NATURAL VEGETATIVE STRIP TECHNOLOGY: A "NO COST" PARADIGN THAT MAY HELP TRANSFORM TROPICAL SMALLHOLDER CONSERVATION

ABSTRACT

Contour hedgerow systems using nitrogen-fixing trees have been widely viewed and promoted as important components of soil conservation in Southeast Asia to minimize erosion, restore soil fertility, and improve crop productivity. Although positive results have been observed and reported in a number of experimental and demonstration sites, farmer adoption is poor. This low adoption is associated with constraints of high labor requirements in establishing and managing hedgerows. However, the concept of contour hedgerows was a popular idea. We saw that some farmers experimented with the concept by placing crop residues in lines on the contour to form "trash bunds". These rapidly revegetated with native grasses and weeds and soon formed stable hedgerows with natural front-facing terraces. Other farmers tried laying out contour lines but didn't plant anything in them. These lines evolved into natural vegetative strips (NVS), which we later observed were superb in soil erosion control and reduced maintenance labor to a minimum. We examined each component of the process of establishing and maintaining low –labor hedgerow practices. The establishment of natural vegetative strips (NVS) requires only a fraction of the needed labor compared to the conventional contour hedgerow of tree legumes. The only labor required is the laying out of contour lines (about 2 person-days per hectare). A locally-led Landcare Association evolved to develop and share more effective ways of achieving a sustainable agriculture in the vicinity where the NVS practice was spreading. Landcare took responsibility for technology dissemination. The approach developed into a dynamic movement that now has 56 self-governing chapters, over 2000 members, and a municipal federation in Claveria. Currently over 600 farmers have installed NVS on their farms. It is quite uncommon for an effective soil conservation structure to be adopted by large number of farmers without public subsidies. Thus, we took note that perhaps we are witnessing the kind of low-labor, zero-cash-cost alternative that might have widespread applicability in other parts of the tropics where farming systems are similar.

1. CONSERVATION FARMING SYSTEMS FOR SLOPING LANDS

Conservation tillage is "any tillage system that reduces loss of soil or water relative to conventional tillage" (Lal, 1989). Slash-and-burn farmers were the initial adherents of conservation tillage. As population density increased, however, most farmers obtain an animal for draft power. This enables a household to intensively till a much larger area than is possible by hand hoe, at a fraction of the time and drudgery. They can plow and harrow frequently enough to control *Imperata cylindrica* and can hold their own against the annual grasses that invade frequently-tilled fields. Yet, as they gain the capacity to till their land more frequently, the exacerbate erosion, particularly since most dryland cultivators farm sloping fields. They find that retaining surface residue is impractical with animal power. So, their clean tillage accelerates soil loss to typical levels of 50 to 200 tons per hectare per year (Sajjapongse and Syers, 1995), rapidly wasting their soil assets at a rate of 10 to 20 times the maximum soil loss tolerance limit.

Clean tillage was the path toward higher yields for small holders: It was the modern way to farm. But while it spread across the upland landscape, it accelerated soil loss at the farm and catchment level. Today, the sedimentation rates from Southeast Asian river systems are an order of magnitude higher than those of any other part of the world (Milliman and Meade, 1983). One way to conceptualize the pathway toward conservation tillage is to look at it in relation to both crop productivity and the sustainability of the soil and water resource base. Productivity generally increased as farming evolved from shifting cultivation to intensive tillage agriculture, in terms of yield per unit agricultural area. But in the process the health of soil and water resources declined dramatically. The new intensive methods produced more, but jeopardized the resource base. Recent approaches in conservation tillage aim to rebuild the sustainability of the land resources while further improving, or at least maintaining, productivity and profitability. But there is a long way to go.

Small holders who have farmed sloping lands with clean-tillage for some years are well aware of the threat of soil erosion, and are keen to learn about and apply conservation measures (Fujisaka, 1993), as long as such methods are practical, and within their very limited resources and labor. Unfortunately, most proposed methods are not practical in the farmer's eyes, and are not adopted. But low-labor, low-investment practices that save soil are eagerly awaited by small farmers. We review here a promising direction toward providing truly adaptable conservation practices that appears to make sense to Southeast Asian upland farmers.

