THE USE OF FARMER PARTICIPATORY RESEARCH (FPR) IN THE NIPPON FOUNDATION PROJECT: IMPROVING THE SUSTAINABILITY OF CASSAVA-BASED CROPPING SYSTEMS IN ASIA

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ABSTRACT

The Nippon Foundation Project entitled "Enhancing the Sustainability of Cassava-based Cropping Systems in Asia" started in 1994 and has as its main objective to develop, together with farmers, crop/soil management practices that will increase yields and farm income while also protecting the soil and water resources from degradation. To attain this objective a farmer participatory research (FPR) methodology was developed that will help diagnose the principal problems in the farm community, make farmers aware of the extent and importance of soil erosion and fertility degradation, test various ways to overcome these problems, and after selecting the most suitable practices to enhance adoption and dissemination of those practices to other farmers and other communities.

The project was implemented by CIAT in collaboration with research and extension organizations in China, Indonesia, Thailand and Vietnam. In each country, "FPR teams" were formed and in mid-1994 an FPR training course was held in Rayong, Thailand, to familiarize team members with the FPR approach and discuss and develop a suitable methodology. The principle behind the approach is to encourage farmers to diagnose their own problems, consider various possible solutions and test those ideas on their own fields, in order to select the best ones for adoption. The basic steps of the FPR methodology used in the four countries included:

1. Select 2-3 pilot sites (villages or subdistricts) where cassava is an important crop and erosion is a serious problem.
2. Show farmers a wide range of options to reduce erosion and soil degradation in demonstration plots with many treatments, and let farmers discuss, score and then select the most suitable options.
3. Help farmers test the selected options on their own fields; the options tested usually involved new varieties, intercropping systems, fertilization practices and methods to control erosion.
4. Together with farmers harvest the trials, evaluate the results, select the best treatments, to be either tested again in the following year or tried on small areas of their production fields.
5. Encourage adoption and dissemination of the best practices.

During the first phase of the project (1994-1998), about 76 FPR trials were conducted in Thailand, 216 in Vietnam, 77 in China and 101 in Indonesia. In addition, some farmers in Vietnam started testing new varieties completely on their own. After 2-3 years of testing and evaluating, many of the participating farmers started adopting some of the most promising practices on larger areas of their fields. Besides planting new varieties and using improved fertilization practices, many farmers adopted some form of erosion control practices: in Thailand and China mainly contour hedgerows of vetiver grass or sugarcane, in Vietnam mainly hedgerows of *Tephrosia candida* or vetiver grass combined with intercropping with peanuts, and in Indonesia mainly contour ridging (Malang) and hedgerows of *Gliricidia sepium* or *Leucaena leucocephala* (Blitar).

The paper also describes some valuable lessons learned during the implementation of the project and concludes that farmer participation in technology development, especially in the case of soil conservation, is absolutely essential for attaining widespread adoption of these technologies.

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INTRODUCTION

In Asia most cassava is grown on rather acid and very infertile Ultisols (55%), followed by slightly more fertile Inceptisols (18%) and Alfisols (11%) (Howeler, 1992). Most of these soils have a sandy or sandy loam texture - especially in Thailand, Vietnam and on Sumatra island of Indonesia - and have an undulating topography. Cassava soils in southern China and on Java island of Indonesia tend to have a heavier texture, but are located on steeper slopes.

Farmers know that if they grow cassava for many years on the same land without application of fertilizers or manures, their yields will decrease and the soil may become so degraded that no other crops will grow. This is not because cassava extracts excessive amounts of nutrients from the soil; if only roots are harvested and removed from the field, nutrient removal by cassava is actually less than that of most other crops, with a possible exception of K (Howeler, 2001). However, soils can seriously degrade due to erosion. When cassava is grown on slopes, especially in light-textured and low organic matter (OM) soils, erosion can be a serious problem due to the wide plant spacing used and the slow initial growth of the crop (Quintiliano *et al*., 1961; Margolis and Campo Filho, 1981; Puthacharoen *et al*., 1998).

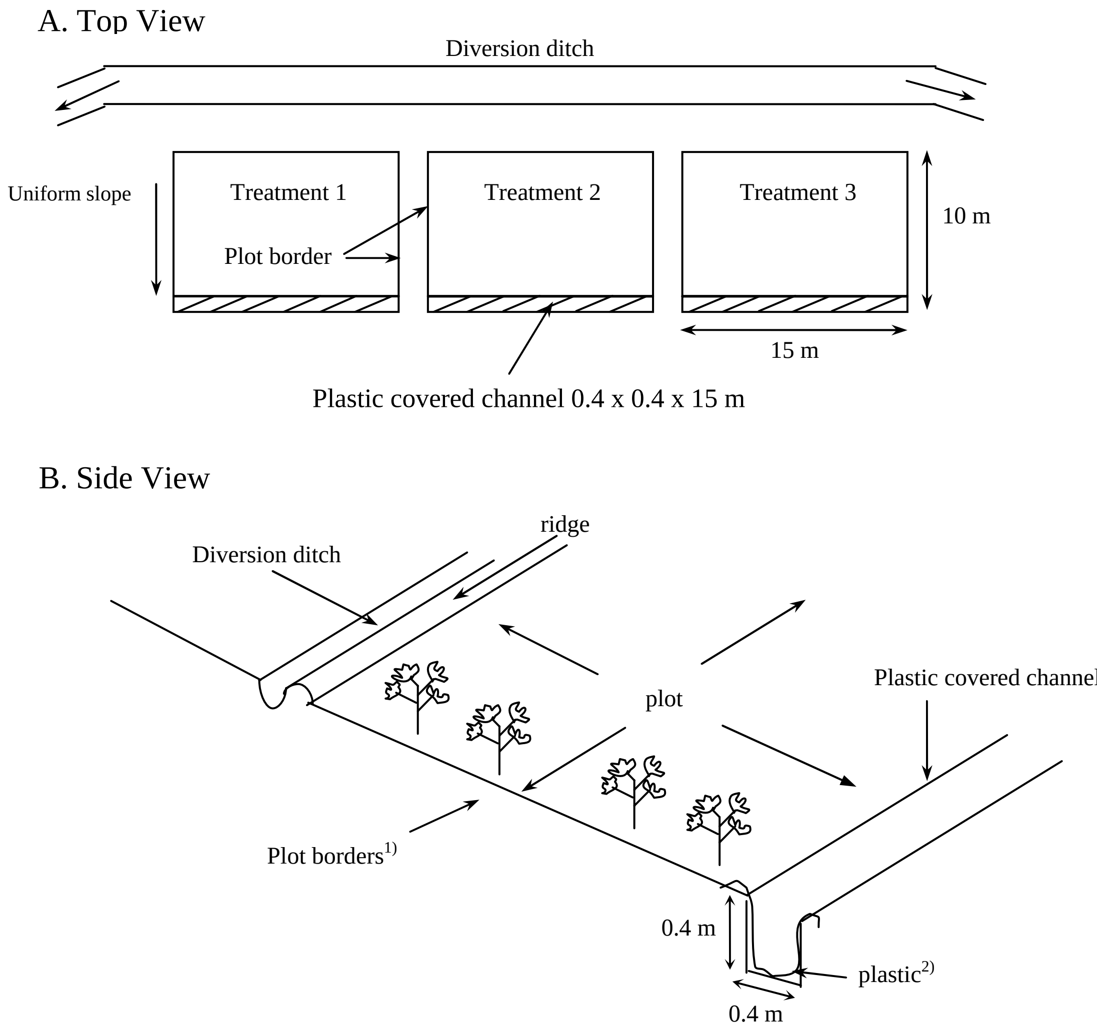
Research on erosion control practices has shown that soil losses due to erosion can be markedly reduced by simple agronomic practices combined with soil conservation practices. This includes agronomic practices such as minimum or zero tillage, mulching, contour ridging, intercropping, fertilizer and/or manure application, and planting at higher density; and soil conservation practices such as terracing, hillside ditches and planting contour hedgerows of grasses or legumes. But these practices are seldom adopted by farmers because they were not appropriate for the specific circumstances of the farmers, either from an agronomic or socio-economic standpoint (Ashby, 1985; Barbier, 1990; Fujisaka, 1991; Napier *et al*., 1991).

