IMPROVING THE SUSTAINABILITY OF CASSAVA-BASED CROPPING SYSTEMS IN ASIA: A FARMER PARTICIPATORY APPROACH TO TECHNOLOGY DEVELOPMENT AND DISSEMINATION

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) is the third most important food crop in southeast Asia; the crop is usually grown by smallholders in marginal areas of sloping or undulating land. Farmers grow cassava because the crop will tolerate long dry periods and poor soils, and will produce reasonable yields with minimum inputs. Most farmers realize, however, that cassava production on slopes can cause severe erosion, while production without fertilizer or manure inputs will lead to a gradual decline in soil productivity. Current production practices may thus not be sustainable.

Research has shown that cassava yields can be maintained for many years with adequate application of fertilizers or manures, and that there are various ways to reduce erosion. Adoption of erosion control practices, however, has been minimal as farmers generally see little short-term benefits, while initial costs of establishing these practices may be substantial.

In order to enhance the adoption of soil conserving practices and improve the sustainability of cassava production under a wide range of socio-economic and bio-physical conditions, a farmer participatory research (FPR) approach was used to develop not only the best soil conservation practices, but also to test new cassava varieties, fertilization practices and cropping systems that tend to produce greater short-term benefits. The FPR methodology was initially developed in 2-3 sites each in China, Indonesia, Thailand and Vietnam. The methodology includes the conducting of RRAs in each site, farmer evaluation of a wide range of practices shown in demonstration plots, FPR trials with farmer-selected treatments on their own fields, field days with discussions to select the best among the tested practices, scaling-up of selected practices to larger fields, and farmer participatory dissemination to neighbors and neighboring communities. Based on the results of these trials, farmers in the pilot sites have readily adopted better varieties, fertilization and intercropping practices, and many farmers have adopted the planting of contour hedgerows to control erosion.

In the second phase of this Nippon Foundation supported project, the farmer participatory approach for technology development and farmer-to-farmer extension is being further developed in 20 pilot sites each in Thailand and Vietnam, and in nine sites in southern China. Farmers are generally very interested in participating in the trials. After becoming aware of the seriousness of erosion in their cassava fields, they have shown a willingness to adopt simple but effective practices to reduce erosion while at the same time obtaining short-term benefits from the adoption of new varieties and other improved practices. The testing by farmers on their own fields of new cassava varieties and fertilization practices in addition to soil conservation practices was found to be of crucial importance for the adoption of more sustainable production practices.

KEYWORDS: cassava, erosion control, farmer participatory research (FPR) and extension (FPE), Thailand, Vietnam.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz**)** is the third most important food crop grown in southeast Asia and is used for human consumption, animal feed or for industrial purposes. It is usually grown by smallholders in upland areas with poor soils and low or unpredictable rainfall. In some countries it is grown on steep slopes (north and central Vietnam), but in others it is grown mainly on gentle slopes (northeast Thailand); in both cases soil erosion can be serious. Moreover, cassava farmers seldom apply adequate amounts of fertilizers or

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manures to replace the nutrients removed in the harvested products. Thus, both erosion and nutrient extraction can result in a decline in soil fertility and a gradual degradation of the soil resource.

The fact that farmers do not apply sufficient fertilizers and do not use soil conservation practices when the crop is grown on slopes is more a socio-economic rather than a technical problem. Research has shown many ways to maintain or improve soil fertility and reduce erosion, but farmers usually consider these practices too costly or requiring too much labor. To overcome these obstacles to adoption it is necessary to develop simple practices that are suitable for the local situation and that provide short-term benefits to the farmer as well as long-term benefits in terms of resource conservation. Being highly site specific these practices can best be developed by the farmers themselves, on their own fields, in collaboration with research and extension personnel.

Thus, a project was initiated, with financial support from the Nippon Foundation in Tokyo, Japan, to develop a farmer participatory methodology for the development and dissemination of more sustainable production practices in cassava-based cropping systems, that will benefit a large number of poor farmers in the uplands of Asia.

MATERIALS AND METHODS

The first phase of the project was conducted from 1994 to 1998 in four countries, i.e. China, Indonesia, Thailand and Vietnam. The project was coordinated by CIAT and implemented in collaboration with research and extension organizations in each of the four countries. During an initial training course on farmer participatory research (FPR) methodologies, each country designed a work plan to implement the project. The steps in the process, from diagnosing the problem to adoption of suitable solutions, is shown in **Figure 1**. The outstanding feature of this approach is that farmers participate in every step and make all important decisions.

In most countries, one or two suitable pilot sites (villages or subdistricts) were identified through Rapid Rural Appraisals (RRA); farmers from these sites were then shown many options in previously established demonstration plots; they were encouraged to select a few most suitable options for later testing in FPR trials on their own farms.

In both the demonstration plots and FPR erosion control trials on farmers field, a simple methodology is used to measure soil loss due to erosion in each treatment. Plots are laid out along the contour on a uniform slope and below each plot a ditch is dug and covered with plastic (**Figure 2**). Small holes in the plastic allow runoff water to seep away, while eroded sediments collect on the plastic. These sediments are weighed two or more times during the cropping cycle. After correcting for moisture content, the amount of dry soil loss/ha is calculated for each treatment. This simple methodology gives both a visual as well as a numeric indication of the effectiveness of the various practices in controlling erosion (Howeler, 2001).

The FPR trials did not only involve soil conservation practices, but also new varieties, intercropping systems and fertilization, with the objective of developing a combination of practices that would increase farmers' income, reduce erosion and improve soil fertility. After one or more years of testing in small plots, farmers quickly identified the best varieties and production practices for their area and started using those on larger areas of their production fields.