2. CONTOUR HEDGEROW SYSTEMS

The main conservation farming practice prescribed for open-field intensive cultivation systems in Southeast Asia has been contour hedgerow systems (Garrity, 1995). Contour hedgerow farming with leguminous trees has thus become a common feature of extension programs for sustainable agriculture on the sloping uplands in Southeast Asia. These systems control soil erosion effectively, even on steep slopes (Kiepe, 1995; Garriyt, 1995) Data from the IBSRAM Sloping Lands Network trials in six coutries have confirmed that annual soil loss with hedgerow systems is typically reduced 70 to 99 percent (Sajjapongse and Syers, 1995).

There are also numerous reports of increased yield levels of annual crops when grown between hedgerows of leguminous trees. However, farmer adoption of these systems is very low. Constraints include the tendency for the perennials to compete for growth resources and hence reduce yields of associated annual crops, and the inadequate amounts of phosphorus cycled to the crop in the prunings. But the major problem is the extra labor needed to prune and maintain them. We found that farmers' labor investment to prune their leguminous-tree hedgerows was about 31 days per hectare, or 124 days of annual labor for four prunings (ICRAF, 1996). This increase the total labor for upland rice an average of 64%. Labor for maize crop increased 90% due to pruning operations.

Such an increase in production costs was seldom rewarded by a commensurate increase in returns. The extra labor didn't pay off.

3. THE CASE FOR NATURAL VEGETATIVE STRIPS

In Claveria, Mindanao, Philippines, tree legumes and fodder grasses were tried and adopted by farmers during the first years of a research and farmer-to-farmer training project. Farmers that perceived soil erosion to be a problem were much more interested in vegetative barrier techniques that minimized labour (Fujisaka et al 1994). Some farmers independently developed the practice of laying out contour strips that were left unplanted, and were revegetated by native grasses and forbs. Researchers found that these natural vegetative strips had many desirable qualities (Garrity, 1993). They needed much less pruning maintenance compared to the introduced species (Ramiaramanana, 1993). They were very efficient in minimizing soil loss (Agus, 1993). And they did not show a tendency to cause greater weed problems for the associated annual crops (Moody, 1992, pers. Comm.). Natural vegetative strips (NVS) were also found to be an indigenous practice on a few farms in other localities, including Batangas and Leyte Provinces.

Installing NVS is quite simple. Once contour lines are laid out there is no further investment in planting materials or labor. The vegetative strips do not need to conform closely to the contour, they act as filter strips rather than bunds. Their biomass production, and economic value as fodder, is lower than many other hedgerow options, but labor is minimized. Vetiver grass (*Vetiver zizanoids)* fills a similar niche as a low value but effective hedgerow species. But for vetiver or any other introduced hedgerow species the planting materials must be obtained and planted out, requiring extra labor.

One limitation of low maintenance NVS hedgerows is that they do not enhance the nutrient supply to the crops. In this respect they do not differ from many other hedgerow enterprises, including fodder grasses or perennial cash crops like coffee. With continuous cropping, NVS or other low management hedgerow options can only be sustainable with fertilization. They have proven to be popular in northern Mindanao and have been adopted by hundreds of farmers in recent years.

4. CASH PERENNIALS IN HEDGEROWS

Perennials with economic value are an attractive option to many farmers. When trees are combined with NVS or planted grass strips they may provide a profitable solution to the problem of taking land out of productive use when hedgerows are established. Farmers who have established NVS are experimenting with a wide range of perennial crops in hedgerows, including many types of fruits, coconuts, coffee, mulberry, and even fast-growing timber species. Unlike pruned hedgerows, cash perennials tend to be full-canopy trees. Little is known about the trade-offs between their yield and the crop losses due to shading choice in this class of tree-crop systems.