CIAT has developed a simple methodology for measuring the effect of soil/crop management treatments on erosion, using plastic-covered ditches dug along the lower edge of each plot to trap eroded sediments (**Figure 1**); this allows research on erosion control to be carried out on-farm. Using this simplified methodology, many soil/crop management and erosion control practices can be compared in terms of yield, gross and net income, as well as soil losses due to erosion. This allows farmers to be directly involved in the development and dissemination of more sustainable practices; the practices selected by farmers are likely to be effective in controlling erosion and appropriate for the local conditions, and also provide substantial short-term economic benefits. It was decided to use a farmer participatory approach in seeking solutions, and to enhance the dissemination and adoption of these practices.

A. FARMER PARTICIPATORY RESEARCH (FPR)

Methodology and Principal Activities

An outstanding feature of farmer participatory research (FPR), which sets it apart from “on-farm” research, is that farmers themselves make all major decisions. They evaluate and select the most appropriate technology options available, select treatments in the trials, evaluate the results and decide what practices, if any, to adopt. The researchers and extensionists merely facilitate the decision making process and provide new technological options as well as materials, such as seeds or planting material of new varieties or crops etc. This bottom-up



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

approach is completely different from the traditional top-down approach used by most research and extension organizations; some initial persuasion and much hands-on experience is necessary for people to feel comfortable with this new approach.

The project was initiated in early 1994 by contacting potential collaborating institutions in the four countries participating in the project, i.e. Thailand, Indonesia, China and Vietnam. Participating institutions are shown in **Table 1**. They usually include a research institute or university involved in cassava research as well as an extension organization. Within the collaborating institutes the most suitable persons were identified, ideally including agronomists/soil scientists knowledgeable about cassava, as well as socio-economists. These formed the "FPR teams" in each of the four countries.

Table 1. Institutions collaborating with CIAT in the first phase of the Nippon Foundation Project on Improving Agricultural Sustainability in Asia, 1994-1998.

Country/Province	Institution	FPR project	Research
China-Hainan	Chinese Acad. Tropical Agric. Sciences (CATAS)	✓	✓
China-Guangxi	Guangxi Subtropical Crops Research Institute (GSCRI)		✓
China-Guangdong	Upland Crops Research Institute (UCRI)		✓
Indonesia-E.Java	Brawijaya University (UNIBRAW)	✓	✓
Indonesia-E.Java	Research Institute for Legumes and Tuber Crops (RILET)	✓	✓
Indonesia-W.Java	Central Research Institute for Food Crops (CRIFC)		✓
Philippines-Leyte	Phil. Root Crops Research and Training Center (PRCRTC)		✓
Philippines-Bohol	Bohol Experiment Station (BES)		✓
Thailand-Rayong	Field Crops Research Institute (FCRI) of Dept. of Agriculture	✓	✓
Thailand-Bangkok	Field Crops Promotion Division of Dept. Agric. Extension	✓	
Thailand-Korat	Thai Tapioca Development Institute	✓	
Thailand-Bangkok	Kasetsart University		✓
Vietnam-Thai Nguyen	Agro-Forestry College of Thai Nguyen University	✓	✓
Vietnam-Hanoi	National Inst. for Soils and Fertilizers (NISF)	✓	
Vietnam-Ho Chi Minh	Institute of Agric. Sciences (IAS)		✓

In June 1994 a one-week Workshop was held in Thailand to acquaint the FPR team members of the four countries with the objectives and principles of FPR, and train them in the use of FPR methodologies, including various surveying techniques, such as Rapid Rural Appraisal (RRA) and formal socio-agronomic surveys. After discussing the general methodology proposed for the project, each team worked out and presented a specific workplan for implementing the project in their country.

To implement the FPR component of the project a relatively standardized methodology was used, but modifications could be made to adapt to local institutional arrangements and socio-economic conditions. The general proposed methodology included the following steps:

1. Establishment of demonstration plots which compare a wide range (usually 15-25) of management options to increase cassava yields (or income) and reduce erosion. The plots were established on a uniform slope and a plastic-covered channel below each plot allowed the collection of eroded sediments, in order to measure the effect of each treatment on soil erosion (**Figure 1**).
2. The conducting of Rapid Rural Appraisals (RRAs) in preselected pilot sites to obtain basic information about soil, climate, topography, cropping systems, cultural practices and socio-economic conditions in each site, in order to select the most suitable pilot sites for the project. In each country, at least two pilot sites were selected for the FPR project, based on the criteria that cassava is an important crop in the area, cassava is grown on slopes, erosion is a serious problem and is as such perceived by the farmers. The principal characteristics of the selected pilot sites in the four countries are shown in **Table 2**, and one example of a more detailed RRA conducted in Vietnam is shown in **Table 3**. **Figure 2** shows the location of the selected pilot sites.
3. The organization of farmers' field days to explain the objectives and activities of the project to farmers of the selected pilot sites, and to visit and discuss with these farmers the demonstration plots. In the demonstration field, farmers are asked to score the various treatments in terms of their general usefulness. After a discussion of the *pros* and *cons* of each treatment, farmers select those treatments that they think are most useful for their own particular conditions. The field day may also include training, to familiarize farmers with the newest cassava varieties and production practices.
4. A meeting at each pilot site between farmers and FPR team members, to further diagnose the farmers' production problems, to decide on the type of FPR experiments to be conducted, the treatments to be included, and who will do what and when. In general, farmers volunteer to participate in the project, but if too many farmers volunteer, some form of selection of participating farmers is used. While the project focuses on management practices to control erosion by conducting FPR erosion control trials, farmers may also want to conduct trials on new varieties, as well as on fertilization and intercropping practices. These latter trials are usually done by farmers having mainly flat land.
5. Farmers conduct FPR trials on their own fields. FPR team members and local extension agents provide the basic planting materials and help farmers to select the most suitable sites for the trials, set out contour lines and plot borders, plant cassava and establish the selected treatments. Farmers manage the trials on their own fields. FPR team members visit the trials several times during the cropping cycle to make observations or take data (such as the harvest of intercrops or the weighing of eroded sediments) and to discuss the progress or problems with the farmers.

At time of cassava harvest the FPR team members and farmers together harvest the trials, determine cassava root yield, intercrop yields, and erosion losses. These data are quickly tabulated and presented to the farmers. The results are discussed and evaluated, and farmers indicate which treatments they prefer and for what reason.

6. The best treatments or other alternative treatments are tested again in similar FPR trials during the next and following crop years in a reiterative process of testing, evaluating, selecting and adapting, in order to develop the best practices for the farmer's particular bio-physical and socio-economic conditions.

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. (^{o}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

Table 3. Cropping systems, varieties and agronomic practices, as determined from RRAs conducted in four FPR pilot sites in Vietnam in 1996/97.

