 10 ha. Terraces are built according to the project specification on soil with slope less than 50 percent and depth more than 30 cm. For land with greater than 50 percent slope, permanent vegetation is established. The agricultural technical package includes seeds, grass, fertilizers, and insecticides for three cropping cycles. The livestock component depends on the amount of grass produced from the terrace risers and other available forage. Farmers in the model farms are expected to become a source of technology and seed for other farmers in the area.
3. Nurseries. The nurseries are planted half with grass and half with tree crops. The grass and tree crops are given free to the farmers in the model farms and expansion areas.
4. Expansion areas. In these areas, farmers voluntarily duplicate the model farms. The labor to build terraces is provided by the farmers. Grass, tree seedlings, seeds (food crops), and fertilizers are free. If the terrace risers have more than 70 percent grass groundcover, in the second year the farmer qualifies for credit to purchase livestock.
5. Access roads. Access roads to model farms are constructed as needed under the administration of the local government.
6. Extension and training. Extension workers, from the Rural Extension Center, transfer improved upland technology to farmers on the model farms and in the expansion areas. At first, extension workers are highly concentrated in the model farms. They move away from them as the nearby, voluntary expansion program takes place. Basic training in agricultural and extension methods is given to all new extension workers. Other courses are offered for key farmers and local government officials.

7. Consultants. Foreign and national consultants are assigned to guide the counterpart staff. The present consultant team has experts in watershed management, planning and programing, local government, upland agricultural extension, irrigation extension, cropping system research, soil conservation, and socioeconomic concerns.

Present constraints. After the first year of implementation, the major constraint is the understanding of the project goals and mechanisms. Coordination among the various agencies and levels of government is also difficult. Notwithstanding, the project is working. People are recognizing the weak spots and acting to improve operations. The major problems have been making the budget available on time to provide farm inputs for the planting season and providing an adequate supply of grass for vegetative stabilization of the terrace risers and forage for livestock.

Inadequate grass delays the implementation of the livestock program and causes some deterioration of the terrace risers. A lack of large quantities of quality food crop seeds is another major constraint.

Preliminary results. Officials have shown tremendous understanding, willingness to cooperate, and desire to solve the problems as the project moves ahead. Farmers have shown excellent response in the voluntary expansion program, building all the soil conservation structures at no cost to the government in exchange for the package of technology. During the first year, 300 ha were terraced to project specifications by the farmers under the voluntary expansion program from five model farms. During the second year, with 11 model farms in operation, the voluntary expansion area is expected to be about 1,000 ha.

Conclusion

The objective of the watershed stabilization and development program is not just to build bench terraces on the hillsides, but to prove to the dryland farmers that with the proper techniques and additional resources (high-yielding seeds, fertilizers, forage, and livestock) their dryland bench terraces can be as productive as their irrigated bench terraces. Only then will the farmers build and maintain their dryland terraces as well as their irrigated terraces. But this result depends on the ability of the government to make readily available the supplies and other necessary resources and to deliver, disseminate, and coordinate these resources. In the meantime, the fertile topsoil, the hope for feeding the increasing population of Java, continues washing away. The population of Java will double in the next 35 years, while the rice paddy production is reaching a plateau, thus leaving the uplands as the last frontier for food production. The watershed program is therefore vital to the country's future.