4.1 Managing soil fertility in vegetative strip systems

Rapid redistribution of soil often occurs within the alleyways of contour hedgerow systems, resulting in quite dramatic yield reductions in the upper zones. Is this a threat to the sustainability of contour hedgerow systems? Recent work suggests that while it is a threat on strongly acidic soils, it ought to be manageable one. Farmers who have encountered scouring have developed practical ways of coping. These are currently being validated experimentally. Robust management solutions will depend on a more fundamental understanding of the processes governing fertility resilience in contour hedgerow systems. Emerging models that include landscape aspects will assist us in achieving it.

When farmers install contour hedgerow systems to help sustain annual cropping on sloping land they face many unusual management challenges. They must cope with the increase labor demands to prune and maintain the hedgerows. They may also need to make adjustments to minimize competition between the hedgerow species and the associated food crop. And often, they encounter accelerated soil deterioration in the upper zone of their alleyways. This soil deterioration is caused by the redistribution of topsoil within the alleyway, from the upper to the lower zones, as terraces naturally develop.

We examined how farmers react to the problem, and discuss the practical solutions that our preliminary research has identified and attempted to validate. Rapid soil redistribution within the alleyways of contour hedgerow systems was viewed very positively in the early literature on hedgerow research and extension. Biological barriers were very effective in creating permanent bunds. The land between the barriers may begin to flatten out within just a few years. The process leads to a reduction in slope and creates front-facing terraces. Thus, terrace development occurs as a by-product of normal tillage within the alleyway. There is no additional work and expense for soil excavation. The visual effect was often quite striking (Fujisaka et al, 1995; Sajjapongse, 1992). The reduction in soil loss was typically also striking, often on the order of 50-90% (Garrity, 1994).

We began to observe serious upper-alley yield declines within a few years of hedgerow establishment in a number of on-farm trials in Claveria, Philippines in the later 1980s (Garrity, 1994). The soil was an Oxic Palehumult which had physical and chemical properties fairly typical of the strongly acidic, low phosphorous status of some 186 million hectares of sloping upland soils in Southeast Asia (IRRI, 1986). At first it was assumed that the effect might be due to more intense competition exerted by the hedgerow toward the crop in the upper alleyway compared to the lower alley zone. Root barrier studies (Solera, 1993), soon discounted this hypothesis. However, soil analyses of affected fields consistently showed that soil organic carbon, total N, and available phosphorus had declined substantively in the upper zones, while they increased in the lower zones (Agus, 1993; Samzussaman, 1994; Garrity et al., 1995). The spatial changes were reported in hand hoe cultivation systems in Uganda (ICRAF, 1994) and on an Ustic Kandihumult in Thailand (Turkelboom et al., 1993).

The picture emerged that these upper-alley yield declines might be a serious sustainability problem. It results from the degradation of the upper-alley soil environment (Garrity, 1994). We now suspect that previous studies on hedgerows may have not observed the phenomenon for two reasons: Most of the alley cropping work that was done on slopes (at least in Southeast Asia) was on young, deep volcanic soils with moderate to high available phosphorous levels (e.g MBRLC, 1988). Topsoil scouring in these soils would not be expected to degrade the soil environment in the upper-alley zones to the extent that it would in strongly acidic, P-deficient soils. However, sloping soils with these latter constraints are much practices the rage of soil redistribution is much slower. Unfortunately, reduced-tillage is often difficult for smallholders. Where animal or he tillage is practiced several times in a year for weed management to accommodate intensive cropping systems, as is commonly observed, the redistribution process is greatly accelerated, and soil degradation proceeds more rapidly.

How do farmers react to the problem? Fortunately, we were in a good position to answer this question. In the vicinity of the Claveria research site scores of farmers had gained experience with the installation of hedgerows on their farms during the late 1980s and early 1990s. We surveyed a representative group of 30 smallholders that had been practicing contour hedgerow farming for up to seven years. Most adopters had observed reduced crop yields on their upper alleyways. Interestingly, however, they did not perceive the scouring effect to be a serious constraint, or a permanent one (ICRAF, 1997). They noted yield increase on the lower zones that apparently offset the declines in the upper zones. They were confident of the satisfactory soil conservation effects of biological terracing, and pointed out that scouring also occurred on the whole of the upper part of unhedgerowed fields. Their perception was that the investment in the buffer strip system seemed to increase yields over the whole field. A telling finding was that more than half of the respondents estimated that installation of the hedgerow system increased their land values by more than 50%.