Province	Hoa Binh	Phu Tho	Thai Nguyen	
District	Luong Son	Thanh Ba	Pho Yen	
Village		Phuong Linh		
Hamlet	Dong Rang	Kieu Tung	Tien Phong	Dac Son
Cropping system[1]				
-upland	tea C+T C monoculture peanut, maize	C monoculture C+P tea, peanut maize	C+P or C+B or 2 yr C rotated with 2 yr fallow sweet potato	C monocult. or C-P rotation or C-B, C-SP sweet potato
Varieties				
-rice	CR 203, hybrids from China	DT 10, DT 13, CR 203	DT 10, DT 13 CR 203	CR 203 DT 10, DT 13
-cassava	Vinh Phu, local	Vinh Phu, local	Vinh Phu Du, Canh Ng	Vinh Phu
Cassava practices				
-planting time	early March	early March	Feb/March	Feb/March
-harvest time	Nov/Dec	Nov/Dec	Nov/Dec	Nov/Dec
-plant spacing (cm)	100x80	80x80; 80x60	100x50	100x50
-planting method	horiz./inclined	horizontal	horiz./inclined	horizontal
-land preparation	buffalo/cattle	by hand/cattle	buffalo	buffalo
-weeding	2 times	2 times	2 times	2 times
-fertilization	basal	basal+side[2]	basal+side[3]	basal+side[4]
-ridging	mounding	flat	flat	flat
-mulching	rice straw	peanut residues	peanut residues	peanut residues
-root chipping	hand chipper	knife	small grater	small grater
-drying	3-5 days	3-5 days	2-4 days	2-4 days
Fertilization				
-cassava				
-pig manure (t/ha)	5	5	3-5	8-11
-urea (kg/ha)	0	50-135	83	83-110
-SSP (18% P_2O_5) (kg/ha)	50-100	0	140	0-280
-KCl (kg/ha)	0	0	55	0-280
-rice				
-pig/buffalo manure (t/ha)	5	0	-	-
-urea (kg/ha)	120-150	80	-	-
Yield (t/ha)				
-cassava	11-12	8-15	8.5	8.7
-rice (per crop)	3.3-4.2	4.2	3.0-3.1	2.7-3.0
-taro	1.9-2.2	-	-	-
-sweet potato	-	-	8.0	3.3
-peanut	0.8-1.2	0.5-1.1	1.4	1.3
pigs (kg live weight/year)	100-120	-	-	-

[1] C=cassava, P=peanut, B=black bean, T=taro, M=maize
C+P=cassava and peanut intercropped; C-P=cassava and peanut in rotation
[2] urea at 2 MAP
[3] urea when 5-10 cm tall; NPK+FYM when 20 cm tall
[4] NPK when 30 cm tall; hill up

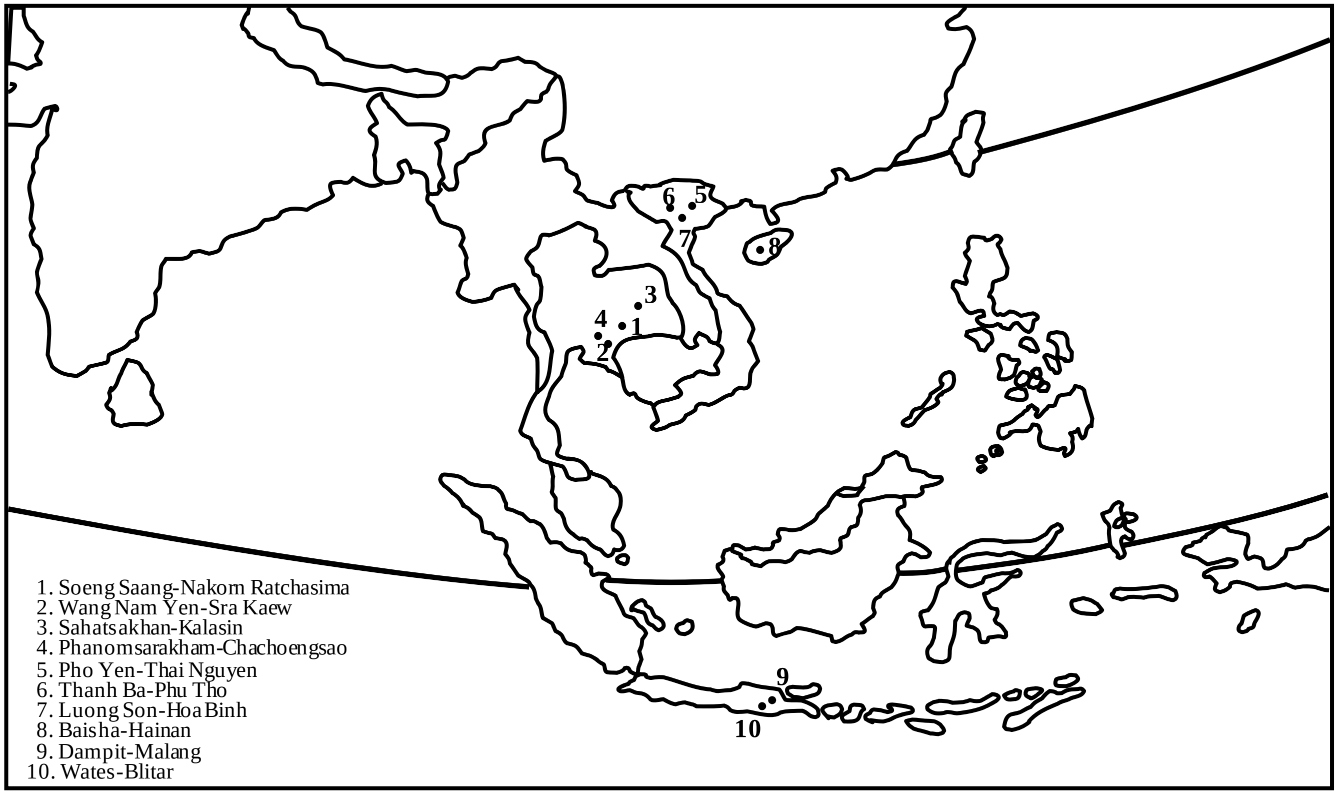


Figure 2. Location of pilot sites in the Nippon Foundation FPR project on Improving the Sustainability of Cassava-based Cropping Systems in Asia, 1994-1998.

7. Farmers make further adaptations, if necessary, and try out the best of the available options on small areas of their regular production fields
8. Neighboring farmers or those from neighboring villages are invited to participate in the field days, to visit the trials or to conduct their own trials. Once suitable technologies have been selected these may spead to neighbors who may also decide to adopt them.

By working directly with farmers, FPR team members learn about real farming conditions, about the farmers' selection criteria as well as the farmers' needs and limitations. When certain production problems arise, these are fed back to the research stations to conduct further adaptive or applied research (see below) to try to solve the problems. The conceptional model of this FPR methodology is shown in **Figure 3**.

In the subtropical regions of north Vietnam and southern China, cassava is generally planted in early spring (Feb-April); in the tropical regions of Thailand and Indonesia the crop is planted mainly at the beginning of the rainy season, which in Thailand is generally in March-May and in Indonesia in Oct-Nov. Thus, in Indonesia all activities tend to be about six months behind those in the other three countries, due to a different pattern of rainfall distribution. A schedule of the specific activities conducted in each country during the course of the 5-year project is shown in **Table 4**.

Table 5 shows the type and number of FPR trials conducted by farmers in the nine pilot sites in four countries during the four cropping cycles of the project. In Vietnam the number of trials increased over the years as more and more farmers wanted to participate in the project. In the other three countries the number of trials tended to decrease when farmers felt that they had tested adequately the available new technologies and started to adopt some selected soil erosion control practices in small "demonstration fields" of their regular production areas.

In Thailand, a new pilot site in Sahatsakhan district of Kalasin province was selected in 1997, demonstration plots were established and about 30 farmers initiated FPR trials on erosion control, varieties and fertilization practices in 1998. Farmers in a second new pilot site in Phanom Sarakham district of Chachoengsao province also started FPR trials in late 1998.