The second phase of the project is being conducted from 1999 to 2003. This phase is being implemented in collaboration with five institutions in Thailand, six in Vietnam and three in China. **Table 1** shows the network of institutions currently implementing the project. During the second phase the emphasis has shifted from farmer participatory research (FPR)

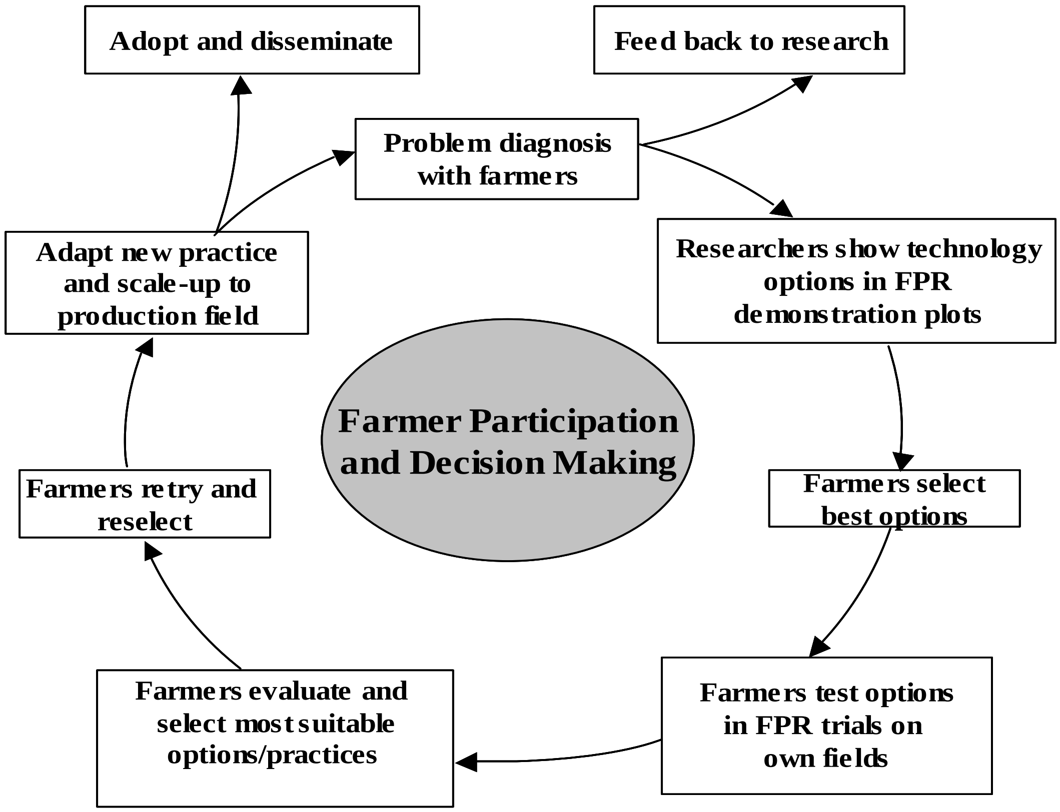
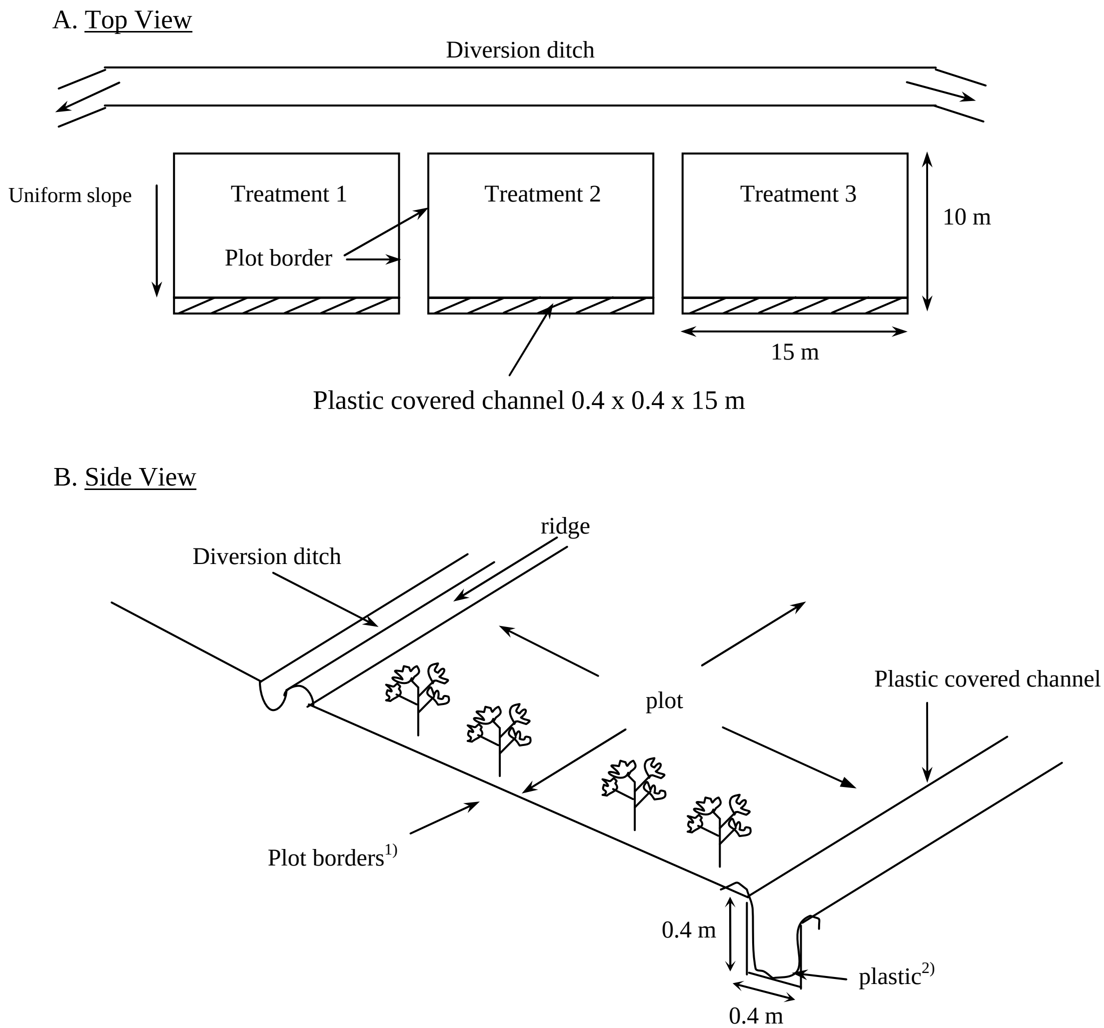


Figure 1. Farmer participatory model used for the development of sustainable cassava-based cropping systems in Asia.