Many farmers had developed their own practices to overcome the scouring problem. The most common of these was to apply more mineral fertilizer on the upper alleyway zones than on the lower zones (usually up to double on the upper zone). Also, farmers frequently applied hedgerow prunings selectively to the uppermost zone. A few even brought in additional biomass from off-field for the upper zone, or scraped soil from the bund down onto the upper alleyway. We have been conducting trials with hedgerow farmers during the past few years to validate these practices and to try to understand the underlying processes involved in rehabilitating the soils in upper alleyways. The results have tended to confirmed the utility of skewing higher fertilizer applications toward the upper alleyway: This practice increases maize yields in these zones to levels similar to those in the lower zones. It appears, however, that uniform fertilizer applications give similar overall yields on a whole alley (or field) basis when applied at moderate levels.

What is the key to sustaining good crop yields as terraces develop behind vegetative buffer strips? In the short term, it appears that the importation of nutrients through manure and/or fertilizers containing adequate amounts of crop-available P, are essential in maintaining yields. In the medium-term, however, we hypothesize that rebuilding soil

fertility in the upper alleyways depends on replenishing the soil organic matter levels in the topsoil of the scoured zones. More and longer-term field research is needed to validate these presumptions on strongly acid soils, and upon a much wider range of sloping lands in the tropics where farmers cope with the challenges of producing annual crops continuously. We are impressed with the apparent resilience of the intensively managed ultisols and oxisols of northern Mindanao. However, we suspect that the shallow, calcareous soils typical of much of the sloping farmland of Southeast Asia will not be as forgiving as the deep, well-structure soils on which we have worked. To be adequately predictive we will need to understand the fundamental processes governing soil fertility resilience in contour hedgerow systems.

Contour hedgerow systems continue to be adopted by increasing numbers of farmers in the vicinity of the research site in northern Mindanao. We estimate that over 600 farmers are now practicing the system. Many adopted spontaneously through a farmer-to-farmer diffusion process. An important factor in the spread was the shift to hedgerows composed of natural vegetative strips (NVS) in lieu of the pruned tree hedgerow systems conventionally recommended by extensionists throughout the region. NVS systems proved much more popular because they dramatically reduced the labor requirements for installation and maintenance, while their effectiveness in reducing off-field soil loss was superior (Garrity, 1994).

NVS systems do not fix and cycle nitrogen, as is attributed to hedgerows of leguminous trees. But in a P-limiting environment, tree-based hedgerows are themselves not effective in cycling adequate amounts of P to meet crop demand, and are therefore unable to sustain crop yields. Increasingly, the future for contour hedgerow systems looks certain to shift to low labor alternatives like NVS, with soil fertility being maintained by nutrient importation. The need for nutrient importation to balance crop off-take is not different than in most other types of agricultural systems, except that these systems make sustainable annual cropping possible on steeply sloping lands prone to severe erosion. Thus, they-re not ideal, but they are pretty remarkable nonetheless.

5. A RIDGE TILLAGE SYSTEM FOR ANIMAL-DRAFT FARMING

As we searched for practical ways to farm hedgerow systems to avoid the movement of soil downslope by tillage, we examined the principles of permanent-ridge as practices in the United States. The principle of the permanent-ridge tillage system is to maintain alternate strips of untilled and tilled land in a row-cropped field: The untilled strip (the ridge) is where the crop is planted in the same exact row position in each successive season; the inter-row area is where cultivation is practiced for weed control and hilling-up is done.