Results and Discussion

1. *Selection of Options from the Demonstration Plots*

When farmers visited the demonstration plots they were asked to score each treatment. After discussing the merits of the various treatments they selected 3-4 treatments that were considered most suitable for their own conditions. Various examples of results of these demonstration plots were reported by Nguyen The Dang *et al*. (1998; 2001), Vongkasem *et al*. (1998), Zhang Weite *et al*. (1998), Huang Jie *et al*. (2001) and Utomo *et al*. (1998; 2001). Farmers generally select those treatments that produce high cassava and/or intercrop yields, a high net income and low levels of erosion, and that fit well in their current production system. In Vietnam this included intercropping cassava with peanut and using either hedgerows of *Tephrosia candida* and vetiver grass or contour ridges to reduce erosion. In Indonesia, farmers generally preferred intercropping with maize and planting either elephant grass or *Gliricidia sepium* as contour hedgerows to reduce erosion and supply animal feed during the dry season.

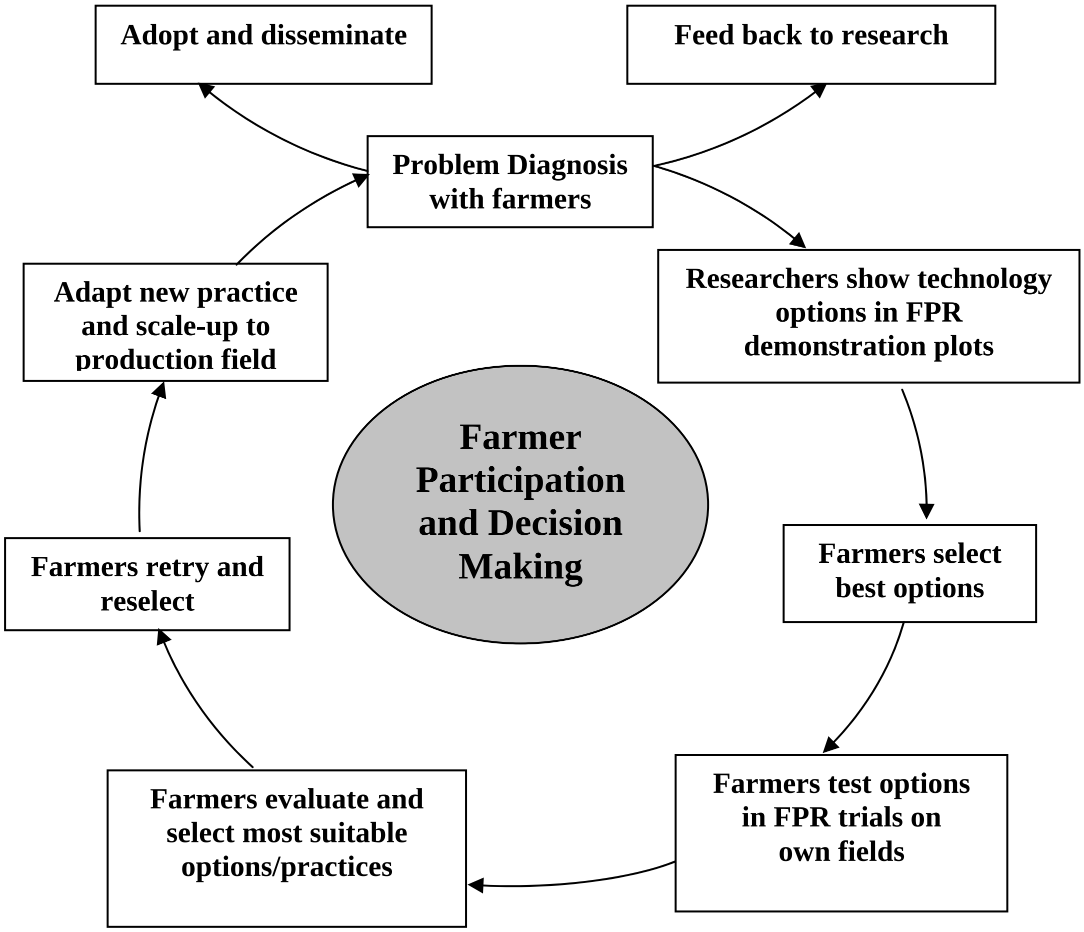


Figure 3. Farmer participatory model used for the development of sustainable cassava-based cropping systems in Asia.

Table 4. Schedule of activities in the Nippon Foundation Project in the four participating countries.

Activity	China	Indonesia	Thailand	Vietnam
Institutional arrangements	early'94	mid'94	early'94	early'94
FPR training workshop	July'94	July'94	July'94	July'94
Plant demonstration plots	March'94	Nov'94	Aug'94	Feb'94
RRA	Aug'94	Jan-May'95	Dec'94-Jan'95	Oct-Nov'94
Farmers' field day	Jan'95	March'95	Jan'95	Nov'94
Install FPR trials-1st cycle	May'95	Nov'95	April-May'95	Feb'95
Second farmers' field day	Oct'95	Sept'95	Aug-Sept'95	-
Third farmers' field day	Jan'96	July-Aug'96	Jan'96	Nov'95
Install FPR trials-2d cycle	April'96	Nov'96	April'96	Feb'96
5th Regional Cassava Workshop	Nov'96	Nov'96	Nov'96	Nov'96
Fourth farmers' field day	Jan'97	Aug'97	Feb'97	Dec'96
Install FPR trials-3d cycle	March'97	Oct'97	April'97	Feb'97
Training-of-Trainers in FPR	June'98	May'98	Sept'97	Sept'97
Fifth farmers' field day	Dec'97	Aug'98	Feb'98	Dec'97
Install FPR trials-4th cycle	March'98	Oct'98	April'98	Feb'98
Sixth farmers' field day	Dec'98	Aug'99	Febr'99	Dec'98
Project evaluation	← June-July 1998 →			
Final Project Report	← Oct 1998 →			

Table 6 shows the ranking of treatments by farmers in seven pilot sites in 1995. It is clear that farmers in different countries, and even within the same country, select very different options, depending on the local conditions and their traditional cropping patterns. Thus, in Thailand, where labor tends to be scarce, intercropping treatments are seldom preferred options, while in those parts of Indonesia where land is very scarce (Java), intercropping is a highly preferred option. Vetiver grass contour hedgerows were shown to be quite effective in reducing erosion in the demonstration plots in Thailand and Vietnam, and farmers from both pilot sites in these two countries selected this as one of the treatments they wanted to try on their own fields. In China, vetiver grass was initially not considered a preferred option, and in Indonesia this treatment was not included in the demonstration plots on the assumption that farmers would prefer hedgerows of a grass or legume species that can also be used as animal feed. When vetiver grass was later included as a treatment in either demonstration plots or FPR erosion control trials, farmers in both China and Indonesia considered it as a useful option that they wanted to test further in their FPR trials.

2. *Selection of Treatments for FPR Trials*

During the first year of FPR trials (1995) farmers generally selected some of the preferred options from the demonstration plots as treatments for their FPR erosion control trials. In some cases, however, farmers made their own adaptations. Thus, in one site in Thailand, farmers decided to try contour hedgerows of sugarcane instead of king grass that they had seen used in the demonstration plots, since the sugarcane stalks (for chewing) can be sold at the local market, while king grass is of little use to them.

Table 5. 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 6. 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		

In the second and subsequent cycles of FPR trials, farmers selected those treatments that had shown promise and eliminated others that were found to be less useful, replacing these with other alternative options, either observed in the demonstration plots or adaptations from previously tried treatments.