[1]Plot border of sheet metal, wood or soil ridge to prevent water, entering or leaving plots.
[2]polyethylene or PVC plastic sheet with small holes in bottom to catch eroded soil sediments but allow run-off water to seep away. Sediments are collected and weighed once a month.

Figure 2. Experimental lay-out of simple trials to determine the effect of soil/crop management practices on soil erosion.

Table 1. Institutions collaborating with CIAT in the first and second phase of the Nippon Foundation Project on Improving the Sustainability of Cassava-based Cropping Systems in Asia.

Country-Province		Institution	2d Phase		
			Research	FPR	FPE
China	- Hainan	CATAS	✓	✓	✓
	- Guangxi	GSCRI		✓	✓
	- Yunnan	AHVSY		✓	✓
Indonesia	- W. Java	CRIFC	✓		
Thailand	- Rayong	FCRI/DOA	✓	✓	✓
	- Bangkok	FCPD/DOAE		✓	✓
	- Bangkok	Kasetsart Univ.	✓		
	- Bangkok	SWCD/LDD		✓	✓
	- Korat	TTDI	✓	✓	✓
Vietnam	- Thai Nguyen	AFC/TNU	✓	✓	✓
	- Hanoi	NISF		✓	✓
	- Hanoi	VASI		✓	✓
	- Hue	AFC/HU	✓	✓	✓
	- Ho Chi Minh	IAS	✓	✓	✓
	- Ho Chi Minh	AFU/TD		✓	✓

to extension (FPE) in order to reach more farmers and achieve more widespread adoption. These farmer participatory extension activities include the organization of cross-visits, in which farmers from a new site visit those from an older site where FPR trials are being conducted or where some selected practices are already being adopted. It also includes training courses for key farmers and local extensionists; farmer field days at time of harvest with participation of farmers and extensionists from neighboring villages; large-scale farmer field days with participation of many farmers, high-level government officials, press and TV; and the establishment of community-based self-help groups. In addition, more conventional extension tools, such as videos, and booklets on various aspects of cassava production and utilization have been prepared.

Once farmers have selected certain practices and want to adopt those on their fields, the project staff tries to help them, for instance, in setting out contour lines to plant hedgerows for erosion control; or to provide seed or vegetative planting material of the selected hedgerows species, intercrops or new varieties.

RESULTS AND DISCUSSION

1. First Phase (1994-1998): Farmer Participatory Research (FPR)

a. Pilot site selection:

Suitable pilot sites were selected in areas where cassava is an important crop, where it is grown on slopes and erosion is a serious problem. **Table 2** shows some of the characteristics of the

Table 2. Characteristics of eight pilot sites for the Farmer Participatory Research (FPR) trials in Asia in 1994/95.

	Thailand		Vietnam			China	Indonesia	
	Soeng Saang	Wang Nam Yen	Pho Yen	Thanh Ba	Luong Son	Kongba	Malang	Blitar
Mean temp. (°C)	26-28	26-28	16-29	25-28	16-29	17-27	25-27	25-27
Rainfall (mm)	950	1400	2000	~1800	~1700	~1800	>2000	~1500
Rainy season	Apr-Oct	Apr-Nov	Apr-Oct	Apr-Nov	May-Oct	May-Oct	Oct-Aug	Oct-June
Slope (%)	5-10	10-20	3-10	30-40	10-40	10-30	20-30	10-30
Soil	± fertile loamy Paleustult	± fertile clayey Haplustult	infertile sandy loam Ultisol	very infertile clayey Ultisol	± fertile clayey Paleustult	± fertile sandycl.l. Paleudult	infertile clay loam Mollisol	infertile clay loam Alfisol
Main crops	cassava rice fruit trees	maize soybean cassava	rice sweet pot. maize	rice cassava tea	rice cassava taro	rubber cassava sugarcane	cassava maize rice	maize cassava rice
Cropping system[1)]	C monocrop	C monocrop	C monocrop	C monocrop	C+T	C monocrop	C+M	C+M
Cassava yield (t/ha)	17	17	10	4-6	15-20	20-21	12	11
Farm size (ha)	4-24	3-22	0.7-1.1	0.2-1.5	0.5-1.5	2.7-3.3	0.2-0.5	0.3-0.6
Cassava (ha/hh)	2.4-3.2	1.6-9.6	0.07-0.1	0.15-0.2	0.3-0.5	2.0-2.7	0.1-0.2	0.1-0.2

[1)] C = cassava, T = taro, M = maize

selected sites in Thailand, Vietnam, China and Indonesia. Detailed information obtained through Rapid Rural Appraisals (RRA) in each site have been reported by Zhang Weite *et al*. (1998), Vongkasem *et al*. (1998), Utomo *et al*. (1998) and Nguyen The Dang *et al*. (1998).

b. Demonstration plots

Each year demonstration plots are laid out on an experiment station or farmer;s field to show the effect of many alternative treatments on yield, income and soil erosion. **Table 3** shows the ranking of treatments by farmers from various pilot sites. It is clear that farmers from the selected pilot sites are asked to discuss and score the usefulness of each treatment. It is clear that farmers from different countries, and from different areas in the same country, have different preferences, depending on the local bio-physical and socio-economic conditions, as well as on their traditional practices. That's why it is important to let farmers select and test rather than to make recommendations. From this range of many options farmers may select 3-4 treatments that they would like to test, in comparison with their traditional practice, in FPR trials on their own fields.

c. FPR trials:

Table 4 shows the type and number of FPR trials conducted in each site from 1995/96 to 1998/99. During the first phase of the project farmers conducted a total of 177 FPR erosion control trials, 157 variety trials, 98 fertilizer trials and 35 intercropping trials, for a total of 467 trials. At time of harvest in a particular site, a field day is organized to harvest each trial by the participating farmers and their neighbors. The yields of cassava and intercrops, the dry soil loss due to erosion, as well as the gross income, production costs and net income are calculated and presented in a joint meeting to the farmers. **Table 5** shows a typical example of an FPR erosion control trial conducted by six farmers having adjacent plots on about 40% slope. It is clear that contour hedgerows of vetiver grass, *Tephrosia candida* or pineapple reduced erosion to about half, while intercropping with peanut and vetiver grass hedgerows markedly increased net income. Results of many other FPR trials have been reported in detail by Nguyen The Dang *et al*. (2001), Huang Jie *et al*. (2001), Vongkasem *et al*. (2001) and Utomo *et al.* (2001), and have been summarized by Howeler (2001).

d. Scaling-up and adoption

After having selected the most promising cassava varieties and production practices from FPR trials, farmers generally like to test some of these on small areas of their production fields, making adaptations if necessary. Some practices may look promising on small plots, but are rejected as impractical when applied on larger areas; this may be due to lack of planting material (like lemon grass) or lack of markets for selling the products (like pumpkin or lemon grass). **Table 6** summarizes the varieties and practices that had been adopted by participating farmers in the four countries at the end of the first phase of the project in 1998.

2. Second Phase (1999-2003): Farmer Participatory Extension (FPE)

Since the objective of the second phase was to achieve widespread adoption of more sustainable production practices by as large a number of farmers as possible, it was necessary to markedly expand the number of pilot sites and to develop farmer participatory extension (FPE) methodologies to disseminate the selected practices and varieties to many more farmers.

Implementing the project in collaboration with many different institutions in China, Thailand and Vietnam (see **Table 1**), and with generous financial support from the Nippon Foundation, it was possible to expand the number of pilot sites each year. In 2001 the project was

Table 3. Ranking of conservation farming practices selected from demonstration plots as most useful by cassava farmers from several pilot sites in Asia in 1995/96.

Practice	Thailand		Vietnam		China	Indonesia	
	Soeng Saang	Wang Nam Yen	Pho Yen	Thanh Hoa	Baisha	Blitar	Dampit
Farm yard manure (FYM)				2			
Medium NPK	5						
High NPK					2		
FYM+NPK				1			
Cassava residues incorporated			5				
Reduced tillage	4						
Contour ridging		2					
Up-and-down ridging					5		
Maize intercropping	2					1	1
Peanut intercropping		5			4		2
Mungbean intercropping					3		
Black bean intercrop+*Tephrosia* hedgerows			1	4			
Tephrosia green manure			3	5			
Tephrosia hedgerows			4				
Gliricidia sepium hedgerows						2	4
Vetiver grass barriers	1	1	2	3			
Brachiaria ruziziensis barriers	3	4					
Elephant grass barriers						3	3
Lemon grass barriers		3					
Stylosanthes barriers					1		

Table 4. Types and number of Farmer Participatory Research (FPR) trials with cassava conducted in four countries in Asia from 1995 to 1998.

	Thailand		Vietnam			China		Indonesia	
Type of trial	Soeng Saang Nakorn Ratchasima	Wang Nam Yen Sra Kaew	Pho Yen Thai Nguyen	Thanh Ba Phu Tho	Luong Son Hoa Bin	Baisha Hainan	Tunchang Hainan	Dampit Malang	Wates Blitar
1995/96									
Erosion control	9	6	6	7	3	12	-	10	7
Varieties	5	7	6	-	1	15	-	-	8
Fertilization	5	-	4	-	1	10	-	-	-
Intercropping	-	-	8	-	-	-	-	-	
Total	**19**	**13**	**24**	**7**	**5**	**37**	**-**	**10**	**15**
1996/97									
Erosion control	8	7	5	7	3	4	1	10	9
Varieties	3	6	11	3	3	4	1	1	5
Fertilization	8	-	6	4	3	4	1	1	-
Intercropping	-	-	11	-	-	-	-	-	-
Total	**19**	**13**	**33**	**14**	**9**	**12**	**3**	**12**	**14**
1997/98									
Erosion control	2	1	5	7	3	4	-	5	6
Varieties	4	5	15	8	2	4	-	-	-
Fertilization	-	-	5	5	3	4	-	5	4
Intercropping	-	-	8	-	-	-	-	-	-
Total	***6***	***6***	***33***	***20***	***8***	***12***	***-***	***10***	***10***
1998/99									
Erosion control	-	-	5	7	3	5	-	10	-
Varieties	-	-	18	1	3	8	-	10	-
Fertilization	-	-	5	5	5	-	-	10	-
Intercropping	-	-	8	-	-	-	-	-	-
Total	***-***	***-***	***39***	***13***	***11***	***13***	***-***	***30***	***-***

Note: During 1997/98 and 1998/99 the number of FPR trials in Thailand decreased as farmers in the two pilot sites adopted some erosion control measures in large "demonstration fields" in their cassava production areas. In addition, a new pilot site was initiated in Sahatsakhan district of Kalasin province in 1997 and in Sanaam Chaikhet district of Chachoengsao province in 1998.

Table 5. Results of an FPR erosion control trial conducted by six farmers in Kieu Tung village, Thanh Ba district, Phu Tho, Vietnam, in 1999.