The sequence of operations is to make a shallow furrow through the stubble of the previous crop and plant in the same row. Then the crop is cultivated with the moldboard plow in the standard way of maize farmers in the Philippines (usually an off-barring operation at about 14 days after emergence, and hilling-up at about 28 days after emergence). This creates the ridges. After harvest, the next crop is replanted through the

stubble in the same rows as the previous one, without any plowing or harrowing operations. If there is considerable weed growth on the ridges, a band-spray of a broad-spectrum systemic herbicide (usually glyphosate is preferred(is applied on the ridges. Inter-row cultivation controls weeds and rebuilds the ridges. The ridge-till field looks little different than a conventional row-crop field. The ridges are just slightly more pronounced than those in conventional maize.

What are the advantages of such a system? First, many studies in the US have shown that the permanent ridge system dramatically reduces soil loss. The ridges act as a partial barrier to the surface flow of water, but their major distinction is that they act as a zone of greater infiltration. The no-tillage area tends to accumulate organic matter and macro-pores, due to soil biological activity and root channels. Since primary and secondary tillage operations are not practiced for land preparation between crops, the land is less subject to erosion in the off-season. Labor and expense in land preparation is eliminated. Pre-plant weed control is accomplished by judicious use of a herbicide.

We recently completed a four-year study of permanent-ridge till systems on two farms in Claveria, Philippines (Thapa et al, 1996). The soils were very fine kaolinitic clays classified as Lithic and Rhodic Huplodox, with strongly acidic surface soils (pH of 4.1-4.4), organic carbon contents of 1.6%. The conventional cropping system in this area is two crops of maize per year. Most cropland has slopes in the range of 10 to 60 percent. Annual rainfall is about 2000 mm. Farmers plow and harrow twice to prepare the land for each crop using a single draft-animal and moldboard plow. Planting is done by hand in furrows made with the plowpoint. Seeds, usually single-cross hybrids, are dibbled in the furrow and covered by foot. Inter-row cultivation is also the same moldboard plow. We used the same local equipment for the permanent-ridge till system.

In conventional maize production in Claveria farmers generally plant on the contour, more or less. We compared the conventional system with ridge tillage, and with natural vegetative strips (NVS) laid out at an 8 m distance from each other, a difference of 1.5 meters in vertical drop. The fourth treatment was a combination of ridge tillage in the alleyways between natural vegetative strips. Hybrid maize was produced in all treatments in rows spaced 60 cm apart.

The slopes of the on-farm experiments wer 14% at Patrocenio village and 20% in Anei. The annual soil loss was 85.5 tons/hectare on bare, uncropped soil. Ridge tillage reduced soil loss by 49% in Patrocinio, and 58% inANei. Natural vegetative strips reduced soil loss even more: 97% in Patrocinio and 90% in Anei. When the two conservation tillage systems were combined, annual soil loss was 0.3 t/ha in Anei, 1.1 t/ha in Patrocinio. Clearly, both systems were effective measures to dramatically reduce erosion. When combined they proved exceedingly effective.

The permanent ridges in the ridge-till treatments had infiltration rates of 49 cm/hr, 30% higher than in the rows of the conventional treatment. Infiltration rates were also high for the zone just above the natural grass strips (59 cm/hr). The high infiltration rates reduced runoff from row-to-row in the ridge-till system, and reduced runoff through the grass

barriers in the NVS. Kiepe (1995) demonstrated that a much higher infiltration rate in the vicinity of contour hedgerows is the major factor explaining the exceptional ability of contour hedgerows systems to reduce runoff and off-field soil losses.

Mean grain yields of six crops over the three-year period were the same for the conventional system and ridge-till (3.9 t/ha and 3.8 t/ha, a difference that was not significant). The grass strips occupied 12.6% of the field area. This resulted in grain yields that were about 10% lower than those for the conventional system or the ridge-till system alone. Thus, ridge tillage maintained maize yields, although it drastically reducing the amount of labor invested tillage and weed control. It was not as effective as NVS in erosion control, but did not cost the farmer any penalty in crop yield compared to conventional maize production.