While initially in some sites each farmer selected their own preferred treatments, it was found that it is better if farmers as a group decide on the 3-4 treatments to be tested (in comparison with their own "traditional practice"), so that average yields and erosion losses can be calculated for each treatment from data of several trials, and more definite conclusions can be drawn. In case of FPR variety trials, there was sometimes not enough planting material of each variety for each farmer, so different farmers compared 1-3 new but different varieties with their own traditional variety. This is an alternative way of screening and multiplying a large number of new materials, while the best materials can then be further tested with replication in subsequent years.

3. *Results of FPR Trials*

Tables 7 to **10** show examples of FPR trials conducted in 1997/98 on erosion control, varieties, intercropping and fertilization. After discussing the results of the trials during the farmers' field day at harvest time, farmers ranked or scored the treatments, indicating which they preferred most. In an FPR erosion control trial conducted in Kieu Tung village in Vietnam

(**Table 7**) the practice of intercropping cassava with peanut, applying a balanced fertilizer (both chemical fertilizers and pig manure) and growing hedgerows of vetiver grass was the most preferred option, as this treatment nearly doubled the net income and reduced to one third soil loss due to erosion, as compared to the traditional farmers' practice of planting cassava in monoculture and applying only animal manure. Farmers in this village indicated that the new erosion control practices they had developed through FPR trials not only increased their income, improved their soil (through incorporation of peanut residues and less soil and nutrient losses), but also saved them the hard work of having to dig the acid and infertile soil, eroded from surrounding uplands, out of their rice paddies every year.

Table 8 indicates that farmers in Kongba village on Hainan island of China clearly preferred the new variety SC8013, not only for its higher yield but also for its typhoon resistance.

Table 9 shows that in Pho Yen district of Vietnam intercropping with one row of peanut between cassava rows increased net income, and this practice has now been widely adopted by farmers. In the same site, the FPR fertilizer trials (**Table 10**) indicate that a balanced application of a moderate amount of pig manure with chemical fertilizers that are high in N and K could almost double the net come in comparison with farmers' traditional practices.

Table 11 summarizes the results of three years of FPR erosion control trials conducted in the various pilot sites in the four countries, comparing the best farmer-selected practice with the traditional farmers' practice. In most cases, the new practice selected by farmers markedly reduced soil losses due to erosion while also increasing the gross or net income.

4. *Adoption of Technologies*

After several years of testing new varieties and more sustainable management practices in their FPR trials, farmers in the pilot sites started to adopt some technology components they had tested in their production fields (**Table 12**). In general, farmers were most interested in the testing and multiplication of new varieties, and this was the first component to be adopted. In both pilot sites in Thailand new varieties have now completely replaced the traditional variety Rayong 1, while in Vietnam and China participating farmers have now largely replaced their traditional varieties, Vin Phu and SC205, respectively, with new higher yielding varieties. Adoption, however, has been much slower in Indonesia, since the new varieties were only marginally higher yielding than the local varieties, which are well adapted to ecological niches and have been selected over the years for local taste preferences.

FPR fertilizer trials generally showed that a balanced application of farmyard manure (FYM) and chemical fertilizers that are high in N and K but low in P produces the highest net income. The greater use of chemical fertilizer was readily adopted by participating farmers as long as these fertilizers are available at a reasonable cost.

Intercropping with peanut was readily adopted in Vietnam because it increased total net income, improved the soil, and reduced weeds and soil losses by erosion. Intercropping was less successful in China and Thailand, mainly because of drought or excessive rain, or due to rat damage of the intercropped peanut in China. In Indonesia, intercropping with maize, upland rice and various grain legumes is already a traditional practice, which could be further improved, however, by introducing higher yielding varieties of the intercrops.

Table 7. Effect of various crop management treatments on the yield of cassava and intercropped peanut, as well as the gross and net income and soil loss due to erosion in an FPR erosion control trial conducted by six farmers on about 40% slope in Kieu Tung village of Thanh Ba district, Phu Tho province, Vietnam in 1997.

Treatments[1)]	Dry soil loss (t/ha)	Yield (t/ha)		Gross income[2)]	Product. costs	Net income	Farmers' ranking
		cassava	peanut	<-------------(mil.dong/ha)------------->			
1. C monoculture, no fertilizers, no hedgerows (TP)	106.1	19.17	-	9.58	3.72	5.86	6
2. Cassava+peanut, no fertilizers, no hedgerows	103.9	13.08	0.70	10.04	5.13	4.91	5
3. C+P, with fertilizers, no hedgerows	64.8	19.23	0.97	14.47	5.95	8.52	-
4. C+P, with fertilizers, *Tephrosia* hedgerows	40.1	14.67	0.85	11.58	5.95	5.63	3
5. C+P, with fertilizers, pineapple hedgerows	32.2	19.39	0.97	14.55	5.95	8.60	2
6. C+P, with fertilizers, vetiver hedgerows	32.0	23.71	0.85	16.10	5.95	10.15	1
7. C monoculture, with fertilizers, *Tephrosia* hedgerows	32.5	23.33	-	11.66	4.54	7.12	4

[1)]Fertilizers=60 N+40 P_2O_5+120 K_2O; all plots received 10 t pig manure/ha
TP=farmer traditional practice
[2)]Prices: cassava: d 500/kg fresh roots
peanut: 5,000/kg dry pods
1US $ = approx. 13,000 dong

Table 8. Results of four FPR variety trials conducted by farmers in Kongba village, Baisha county, Hainan, China in 1997.

	<---------Cassava yield (t/ha)--------->					Farmers'
	A[1)]	B	C	D	Av.	preference[2)]
SC 205	-	16.93	14.32	20.83	17.36	9
SC 8002	-	-	20.83	-	20.83	0
SC 8013	36.46	21.48	19.53	27.99	26.36	14
SC 8639	28.65	-	-	36.46	32.55	14
ZM 9036	-	15.62	-	-	15.62	0
ZM 9244	27.02	-	-	47.53	37.27	10
ZM 9247	-	23.44	-	26.04	24.74	13
ZM 9315	-	18.23	-	31.25	24.74	10
ZM 94107	19.53	19.53	-	33.85	24.30	0
OMR 33-10-4	26.69	18.23	20.83	-	21.92	5
OMR 34-11-3	25.06	16.93	18.23	28.65	22.22	4
OMR 35-70-7	29.95	-	-	29.30	29.62	13

[1)] A = Mr. Lu Huan Cheng
B = Mr. Zhou Yong Ming
C = Mr. Tan Yin Chai
D = Mr. Fu Yong Quan
[2)] Number of farmers liking variety (out of 14 farmers)

Table 9. Average results of ten FPR trials on planting arrangement in intercropping cassava with peanut conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district, Thai Nguyen province, Vietnam in 1997.

	Yield (t/ha)		Gross income[1)]	Production costs[2)]	Net income	Farmers' preference
	cassava	peanut	<------(mil.dong/ha)		------>	(%)
1. Farmer's practice[3)]	20.87	0.64	13.64	3.82	9.82	10
2. Cassava+1 row of peanut[4)]	27.23	0.32	15.22	3.34	11.88	55
3. Cassava+2 rows of peanut[5)]	21.64	0.49	13.27	3.52	9.75	52
4. Cassava+3 rows of peanut[6)]	19.02	0.58	12.41	3.70	8.71	0

[1)]Prices: cassava: d 500/kg fresh roots
peanut: 5000/kg dry pods
peanut seed: 6000/kg dry pods
1 US $ = approx. 13,000 dong
[2)]Peanut seed requirements: T_1=120, T_2=40, T_3=70, T_4=100 kg/ha
[3)]Cassava on ridges spaced at 1.0-1.2m between ridges, peanut planted cross-wise on ridge in short rows, 0.6-0.8m between rows (to reduce excess moisture)
[4)]Cassava at 1x0.6m; peanut between cassava rows at 0.1m between plants
[5)]Cassava at 1x0.8m; 2 rows of peanut at 0.35x0.1m
[6)]Cassava at 1.2x0.8m; 3 rows of peanut at 0.35x0.1m

Table 10. Average results of five FPR fertilizer trials conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district, Thai Nguyen province, Vietnam in 1997.