Treatment	Slope (%)	Dry soil loss (t/ha)	Yield (t/ha) cassava	Yield (t/ha) peanut[1)]	Gross income[1)] (mil. dong/ha)	Product. costs (mil. dong/ha)	Net income (mil. dong/ha)
1. C monocult., with fert.[2)], no hedgerows	40.5	51.8	26.3	-	10.52	3.04	7.48
2. C+P, no fert., no hedgerows	45.0	25.1	11.5	0.45	7.07	4.45	2.62
3. C+P, with fert., no hedgerows	42.7	33.7	18.6	0.47	10.02	5.26	4.76
4. C+P, with fert., *Tephrosia* hedgerows	39.7	6.2	23.8	0.49	12.21	5.26	6.95
5. C+P, with fert., pineapple hedgerows	32.2	10.5	24.0	0.66	13.23	5.26	7.97
6. C+P, with fert., vetiver hedgerows	37.7	8.0	33.8	0.37	15.55	5.26	10.29
7. C monocult, with fert., *Tephrosia* hedgerows	40.0	3.3	21.7	-	8.68	3.04	5.64

[1)]Prices: cassava dong 400/kg fresh roots
peanut 5500/kg dry pods

[2)]Fertilizers = 60 kg N + 40 P_2O_5, + 120 K_2O/ha; all plots received 10 t/ha pig manure
Cost fertilizers = 0.810 mil. dong/ha; cost of intercropping = 2.22 mil.dong/ha

Table 6. Technological components selected and adopted by participating farmers from their FPR trials conducted from 1994 to 1998 in four countries in Asia.

Technology	China	Indonesia	Thailand	Vietnam
Varieties	SC8013***[1)] SC8634* ZM9247* OMR35-70-7*	Faroka*** 15/10* OMM90-6-72*	Kasetsart 50*** Rayong 5*** Rayong 90**	KM60*** KM94* KM95-3*** SM1717-12*
Fertilizer practices	15-5-20+Zn +chicken manure 300kg/ha*	FYM 10 t/ha (T)+ 90 N+36 P_2O_5+ 100 K_2O**	15-15-15 156 kg/ha***	FYM 10 t/ha (TP)+ 80 N+40 P_2O_5+ 80 K_2O**
Intercropping	monoculture(TP) C+peanut*	C+maize(TP)	monoculture(TP) C+pumpkin* C+mungbean*	monoculture(TP) C+taro(TP) C+peanut***
Soil conservation	sugarcane barrier*** vetiver barrier*	*Gliricidia* barrier** *Leucaena* barrier* contour ridging**	vetiver barrier*** sugarcane barrier**	*Tephrosia* barrier*** vetiver barrier* pineapple barrier*

[1)] * = some adoption
** = considerable adoption
*** = widespread adoption
TP = traditional practice; FYM=farm yard manure.

working in about 50 sites (**Figure 3**), and this may further increase to about 80 sites by the end of the project in 2003. Once the benefits of the new technologies become clear, the number of sites tend to increase automatically, as neighboring villages also want to participate in order to increase their yields and income.

The following farmer participatory extension methods were used and found to be very effective in raising farmers' interest in soil conservation, in disseminating information about improved practices and in enhancing adoption of soil conserving practices:

1. Cross-visits

Farmers from new sites were usually taken to visit older sites that had already conducted FPR trials and had adopted some soil conserving technologies. These cross-visits, in which farmers from the older site could explain their reasons for adopting new technologies, was a very effective way of farmer-to-farmer extension. After these cross-visits, farmers in some new sites decided to adopt some technologies immediately, while others decided to conduct FPR trials in their own fields first. In both cases, the "FPR teams" of the various collaborating institutions, together with provincial, district or subdistrict extension staff, helped farmers to establish the trials, or they provided seed or planting materials required for the adoption of the new technologies.

2. Field days

At time of harvest, field days were organized at the site in order to harvest the trials and discuss the results. Farmers from neighboring villages were usually invited to participate in these field days, to evaluate each treatment in the various trials and to discuss the *pros* and *cons* of the various practices or varieties tested. In a few cases, large field days were also organized with participation of hundreds of neighboring farmers, school children, local and high-level officials, as well as representative of the press and TV. The broadcasting or reporting about these events also helped to disseminate the information about suitable technologies. During the field days farmers explained the results of their own FPR trials to the other visiting farmers, and literature about the project and the results obtained was distributed.