Did permanent-ridge tillage reduce down-slope soil scouring form the upper alleyways to the lower alleyways? (This was the issue that first prompted our interest in adapting this unique tillage system to animal-powered farming systems.) Preliminary examination of the data suggests that ridge tillage did indeed dramatically slow down the down-slope movement of soil across the alleys ways. This would slow the rate at which topsoil is removed on the upper alleyways and is deposited above the grass strip down-slope. The practice, therefore, appears promising. It could be the most effective way to manage contour hedgerow systems on land with quite shallow soils, such as in areas where the topsoil is often only 20-30 cm deep over limestone rock, as in some parts of Southeast Asia. Under these conditions the scouring effect can be devastating to long-term crop production if hedgerows are installed.

6. FARMER-DRIVEN MECHANISMS TOWARD WIEDESPREAD DISSEMINATION OF CONSEVATION FARMING PRACTICES: THE LANDCARE APRPOACH

An adoptable technology must have minimal cost to the farmer, and be easy to extend to large numbers of farmers. In late in 1995 ICRAF was approached by farmers for assistance in installing contour strips to prevent soil erosion. We responded by combining our technical expertise with the extension skills of a technician from the Department of Agriculture, and the practical knowledge of a motivated farmer. This Contour Hedgerow Extension Team (CHET) was composed of three individuals. They initially worked with individual farmers who requested their assistance. Subsequently, group trainings were conducted to reach more farmers These involved 5-7 participants from each of the 7 villages in which the team was working. Before the end of the training the participants decided to organize themselves into a peoples' self-help organization for conservation farming. Officers were elected and the organization came to be known as the Claveria LandCare Association (CLCA). The Landcare Association evolved to develop and share more effective ways of achieving a sustainable agriculture. Landcare took responsibility for technology dissemination. The approach developed into a dynamic movement that now has 56 self-governing chapters, over 2000 members, and a municipal federation in Claveria. More than 600 farmers have installed NVS on their farms. The local government units were impressed with the energy of this movement,

and has begun supporting the effort financially, with active involvement of the village leaders. The Landcare approach has also been embedded in the natural resources management plan of another nearby municipality, Lantapan, Bukidnon. Currently about 125 Lantapan farmers have established NVS systems on their farms. We are testing the approach in collaboration with the Municipal Government, the conservation farming practices were validated through farmer-participatory research in Lantapan: NVS systems and ridge-tillage systems. We produced a series of Conservation Guides based on several years research. These guides have been distributed to hundred of farmers. We have begun to scale-up the method to the provincial and regional levels with the support of the provincial governor.

One of the key issues that emerged in various meetings was the establishment of cash perennials on the NVS. Although, farmers appreciated the role of NVS in controlling soil erosion most want to optimize the hedgerow space. They are keen to establish timber and fruit trees on their NVS. *Gmelina arborea* has been widely planted, and farmers were looking for other species. Farmers were interested in a new species, *Eucalyptus deglupta*, because of its better market potential for poles and lumber. The CLCA put up a nursery. It was agreed that each chapter will contribute the labor required and costs of the establishment and maintenance. ICRAF provided the improved seed. Nursery establishment and management training was conducted with the chapter chairmen, select members, and barangay councilors. The training included lectures and hands-on experience with the very different nursery practices required for *deglupta.*

More than 40 volunteer village nurseries have now been set up and are producing timber and fruit trees seedlings for the NVS. The seedlings raised ar*e Eucalyptus spp* such as: *deplupta, robusta, camaldulensis*, and *torillana* and a wide range of other fruit and timber species. Chapter members provided the nursery sheds, fencing, cellophane bags, and potting material, and implemented all activities in the nurseries. Members rotated in maintaining the nurseries for tasks such as watering and cleaning. The nursery activities did not compete with hedgerow establishment. NVS are established during the land preparation period, which is therefore a seasonal activity only. The demands for NVS establishment assistance are high during the months of February, March, April, May, September and October. The NVS are proving to be a foundation for the evolution of more productive timber or fruit tree-based agroforestry systems.