Treatments	Cassava yield (t/ha)	Gross income[1)]	Fertilizer costs[1)]	Net income	Farmers' preference (%)
		<----------(mil. dong/ha)---------->			
1. Farmer's practice[2)]	18.50	9.25	3.31	5.94	0
2. 10 t/ha FYM+40N+40K_2O	19.87	9.44	2.43	7.01	32
3. 10 t/ha FYM+80N+40P_2O_5+80K_2O	22.37	11.19	3.10	8.09	64
4. 10 t/ha FYM+120N+40P_2O_5+120K_2O	28.00	14.00	3.54	10.46	61

[1)]Prices: cassava: d 500/kg fresh roots
pig manure: 200/kg
urea (45%N): 3000/kg
SSP (17%P_2O_5): 1000/kg
KCl (50%$K_2$0): 2600/kg
1 US $ = approx. 13,000 dong

[2)]Average farmer application: 12.8 t/ha of FYM+58 kg N+31 P_2O_5+34 K_2O/ha

Table 11. Effect of farmer selected soil conservation practices on dry soil loss and gross and net income as compared to the traditional farmers' practice in FPR trials conducted in eight pilot sites in Asia from 1995-1998.

FPR pilot sites	Year	No. of farmers	Dry soil loss(t/ha)	Income ($/ha) Gross	Net
China - Hainan, Baisha, Kongba					
Farmers' practice (C monoculture)	1995	11	47	1220	-
Various intercropping/hedgerows			32	1391	-
Farmers' practice (C monoculture)	1996	4	125	371	-
C+peanut , vetiver hedgerows			89	736	-
Farmers' practice (C monoculture)	1997	4	114	523	-
C+peanut, vetiver hedgerows			60	941	-
Indonesia - E. Java, Malang, Dampit					
Farmer's practice (C monocult, up/down ridge, N)	94/95	D[1)]	72	578	545[2)]
C+maize, elephant grass hedgerows, NPK			48	1069	993[2)]
Farmer's practice (C monoculture, N)	95/96	D[1)]	145	317	155[4)]
C+maize, elephant grass hedgerows, NPK			134	346	37[4)]
Farmer's practice (C+maize, N)	96/97	9	8	615	-
C+maize, vetiver hedgerows, NPK			8	603	-
Indonesia - E. Java, Blitar, Ringinrejo					
Farmers' practice (C monoculture)	94/95	D[1)]	27	312	211[2)]
C+maize, *Gliricidia* hedgerows			28	588	509[2)]
Farmers' practice (C+maize)	95/96	D[1)]	28	307	157[4)]
C+maize, *Gliricidia* hedgerows			23	247	97[4)]
Farmers' practice (C+maize)	96/97	2	55	697	597[2)]
C+maize, *Gliricidia* hedgerows		2	57	40	641[2)]

Table 11. continued

FPR pilot sites	Year	No. of farmers	Dry soil loss(t/ha)	Income ($/ha) Gross	Net
Thailand - Nakorn Ratchasima, Soeng Saang					
Farmers' practice (up/down ridging)	95/96	9	25	1254	870[4)]
Vetiver hedgerows, no ridging			8	1480	1071[4)]
Farmers' practice (up/down ridging)	96/97	7	4	893	322[4)]
Vetiver hedgerows, no ridging			4	871	250[4)]
Farmers' practice (up/down ridging)	97/98	1	24	644	-
Vetiver hedgerows, no ridging			8	521	-
Thailand - Sra Kaew, Wang Nam Yen					
Farmers' practice (up/down ridging)	95/96	6	18	1378	948[4)]
Vetiver hedgerows, no ridging			15	1110	685[4)]
Farmers' practice (up/down ridging)	96/97	6	48	884	384[4)]
Vetiver hedgerows, no ridging			10	724	199[4)]
Farmers' practice (up/down ridging)	97/98	1	17	815	-
Vetiver hedgerows, no ridging			1	496	-
Vietnam - Thai Nguyen, Pho Yen					
Farmers' practice (C monoculture, no fertilizers)	1995	6	30	1024	753[3)]
C+peanut, vetiver hedgerows, NPK			19	1047	892[3)]
Farmers' practice (C monoculture, no fertilizers)	1996	5	8	629	424[3)]
C+peanut , *Tephrosia* hedge., contour ridg., NPK			5	815	606[3)]
Farmers' practice (C monoculture, no fertilizers)	1997	5	8	535	336[3)]
C+peanut, *Tephrosia* hedge., contour ridg., NPK			3	1041	817[3)]
Vietnam - Phu Tho, Thanh Ba, Kieu Tung					
Farmers' practice (C+peanut, no hedge., no fert.)	1995	6	54	1347	921[3)]
C+peanut, vetiver hedgerows, NPK			43	1653	1129[3)]
Farmers' practice (C monocult., no hedge., no fert.)	1996	6	28	695	459[3)]
C+peanut , vetiver hedgerows, NPK			25	1525	1187[3)]
Farmers' practice (C monocult., no hedge., no fert.)	1997	6	106	871	533[3)]
C+peanut, vetiver hedgerows, NPK			32	1464	923[3)]
Vietnam - Hoa Binh, Luong Son, Dong Rang					
Farmers' practice (C monocult., no hedge., no fert.)	1995	1	10	481	139[4)]
C+peanut, *Tephrosia* hedgerows, NPK			1	978	49[4)]
Farmers' practice (C+taro, no hedge., no fert.)	1996	3	43	635	568[2)]
C+peanut , vetiver hedgerows, NPK			2	1012	873[2)]
Farmers' practice (C+taro, no hedge., no fert.)	1997	1	3	522	20[4)]
C+peanut, *Tephrosia* hedgrows, NPK			0	698	99[4)]

[1)] D = demonstration plots
[2)] Gross income minus fertilizer and manure costs
[3)] Gross income minus all material costs
[4)] Gross income minus labor and material costs

Table 12. 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	FYM 10 t/ha (TP)+ +chicken manure 300kg/ha*	15-5-20+Zn 90 N+36 P_2O_5+ 100 K_2O**	FYM 10 t/ha (T)+ 156 kg/ha***	15-15-15 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 barrier***	sugarcane barrier*** vetiver barrier*	*Gliricidia* barrier** *Leucaena* barrier* contour ridging**	vetiver barrier*** sugarcane barrier**	*Tephrosia* vetiver barrier* pineapple barrier*

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

Adoption of soil conservation practices has been slower and not as widespread as that of the other three components. There are several reasons for this:

a. In some pilot sites, erosion was not perceived as a serious problem because slopes were not so steep, or much of the land was already terraced (Pho Yen district of Vietnam and Blitar district of Indonesia).

b. The various contour barriers used to control erosion require additional labor for planting and maintenance; they also occupy part of the land and may compete with neighboring crop plants, thus reducing crop yields. **Table 13** shows that when contour hedgerows of vetiver or sugarcane were planted for erosion control on 1 rai (1600 m^2) plots of farmers' production fields in Thailand, cassava yields were on average 18% lower than without these hedgerows, mainly due to the space occupied by the hedgerows (about 10%). By using sugarcane instead of vetiver as a hedgerow, the reduction of income from a lower cassava yield was offset by the additional income from the sale of sugarcane stalks (see Mrs. Champaa in **Table 13**). It is expected that in the second and subsequent years, the yield reduction will decrease due to improved soil fertility and water conservation as a result of the hedgerows. When contour hedgerows have secondary uses for the farmer, such as sugarcane, *Tephrosia candida* or elephant grass, or when hedgerows are combined with intercropping or better fertilization practices, the initial income reduction due to lower cassava yields can often be compensated by the additional income from the hedgerows, or from the associated soil/crop management practices, such as intercropping, fertilization, improved varieties etc. (see net income data for Vietnam in **Table 11**).