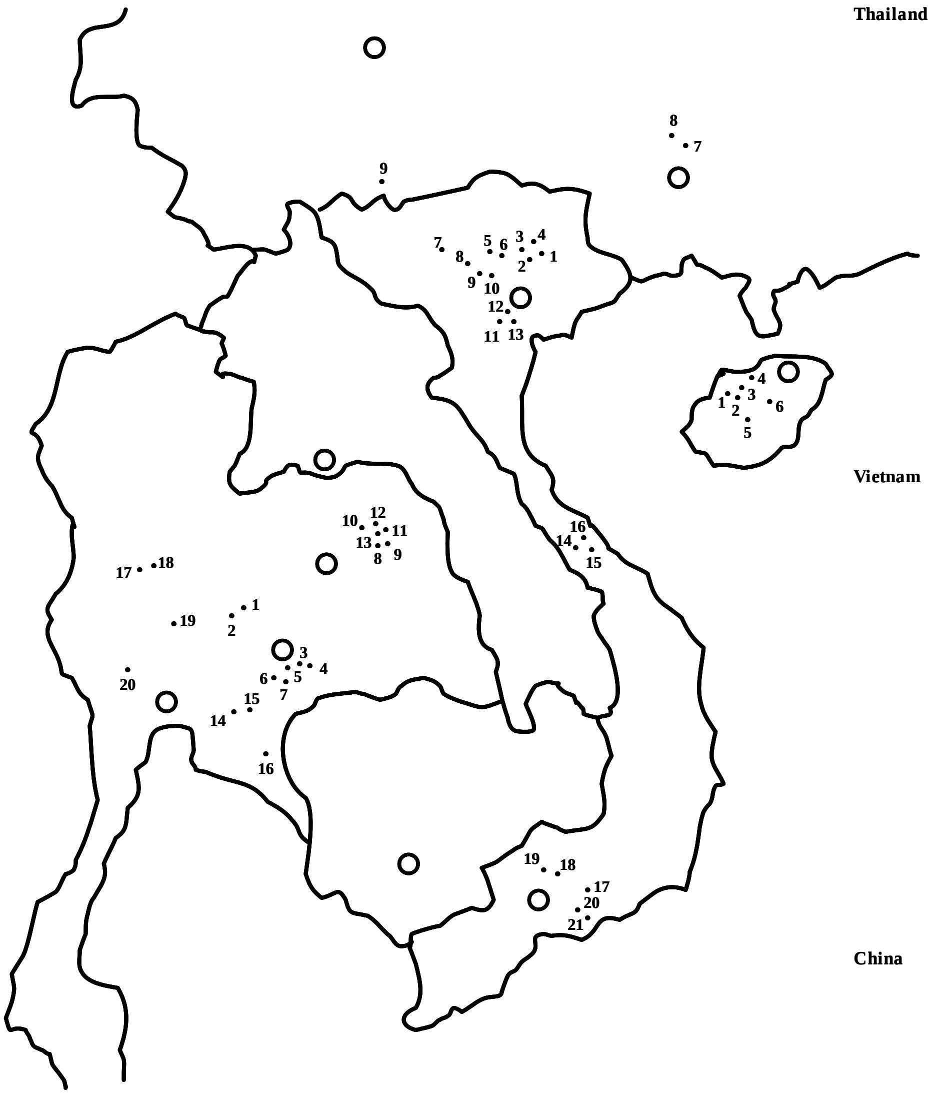
3. Training

Research and extension staff involved in the project had previously participated in Training-of-Trainers courses in FPR methodologies, including training sessions with farmers in some of the pilot sites. While some participants were initially skeptical, most became very enthusiastic about this new approach once they started working more closely with farmers.

In addition, 2-3 key farmers from each site together with their local extension agent were invited to participate in FPR training courses. The objective was to learn about the various FPR methodologies, the basics of doing experiments as well as the implementation of commonly selected technologies, such as setting out contour lines or the planting, maintenance and multiplication of hedgerow species. By spending several days together in these courses, the farmers and extensionist got to know each other well, and they were encouraged to form a local "FPR team" to help other farmers in their community conduct FPR trials or adopt the new technologies.

4. Soil conservation groups

Realising that effective soil conservation practices, such as planting of contour hedgerows, can best be done as a group, farmers from some sites decided to form their own "soil conservation group". These community-based self-help groups are similar to "Landcare units", that have been



Thailand
1.Nakhon Ratch.-Khut Dook
2.Nakhon Ratch.-village 3.6
3.Nakhon Ratch.-Sapphongphoot
4.Nakhon Ratch.-Sratakhian
5.Nakhon Ratch.-Lampiak
6.Prachinburi-Aang Thong
7.Prachinburi-Khaokhaat
8.Kalasin-Noon Sawan
9.Kalasin-Khamplaa
10.Kalasin-Khamsri
11.Kalasin-Noon Sawaat
12.Kalasin-Huay Suaeten
13.Kalasin-Paa Kluay
14.Chachoengsao-Thaa Chiwit May
15.Chachoensao-Nong Yai
16.Sra Kaew-Noon Thong
17.Kamphaengphet-Sii Yaek
18.Kamphaengphet-Ton Thoo
19.Chaiyaphuum-Khook Anu
20.Kaanchanaburi-Nong Kae

Vietnam
1.Thai Nguyen-Tien Phong
2.Thai Nguyen-Dac Son
3.Thai Nguyen-Minh Duc
4.Thai Nguyen-Hong Tien
5.Tuyen Quang-Am Thang
6.Tuyen Quang-Hong Tien
7.Yen Bai-Yen Hung
8.Phu Tho-Kieu Tung
9.Phu Tho-Thong Nhat
10.Phu Tho-Bao Thanh
11.Hoa Binh-Dong Rang
12.Ha Tay-Thach Hoa
13.Ha Tay-Tran Phu
14.Hue-Hong Ha
15.Hue-Thuong Long
16.Hue-Huong Van
17.Dong Nai-An Vien
18.Binh Phuoc-Dong Tam
19.Binh Phuoc-Minh Lap
20.Baria Vungtau-Suoi Rao
21.Baria Vungtau-Son Binh

China
1.Hainan-Kongba
2.Hainan-Tapuling
3.Hainan-Myuammen
4.Hainan-Fulong
5.Hainan-Qiongzhong
6.Hainan-Tunchang
7.Guangxi-Taiping
8.Guangsi-Ningwu
9.Yunnan-Beihei

Figure 3. Location of FPR pilot sites in Thailand, Vietnam and China in 2001.

very effective in promoting soil conservation in the Philippines and Australia. In Thailand, the Dept. of Agric. Extension has encouraged farmers to set up these groups as a way of organizing themselves to conduct FPR trials, to implement the selected practices, and to manage a rotating fund, from which members of the group could borrow money for production inputs. Thus, in 2001, ten such “Cassava Development Villages” were set up in some of the pilot sites. Each group needed to have at least 40 members, elect five officers to lead the group, and establish their own bylaws about membership requirements, election of officers, use of the rotating fund, etc.

The formation of these groups helped to decide on collective action, and to strengthen the community as people gained confidence and the group became more self-reliant. When necessary, the group could request help from local or national extension services, obtain information about certain production problems, or get planting material of vetiver grass or other species for hedgerows or green manures. Some groups started their own vetiver grass nurseries to have material available when needed.

3. Adoption and Impact

After conducting their own FPR trials, or after a cross-visit to another village where those trials were being conducted, farmers often decided to adopt one or more technologies on their production fields with the hope of increasing yields or income and protecting the soil from further degradation.

In Thailand, close to 90% of cassava farmers already plant new varieties (Sarakarn *et al*., 2001) and about 75% of farmers apply some chemical fertilizers (TTDI, 2000), although usually not enough nor in the right proportion. As a result of the FPR fertilizer trials, the application of K has increased, while the official fertilizer recommendation for cassava has changed from an NPK ratio of 1:1:1 to 2:1:2. After trying various ways of controlling erosion, most farmers selected the planting of vetiver grass contour hedgerows as the most suitable. **Table 7** indicates that by the end of 2001, about 622 farmers had planted a total of 1.23 million vetiver plants, corresponding to about 123 km of hedgerows.