The Landcare approach is a method to rapidly and inexpensively diffuse agroforestry practices among thousands of upland farmers. It is based on the farmers' innate interest in learning and sharing knowledge about new technologies that earn more money and conserve natural resources. The evolution of the method and how it has performed to date is discussed in Garrity et al (1998). The essential elements of the approach are: A flexible set of proven technologies for smallholder agroforestation and conservation farming; farmer exposure to these technologies through observation and spontaneous trial on their farms; a farmers' organization to widely diffuse knowledge about the technologies within the municipality; and (in the event that the prior steps are successful) financial support form local government (municipality and village) to enhance the sustainability of the movement. We analyzed the current experience with the Landcare

approach, we recognized that the costs to implement in new municipalities would be modest (Garrity and Mercado, 1998). This is because implementation of the technologies is well within the farmers' own capabilities. Even the development of effective community nurseries has proven to be quite practical through volunteer effort alone. If the Landcare organization proves to be useful within the community, the municipal and local governments will have the incentive to provide financial support for the acceleration of the spread of conservation practices and tree planting. This ensures sustainability more than would dependence on outside resources.

Some outside resources, however, will be important to the success of the approach. The most critical of these is ensuring the presence of sensitive, soundly trained, and highly motivated persons to facilitate the process of conveying the technologies and developing a sound farmers' organization. They will have to be capable of identifying and nurturing the leadership qualities of farmers to become leaders in their organizations. The facilitators will need both technical skills and people skills. Beyond this, resources will be needed for fielding these people, and ensuring that the needs for transport, communications, and training materials are met.

The specific activities of interest to the members of a Landcare Association will vary according the their interests, and their physical and economic environment. Following are some of the many activities that have been or are being developed as focal areas for the Landcare Association's work:

- Establishment of natural vegetative strips (NVS) on the contour to reduce field or farm level soil erosion. This was the initial focal area that launched the organization.
- Planting of cash perennials on or just above the NVS strips to increase farm families cash income and enhance soil and water conservation.
- Planting trees to increase family cash income through production of timber, fuelwood, and other tree products in farm forests, boundary plantings, or other arrangements.
- Planting high-quality fruit trees to provide cash income and better nutrition for the household while enhancing the environment.
- Adoption of minimum-tillage or ridge-tillage farming systems. Ridge tillage has been successfully adapted to farmers' animal-draft systems, and is under wider on-farm tests.
- Adoption of sound riparian buffer zone management along streams to enhance water quality and quantity.

Effective, local action is the basis for achieving real stewardship of a community's natural resources. Solutions to problems that face farmers in their search for sustainable farming systems often come from the ground up. But experience indicates that a national vision and national leadership is also essential for a country to achieve success in conserving its soil and water resources. Without a common vision, and the information and understanding to help people to work together at the local level to meet mutual objectives, local efforts lose momentum. Otherwise, the stream of new conservation farming technologies that provide a basis for hope may dry up. Therefore, finding a

suitable way of expanding the Landcare movement to other municipalities, and developing an national system of technical support for the movement are key challenges to be faced in the coming years.

7. REFERENCES CITED

Agus, F (1993) Soil processes and crop production under contour hedgerow systems on sloping Oxisols. PhD Dissertation, North Carolina State University, Raleigh, NC, USA. 141 p.

Fujisaka, S (1993) A case of farmer adaptation and adoption of contour hedgerow for soil conservation. Experimental Agriculture 29:97-105.

Fujisaka, S. Jayson, E & Dapusala, A (1994) Trees, grasses, and weeds: species choice in farmer-developed contour hedgerows. Agroforestry Systems 25:13-24.

Garrity, D P & Mercado, A R Jr. (1998) The Landcare Approach: a Two pronged method to Rapidly Disseminate Agroforestry Practices in Upland Watersheds. ICRAF Southeast Asia Regional Program, Indonesia. 6 p.

Garrity, D P, Mercado, A R Jr. & Stark, M (1998) Building the Smallholder into Successful Natural Resource Management at the Watershed Scale. In: de Vries, Pl, Frits, W.T. Agus, F. and Kerr, J. (Eds.) Soil Erosion at Multiple Scales: Principles and Methods for Assessing Cause and Impacts. CABI and IBSRAM, 1998. Pp. 73-82.