Table 13. Efect of contour hedgerows of vetiver and/or sugarcane on cassava yield and gross income when planted in production fields of 1600m^2 of five farmers in Soeng Saang and Wang Nam Yen districts in Thailand in 1997/98.

		Cassava yield (t/ha)		Gross income ('000B/ha)[1)]	
Farmer	Hedgerows species	With hedgerows	Without hedgerows	With hedgerows	Without hedgerows
Mrs. Naakaew[2)]	vetiver	25.72	31.31	38.58	46.96
Mrs. Champaa[2)]	sugarcane and vetiver	9.26	12.45	18.71	18.67
Mr. Sawing[3)]	vetiver	15.99	19.05	23.98	28.57
Mr. Somkhit[3)]	vetiver	16.39	21.66	24.58	32.49
Mr. Phuem[3)]	vetiver	23.81	26.25	35.71	39.37
Average		**18.23**	**22.14**	**28.31**	**33.21**

[1)] Prices: cassava: B 1.50/kg fresh roots
sugarcane: 3.0/stalk (for chewing)
[2)] In Soeng Saang district of Nakorn Ratchasima province.
[3)] In Wang Nam Yen district of Sra Kaew province.

c. In some cases contour hedgerows interfere with other production practices, such as mechanized land preparation, weed control or harvesting, which is more conveniently done in straight lines parallel to the longest side of the field. In Thailand, some contour hedgerows of vetiver planted by participating farmers were subsequently destroyed by tractor drivers contracted to do the land preparation. Also, curved contour lines prevent the planting of cassava in straight lines using tight strings as guides, as is often used in Thailand. These are practical problems farmers face when management practices that seem promising in small experimental plots are scaled up to production fields. This is one reason why some recommended practices are never adopted by farmers, and why farmer participation in technology development is essential for the development of truly useful and effective technologies that will be adopted.

d. Lack of planting material. Planting material of some hedgerow species, such as vetiver, are difficult to obtain and slow to multiply. Other species like *Tephrosia candida* can be planted from seed, but production of good quality seed is presently beyond the farmers' capacity as it requires regular spraying of insecticides.

5. *Farmers' Perception of FPR*

During the final evaluation of the project in June/July 1998, the evaluators often asked participating farmers what they had learned from the project, what they were doing differently now than before, and what aspects they appreciated most in the project. Farmers almost invariably expressed the following sentiments (Lynam and Ingram, 2001):

1. Farmers at all pilot sites expressed great appreciation for the project.
2. They particularly liked the close interaction with researchers and extensionists.
3. They liked being able to see the performance of new technologies on their own fields.
4. They particularly liked having access to planting material of new varieties, which they could test and multiply on their own fields.
5. They learned about the importance of a balanced fertilizer application, about improved fertilizer management through split applications, about the benefits of a wider plant

spacing that increases root size and permits intercropping, and they obtained new varieties of intercrops. They indicated that this had resulted in increases in their productivity and income.

6. They became more aware of the amounts of soil lost from their fields due to erosion by seeing the trapped sediments in the plastic-covered channels, and realized the importance of soil conservation. They learned that many management practices, such as intercropping, ridging, fertilization, hedgerows, and planting distance have an effect on erosion and can be optimized to enhance soil and water conservation and maintain high yields.
7. The lack of planting material of vetiver grass or seed of *Tephrosia candida* are the main obstacles to a wider adoption of these technologies (especially in Vietnam and China).
8. They would like to continue experimentation with new varieties, intercropping and fertilization practices, but need financial and technical assistance mainly with erosion control trials.

6. *Institutionalization of FPR*

As indicated before, farmer participation in technology development is a new concept in most research and extension organizations in Asia, and it took time and first-hand experience for people and institutions to feel comfortable with, and be convinced of the effectiveness of, this new approach. In fact, it was a learning experience for all involved.

Interest in, and acceptance of, the new approach varied between countries and between institutions. Probably most enthusiastic about this approach are the Departments of Agriculture (DOA) and Agric. Extension (DOAE) in Thailand, which have already committed substantial amounts of their own budget to extend the FPR cassava project to other sites in the country. In addition, the use of FPR will be initiated in other crops and programs, such as maize and grain legumes. In Vietnam, researchers have always had good contact with the local extension service and with innovative farmers, but this project moved beyond on-farm trials to include farmer participation in decision making. The value of that approach and the need for farmer feedback in technology development is now well recognized in the various participating institutions. In China and Indonesia the FPR teams were relatively small, and their institutions are still strongly rooted in a top-down approach. Still, most people involved in the project participated with great enthusiasm, and a keen interest in the approach was expressed by institute administrators during the FPR training courses (see below). However, it will probably take time for these institutions to fully accept a participatory approach in technology development and dissemination.

B. Strategic and Applied Research on Soil/Crop Management Alternatives

During the 5-year project, strategic and applied research was conducted in many universities and research institutes in five countries (**Table 14**) in collaboration with CIAT. This research was mainly aimed at improving our basic knowledge of the crop as well as providing alternative technology options for farmers to test in their FPR trials.

Some experiments were also designed to solve specific problems identified in the FPR trials, such as finding a more suitable alternative to vetiver grass as an erosion control measure. Detailed results of this research have been reported in papers presented at the 5th and the 6th

Table 14. Collaborative research projects on sustainable cassava production systems conducted in various Asian countries in 1998.

Country	Project	Collaborating Institute	Site
Thailand	a. green manure/mulch trial	Field Crops Research Inst.	Rayong
	b. live barrier trial	Kasetsart University	Khaw Hin Sorn
Indonesia	a. long-term fertility trial	Central Res. Inst. Food Crops	Lampung
	b. erosion control trial	Central Res. Inst. Food Crops	Lampung
	c. fert.x soybean variety trial	Central Res. Inst. Food Crops	Yogyakarta
	d. cassava variety trial	Central Res. Inst. Food Crops	Yogyakarta
	e. erosion control trial	Central Res. Inst. Food Crops	Yogyakarta
	f. erosion control trial	Brawijaya University	Malang
Vietnam	a. long-term fertility trial	Agro-forestry College	Thai Nguyen
	b. erosion control trial	Agro-forestry College	Thai Nguyen
	c. Mg trial	Agro-forestry College	Thai Nguyen
	d. long-term fertility trial	Inst. Agric. Science of S. Vietnam	Hung Loc
	e. soil improvement trial	Inst. Agric. Science of S. Vietnam	Hung Loc
	f. weed control trial	Inst. Agric. Science of S. Vietnam	Hung Loc
	g. erosion control trial	Inst. Agric. Science of S. Vietnam	Hung Loc
China	a. long-term fertility trial	Chinese Acad. Trop. Agric. Science	Danzhou
	b. live barrier trial	Chinese Acad. Trop. Agric. Science	Danzhou
	c. erosion control trial	Guangxi Subtrop. Crops Research Institute	Nanning
	d. on-farm fertilizer trials	Upland Crops Research Inst.	Guangdong
Philippines	a. on-farm fertilizer trials	Bohol Exp. Station	Bohol

Regional Cassava Workshops, held in Hainan, China in Nov 1996 and in Ho Chi Minh city, Vietnam in Feb 2000, respectively, as well as in CIAT's Annual Reports for 1994 through 2000.