Table 8 similarly summarizes the adoption of various new technologies in Vietnam. Over 1400 farmers are now planting new cassava varieties, while hundreds are applying more balanced fertilization (usually pig manure in addition to chemical fertilizers), intercrop with peanut or blackbean, and control erosion by the planting of contour hedgerows of *Tephrosia candida*, vetiver grass or *Paspalum atratum*. In some villages in Pho Yen district of Thai Nguyen province in north Vietnam, the average gross income of many farmers in 2001 was 4-5 times higher than those reported in 1994/95 at the start of the project (CIAT, 2001).

4. Lessons Learned

To be successful in promoting soil conservation the following issues should be taken into account:

1. *Economic profitability is necessary but not sufficient for adoption to occur, and the time horizon for profitability should be as short as possible.* In the trials discribed above, higher net incomes in the "improved" practices were obtained not so much from the soil conservation practices, but from other innovations in the "package", such as higher yielding varieties, fertilization and intercropping. By testing and adopting the whole integrated system, farmers can obtain economic benefits while significantly reducing erosion. Improved cultural practices such as closer spacing, reduced tillage, intercropping and fertilization will all contribute to reducing erosion while they may also increase yield and income. The "right" combination of

Table 7. The adoption of vetiver grass for erosion control in various sites in Thailand in 2001.

Province	District	Subdistrict	Village	Adoption of erosion control practices: No. of farmers	Cassava area (rai)[1)]	Vetiver (No. of plants)	Vetiver hedgerows (km)
1. Nakhorn Rach.	Daan Khun Thot	Baan Kaw	Khut Dook	53	309	130,000	15
2.	Thephaarak	Bueng Prue	3 and 6	26	214	80,000	11
3.	Soeng Saang	Noon Sombuun	Sapphong Phoot	60	828	80,000	20
4.		Sratakhian	Sratakhian*		30	20,000	2
5.	Khonburi	Maabtago-en	Lampiak*			20,000	
6. Prachinburi	Naadii	KaengDinso	Aang Thong	34	170	60,000	4.5
7.			Khao Khaat				
8. Kalasin	Mueang	Phuu Po	Noon Sawan	61	306	85,500	8.6
9.		Khamin	Khamplaa*				
10.	Nongkungsri	Nong Bua	Khamsri	67	690	111,600	11.2
11.	Sahatsakhan	Noonburi	Noon Sawaat	63	370	86,170	8.6
12.		Noonnamkliang	Huay Suea Ten	42	254	128,330	12.8
13.			Paa Kluay				
14. Chachoengsao	Sanaam Chaikhet	Thung Phrayaa	Thaachiwit Mai	6	45	50,000	2
15.	Thaa Takiab	Khlong Takraw	Nong Yai*	42	170	100,000	5.3
16. Srakaew	Wang Nam Yen	Wang Sombuun	Noon Thong	42		90,000	12
17. Kamphaengphet	Khanuwaralakburi	Bo Tham	Siiyaek*	42	170	68,000	3
18.			Ton Thoo				
19. Chaiyapuum	Thep Sathit	Naayaang Klak	Khook Anu*	42	170	68,000	4
20. Kaanchanaburi	Law Khwan	Thung Krabam	Nong Kae*	42	170	80,000	3
(Total) 8	**14**	**17**	**21**	**622**	**3,896 =623 ha**	**1,256,600**	**123**

* initiated in 2001
[1)] 1 hectare = 6.25 rai

Table 8. The adoption of new technologies by farmers in various sites in Vietnam in 2001.

Province	District	Commune	Village	Adoption (no. farmers/ha)				
				Varieties	Fertilization	Erosion control	Intercropping	Silage making
Thai Nguyen	Pho Yen		Tien Phong	81/4.7	45/2.3	4/0.2	40/1.5	-
			Dac Son	22/0.7	15/0.8	3/0.1	8/0.5	-
			Minh Duc	30/0.9	25/0.7	3/0.3	25/1.6	-
			Hong Tien	26/1.0	-	-	-	-
			Van Phai	26/0.3	-	-	-	-
			Nam Tien	7/0.2	-	-	-	-
Tuyen Quang	Son Duong	Thuong Am	Am Thang	16/2.0	15/0.5	15/6.0	-	-
			Hong Tien	18/1.2	18/0.6	8/4.0	-	-
Yen Bai	Van Yen		Yen Hung	5/2.0	-	5/2.0	-	-
			Yen Thai	4/2.0	-	4/2.0	-	-
			Yen Hop	6/2.0	-	6/2.0	-	-
			Mau Dong	9/4.0	-	9/2.0	-	-
			Dong Cuong	7/2.0	-	7/2.0	-	-
			Tan Hop	5/2.0	-	5/2.0	-	-
			Dong An	6/2.0	-	6/2.0	-	-
			Lam Giang	4/2.0	-	4/2.0	-	-
			An Binh	7/2.0	-	7/2.0	-	-
Phu Tho	Thanh Ba	Phong Linh	Kieu Tung	13	-	25	-	-
	Phu Ninh	Thong Nhat	Thong Nhat	32/2.0	-	25/3.5	-	-
			Bao Thanh	5	-	-	2	-
Hao Binh	Luong Son	Dong Xuan	Dong Rang	-	12	45	9	-
Ha Tay	Thach That		Thach Hoa	1000/100	10	15	4	-
	Chuong My	Tran Phu	Tran Phu	40	-	-	60	-
Thua Thien-Hue	A Luoi		Hong Ha	>19	12	25	>20	15
	Nam Dong		Thuong Long	10	-	-	-	20
	Huong Tra		Huong Van	-	-	-	-	40
Dong Nai	Thong Nhat		An Vien	>30	2	-	5	-
Binh Phuoc	Dong Xoai		Dong Tam	-	5	-	5	-
			Minh Lap	-	10	-	5	-
Baria Vungtau	Chau Duc		Suoi Rao	7/1.4	-	5/2.0	-	-
Total			**30**	**>1,435**	**169**	**226**	**>183**	**75**

cost-effective cultural practices and soil conservation practices (hedgerows, agro-forestry) is highly site-specific and must be developed locally in a cooperative effort between farmers, extensionists and researchers. Only those combinations of practices that are profitable in the short-term and effective in erosion control will be adopted. The planting of new higher-yielding varieties was the main incentive for farmers to participate in the project and was a very important "entry point" for getting farmers interested in testing methods of soil conservation. For that reason, FPR trials were never limited to only erosion control, but included varieties, intercropping, fertilization, weed control etc.