Garrity, D P (1994) The importance of agroforestry and ICRAF's mission in Southeast Asia. In: Present situation, problems, prospects and practical implementation program of education and research on forestry for sustainable agriculture and natural resources conservation in Asia. Tsukuba, Japan. University of Tsukuba.

Garrity, D P (1993) Sustainable land-use systems for sloping uplands in Southeast Asia. In: Technologies for Sustainable Agriculture in the Tropics. American Society of Agronomy Special Publication 56 Madison Wisconsin, USA. P. 41-66.

Garrity, D P (1995) Improved agrorestry technologies for conservation farming: Pathways toward sustainability. In: Proc International Workshop on Conservation Farming for Sloping Uplands in Southeast Asia: Challenges, Opportunities and Prospects, IBSRAM, Bangkok, Thailand. Proceedings No 14, pp 145-168.

Garrity, D P, Mercado, A R Jr. & Solera, C (1995) The nature of species interference and soil changes in contour hedgerow systems on sloping acidic lands. In: Kang, B T (ed) Proceedings of the International Conference on Alley Farming, International Institute of Tropical Agriculture, Ibadan, Nigeria.

ICRAF (1994) Annual report for 1993. International Centre for Research in Agroforestry, Nairobi, Kenya.

ICRAF (1996) Annual report for 1995. International Centre for Research in Agroforestry, Nairobi, Kenya.

ICRAF (1997) Annual report for 1996. International Centre for Research in Agroforestry, Nairobi, Kenya.

IRRI (1996) International Rice Research Institute, Los Baños: Annual Report for 1985.

Kiepe, P (1995) No runoff, no soil loss: Soil and water conservation in hedgerow barrier systems. Wageningen Agricultural University, Wageningen, The Netherlands.

Lal, R (1989) Conservation tillage for sustainable agriculture: tropics versus temperate environments. Advances in Agronomy 42:85-197

Miliman, J D & Meqade, R H (1993) Worlwide delivery of river sediments to the oceans. Journal of Goelogy 91:1-21.

Moody, K (1992) Personal communication. Los Baños, Laguna.

Ramiaramanana, D M (1993) Crop-hedgerow interactions with natural vegetaive filter strips on sloping acidic land. MSc Thesis, Univiersity of the Philippines at Los Baños, 141 p.

Sajjapongse, A & Syers, K (1995) Tangible outcomes and impacts from ASIALAND management of sloping lands network. I: Proceeding of International Workshop on Conservation Farming for Sloping Uplands in southeast Asia: Challenges, Opportunities and Prospects. IBSRAM, Bangkok, Thailand. Proceedings No 14, pp 3-14.

Sajjapongse, A (1992) Management of sloping lands for sustainable agriculture in Asia: an overview. In: Technical report on the management of sloping lands for sustainable agriculture in Asia, Phase I (1988-1991) Network Document 2, International Board for Soil Research and Management, Bangkok, Thailand. P 1-15.

Samzussaman, S (1994) Effectiveness of alternative management practices in different hedgerow-based alley cropping systems. PhD Dissertation, University of the Philippines at Los Baños. 135 p.

Solera, C R (1993) Determinants of competition between hedgerow and alley species in a contour hedgerow intercropping systems. PhD Dissertation, University of the Philpippines at Los Baños. 135 p.

Thapa, B, Cassel, D K, Garrity, D P & Mercado, A R (1996) Sustainable soil management systems on acid steepland soils in the humid tropics. Paper presented during the 12th Annual Scientific Conference of the Federation of Crop Science Socieities of the Philippines, Davao City, 13- 18 May 1996.

Turkelboom, F, Ongprasert, S & Taejajai, U (1993) Alleycropping on steep slopes: Soil fertility gradients and sustainability. Paper presented at the International Workshop on Sustainable Agricultural Development: Concepts and measures, Asian Institute of Technology, Bangkok, Thailand, 14-17, December 1993. 16 p.