The highlights of this research can be summarized as follows:

1. Long-term Fertility Maintenance with Chemical Fertilizers

Results of 11 long-term NPK trials conducted in four countries in Asia (Howeler, 2001) indicate that after continuous cropping for four to ten years, there was a significant or highly significant response mainly to the application of N and K indicating the importance of N and K and the relatively less importance of P for cassava nutrition. These trials are presently being continued in four sites. By relating the relative response to each nutrient to the content of that nutrient in the soil or in cassava indicator leaves, "critical" nutrient concentrations in soil and plant tissue were determined, using the combined data from many of these trials (Howeler, 1998). These critical levels are essential for being able to diagnose nutritional problems from soil or plant tissue analyses.

2. Fertility Maintenance with Green Manures

Soil fertility can be improved by incorporating or mulching green manures, intercrop residues, and prunings of hedgerow species (also called alley cropping). However, green manures occupy the land unproductively during part of the rainy reason, intercrops generally compete with the main crop, and hedgerows also occupy permanently a part of the cropping area; these practices are therefore not readily adopted by farmers. An exception to this is the use of intercrops, since the value of the intercrop usually compensates for the reduction of cassava yield; and the use of *Tephrosia candida* hedgerows in Vietnam where the hedgerows have a dual function of fertility maintenance and erosion control.

An experiment conducted in south Vietnam for nine consecutive years showed no significant improvement in cassava yields through various intercropping and alley cropping practices during the first six years. However, in the 7th and subsequent years, cassava yields increased significantly by alley cropping with *Leucaena leucocephala* or *Gliricidia sepium*. A similar experiment conducted in Rayong Research Center in Thailand showed that mulching of green manures such as *Crotalaria juncea* or *Canavalia ensiformis*, grown intercropped with cassava during the first two months of the cropping cycle, increased cassava yields compared with the check without green manures, but that these yields were still significantly lower than the yields obtained with a higher rate of chemical fertilizers (Howeler, 1998; Tongglum *et al*., 2001). In areas where labor is scarce or expensive, such as Thailand, farmers will generally prefer to buy the chemical fertilizers.

3. Erosion Control

Experiments to develop more effective practices to control erosion have been conducted in eight sites in four countries. It was found that cassava generally causes more erosion than other upland crops like maize, upland rice, peanut or soybean (Wargiono *et al*., 1998; 2001; Howeler, 1998), but that various management practices, such as contour ridging (Zhang Weite *et al*., 1998; Nguyen Huu Hy *et al*., 1998), intercropping (Zhang Weite *et al*., 1998; Tongglum *et al*., 1998), hedgerows of *Gliricidia sepium* or *Flemingia congesta* (Wargiono *et al*., 1998), *Tephrosia candida* and vetiver grass (Nguyen Huu Hy *et al*., 1998), mulching and fertilizer applications (Wargiono *et al.*, 1998; Zhang Weite *et al*., 1998) are all very effective in reducing erosion. Among all these practices, the planting of contour hedgerows of vetiver grass is generally the most effective in reducing soil losses. These hedgerows assist in natural terrace formation, with terrace risers of 40-60 cm height being formed in a relatively short time of 3-4 years. These terraces in turn reduce runoff and erosion and help conserve soil moisture. However, as mentioned above, vetiver grass also has some important limitations, which constrain its adoption.

4. Alternatives to Vetiver Grass

Since vetiver grass hedgerows are very effective in reducing erosion, but are difficult and expensive to establish, alternative grass species are being tested as erosion control barriers in Khaw Hin Sorn in Thailand and at CATAS in China. Experience has shown that an ideal species for erosion control hedgerows should have the following characteristics:

a. an erect but not too tall growth habit, with strong tiller formation to trap soil sediments (similar to vetiver grass).
b. A deep and vertical root system that causes little competition with neighboring crop plants.
c. Drought tolerant and well-adapted to acid and infertile soils.
d. Has other uses, such as animal feed, green manure etc., or has direct commercial value.
e. Can be propagated both from vegetative material and seed, but the seed must not easily spread and create a weed problem.

From four years of testing many grass species in Thailand, it appears that the species *Paspalum atratum* shows the most promise as it fulfils nearly all the above criteria: it is an excellent animal feed, is rather drought tolerant, is less competitive than any of the other grasses tested and can be planted either from seed or vegetative material. If the initial promise of this species holds up in future experiments, it could become an important hedgerow species without some of the limitations of vetiver grass.

C. Training in FPR Methodologies

In addition to the initial training course, aimed at familiarizing the selected FPR team members with FPR methodologies in general and with the proposed project methodologies in particular, four in-country Training-of-Trainers Courses in FPR Methodologies were held in the four participating countries in year 4 and 5 of the project. In Sept 1997 one course was held in Thailand and one in Vietnam, and in May/June of 1998 similar courses were held in Indonesia and China. About 25 to 30 people, mainly researchers and extensionists, participated in each course. Since many participants were not proficient in English, most lectures were either given directly in the native language or were translated from English to that language.

During the first day of each training course, "decision-makers', i.e. high-level administrators of research and extension organizations, were invited along with the course participants. This was done to introduce the new concept of "participatory technology development and dissemination" to the trainees and their bosses alike, so that the latter would understand and be supportive of this new approach, and may eventually decide to institutionalize this concept in their own organizations. The curriculum of the training courses included classroom lectures, but emphasized excercises on various FPR methodologies such as diagnostic tools, like village mapping, transects, rainfall and crop calenders, problem ranking and diagramming; and evaluation tools, like matrix ranking. These methodologies were than practiced with farmers at the pilot sites during 2-3 field days. While many participants were initially doubtful of the usefulness of the participatory approach, most participated in the course with enthusiasm and returned home with a desire to apply this approach in their own work.

The reason for organizing these courses towards the end of the project was to gain first experience and confidence with the FPR methodologies used in the project, and to develop an effective farmer participatory model for enhancing sustainable cassava production systems. Once these methodologies were used and adapted to fit the requirements of the project, they could be taught to others, who might either set up their own FPR projects, teach other FPR training courses, or participate in the proposed second phase of this project. As indicated in **Table 15**, a total of 127 researchers and extensionists from five countries were trained in the various FPR training courses, while 155 farmers participated in the conducting of FPR trials. This large pool of trained and enthusiastic individuals will be a valuable resource in helping to conduct FPR trials in a much larger number of sites, and to disseminate the results to thousands of other farmers, as proposed in the second phase of the project.

Table 15. Number of researchers/extensionists who participated in FPR training courses and number of farmers who participated in FPR trials from 1994 to 1998.

	Researchers/ Extensionists	Farmers
China	28	40
Indonesia	32	27
Philippines	2	-
Thailand	35	32
Vietnam	30	56
Total	**127**	**155**

D. 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 (**Table 11**). 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 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 Nippon Foundation project was able to achieve profitability and raise farmers' interest in the project by the introduction of new varieties, fertilization, intercropping and various new hedgerow species that had previously been developed in on-station research, and that were "on the shelf" for on-farm testing and dissemination. If no good technologies are available for introduction, farmers soon loose interest in participating. 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.

   Thus, 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.

   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 not only select the treatments but also their location within the trial, as farmers' fields are not necessarily uniform. Some of this disuniformity can be exploited and much can be learned from letting the farmer select the right treatment for each particular condition. 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 (see **Tables 7-10**) 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 biophysical 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 support of, and 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.

E. Conclusions

Research on sustainable land use conducted in the past has mainly concentrated on finding solutions to the biophysical 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.

Tribute

In memory of Mr. Chalor Naksri, driver and office assistant in the project, as well as seven other persons, who lost their lives in a road accident on June 5, 1996 during one of the trips in support of the project. May they rest in peace.

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