2. Some incentives may be necessary. Since soil conservation structures may be too expensive for farmers to establish on their own, governments should provide some assistance, as society as a whole also benefits from less flooding, more and better quality water, and lower costs of dredging and maintenance of irrigation and hydro- electric generating systems.

For example, in Thailand vetiver grass contour hedgerows are being adopted because farmers have seen their effectiveness in reducing erosion; in addition, the government supplies free planting material, helps farmers in setting out contour lines, teaches about multiplication and management of vetiver plants, as well as the use of vetiver leaves in the making of handicrafts as an additional source of income. In Vietnam, adoption of *Tephrosia candida* hedgerows is being facilitated by supplying farmers with good quality seed; similarly, in Indonesia farmers adopted *Gliricidia sepium* contour hedgerows after they received good quality seed from the project.

Financial incentives should be kept to a minimum, as this will not be sustainable in the long run, but some incentives in kind may be useful and necessary to allow farmers to adopt the new technology.

3. Farmers must be aware of soil erosion and its impact on soil productivity before they will be interested in soil conservation. Severe soil erosion is usually associated with steep slopes and its impact on soil productivity is most pronounced in shallow soils or in soils having a thin topsoil underlain by a highly infertile subsoil. In that case farmers can clearly see the negative impact of erosion on soil productivity and know that yields will decline unless they protect their soil from erosion. But even in areas with gentle slopes (2-10%) and deep soils, the accumulation of large amounts of runoff water in natural drainage ways can cause severe gulley erosion, break contour ridges and wash away young plants and fertilizers, while the eroded sediments may obstruct roads and irrigation and drainage systems below. By conducting erosion control trials on their own fields and seeing the large amounts of eroded sediments in the plastic-covered ditches, farmers start to appreciate how much soil they are losing each year. They also see that the use of simple practices such as fertilizer application, intercropping and contour hedgerows, can markedly reduce erosion, and in some cases increase yields.

To be convincing, however, and to be able to obtain accurate data on soil losses, these FPR erosion control trials must be laid out exactly on the contour, and care must be taken that no water runs onto the plots from above or from the sides, and no water leaves the plots across side borders. This is not an easy task, especially if the slope is not uniform; it requires much care and experience at the time these plots are laid out and treatments are established. Researchers and farmers generally like rectangular plots, preferably parallel to roads or field borders, while this type of trial may require trapezoidal or irregularly shaped plots to maintain the sediment-collection ditches along the contour and perpendicular to the natural flow of runoff water.

4. Give farmers freedom to experiment. In conducting the trials, farmers should be allowed to select the treatments they think are most useful. On the other hand, having farmers as a group decide on a set of the same treatments, to be tested by all farmers participating in the trials, facilitates the taking of data and allows the calculation of averages across trials within the site, which makes it possible to compare treatments over a range of conditions. Alternatively, some treatments may be common to all trials in the village, while other treatments may be selected by each farmer individually.

5. Yield calculations must be accurate and based on total cropped area. To be believable, yield data must be accurate and must reflect the real on-farm conditions. In treatments with intercrops or hedgerows the yield of each crop should be calculated based on the total area of the plot, or of a subplot that includes all crop components. Calculating yields from "effective" plots that exclude border rows and hedgerows will inevitably overestimate the yield of those treatments, and thus mislead farmers into attributing non-existing benefits to those treatments. Also, treatments of "farmers' traditional practices" should be managed as much as possible like the farmer's production fields; the yields of those plots should be similar to what farmers obtain in nearby production fields. However, asking farmers to plant their trials at a uniform plant spacing will greatly facilitate the accurate determination of yield. In as much as possible, FPR trials should be planted and harvested at the times that farmers in the village normally plant and harvest these same crops.

6.Local officials and self-help groups should be partners in the project. When selecting appropriate pilot sites it is important not only to consider the bio-physical and socio -economic conditions of farmers, but also to gauge the interest of local leaders and extension officers, and to determine the existence of NGO's or local self-help groups. Working in collaboration with these local officials and groups will greatly facilitate the implementation of the trials and the subsequent adoption of selected practices. Support for the project at the highest levels of government will help to convince local officials that their participation in the project is not only approved of but also appreciated. Inviting local leaders and extensionists to FPR training courses will contribute much to their understanding of the approach and their active participation in the project. Finally, the presence of NGOs with interest in sustainable agriculture and rural development, as well as the existence of local self-help groups makes it easier to call meetings, initiate the project, conduct the trials and enhance the adoption and implementation of selected practices.

CONCLUSIONS

Research on sustainable land use conducted in the past has mainly concentrated on finding solutions to the bio-physical constraints, and many solutions have been proposed for improving the long-term sustainability of the system. Still, few of these solutions have actually been adopted by farmers, mainly because they ignored the human dimension of sustainability. For new technologies to be truly sustainable they must not only maintain the productivity of the land and water resources, but they must also be economically viable and acceptable to farmers and the community. To achieve those latter objectives farmers must be directly involved in the development, adaptation and dissemination of these technologies. A farmer participatory approach to technology development has shown to be quite effective in developing locally appropriate and economically viable technologies, which in turn enhances their acceptance and adoption by farmers.

The conducting of FPR trials is initially time consuming and costly, but once more and more people are trained and become enthusiastic about the use of this approach - including participating farmers - both the methodology and the selected improved varieties or cultural practices will spread rapidly. The selection and adoption of those farming practices that are most suitable for the local environment and in tune with local traditions will improve the long-term sustainability of the cropping system, to the benefit of both farmers and society as a whole.

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