Farmer Participatory Approaches in the Development of Technologies to Achieve Sustainable Cassava Production in Thailand and Vietnam [1]

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) is the third most important food crop in southeast Asia, where it 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 most suitable 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 Thailand, Vietnam, Indonesia and China. 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 dissemination was further developed in about 30 pilot sites each in Thailand, Vietnam and China. Farmers were generally very interested to participate in these 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. The resulting increases in cassava yields in Thailand and Vietnam over the past ten years have increased the annual gross income of cassava farmers by an estimated 200 million US dollars.

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

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is usually grown by smallholders in upland areas with poor soils and low or unpredictable rainfall. In the northeastern and eastern regions of Thailand, cassava is often grown on gentle slopes, but in the northern part of Vietnam it is grown on steep slopes; in both cases, soil erosion can be serious. Since most cassava farmers are poor, they do not apply much fertilizers to cassava and this may lead to a decline in soil fertility which in turn causes low yields. Past research by Kasetsart University has shown that cultivation of cassava may cause twice as much soil erosion as that of mungbean, and three times as much as that caused by maize, sorghum and peanut (Puttacharoen *et al.*, 1998).

Research on erosion control practices indicate that soil losses due to erosion can be markedly reduced by various agronomic practices combined with simple soil conservation practices. This includes agronomic practices such as minimum or zero tillage, mulching, contour ridging, intercropping, fertilizer or manure application, and planting at closer plant spacing. Soil conservation practices include terracing, hillside ditches and planting contour hedgerows of grasses or legumes. But these latter practices are

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seldom adopted by farmers because they may not be appropriate for the specific circumstances of the farmers, either from an agronomic or a socio-economic standpoint (Howeler, 2001).

Since 1994, the Nippon Foundation in Tokyo, Japan has supported the project "Integrated Cassava-based Cropping System in Asia: Farming Practices to Enhance Sustainability". It has developed and used farmer participatory research (FPR) and Extension (FPE) methodologies.

MATERIALS AND METHODS

1. First Phase (1994 – 1998)

The first phase of the project was conducted in Thailand, Vietnam, Indonesia and China. 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 countries designed a work plan to implement the project. The steps in the process, from diagnosing the problem to adoption of suitable solutions, are shown in **Figure 1**. The outstanding feature of this approach is that farmers participate in every step and maker all important decisions.

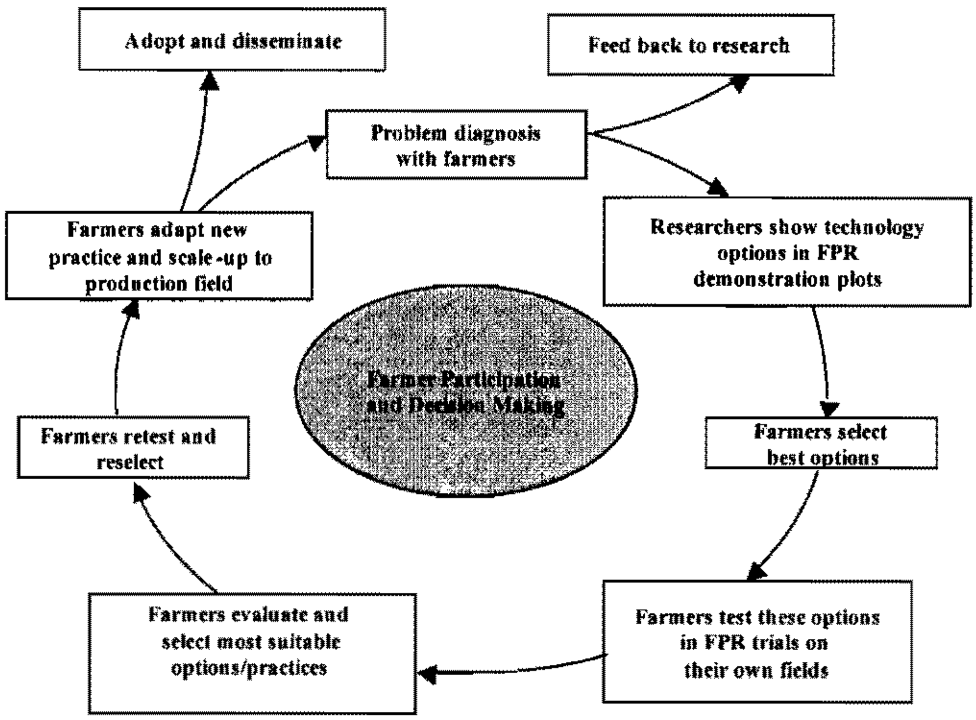

Figure 1. Farmer participatory model used for the development of sustainab le cassava-based cropping systems in Asia.

a. Pilot site selection

Suitable pilot sites were pre-selected in areas where cassava is an important crop, where it is grown on slopes and erosion is a serious problem. Detailed information obtained through Rapid Rural Appraisals (RRA) in each site have been reported by Nguyen The Dang *et al.* (1998) and Vongkasem *et al.* (1998). **Table 1** is a summary of information obtained from RRAs' conducted in several pilot sites in two countries. The detailed information from each site can serve as baseline data to monitor progress and evaluate the impact of newly adopted technologies. After conducting the RRAs, the most suitable pilot sites (villages or subdistricts) were selected to work with farmers in the development and dissemination of new varieties and production practices.

Table 1. Characteristics of five pilot sites for the Farmer Participatory Research (FPR) trials in Thailand and Vietnam in 1994/95.

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

[1)] C = cassava, T = taro

b. Demonstration plots

The demonstration plots were established by research organizations of both countries in areas not too far from the pilot sites. They had many alternative treatments, such as the application of chemical fertilizers, green manures, closer plant spacing, intercropping with different crops and contour hedgerows of different grasses or legume species. Farmers from the selected pilot sites visiting these demonstration plots were asked to discuss and score the usefulness of each treatment. They selected 3-4 suitable treatments which they considered most useful for their own fields. **Table 2** shows that farmers from different sites have different priorities and thus rank options quite differently.

Table 2. Ranking of conservation farming practices selected from demonstration plots as most useful by cassava farmers from four pilot sites in Thailand and Vietnam in 1995/96.

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

In both the demonstration plots and FPR erosion control trials on farmers' fields, a simple methodology was used to measure soil loss due to erosion in each treatment. Plots were laid out carefully and exactly along the contour on a uniform slope; it is important that runoff water does not enter the plots either from above or from the sides. Along the lower side of each plot a ditch was dug and covered with plastic; small holes in the plastic allowed runoff water to seep away, while eroded sediments remained on the plastic. These sediments were collected and weighed monthly or at least 2-3 times during the cropping cycle. After correcting for moisture content, the amount of dry soil loss per hectare was calculated for each treatment. This simple methodology gives both a visual as well as a quantitative indication of the effectiveness of the various practices in controlling erosion (Howeler, 2001, 2002; Watananonta *et al.*, 2003).

c. FPR trials

After farmers had decided to conduct FPR trials, researchers and extensionists discussed the trials with the collaborating farmers, such as the types of trials and the treatments to be tested; project staff helped farmers establish the trials and provided the necessary materials. During the crop season, researchers and extensionists visited the farmers several times to discuss and solve their problems. At time of harvest, collaborating farmers and project staff harvested all the cassava trials together, recorded the data on yield and soil loss from every treatment, which were then presented to the participating farmers and others interested. The meeting then discussed the results of each trial and selected the best treatments, either for adoption or for retesting in next year's trials (Howeler, 2001; Watananonta, *et al.*, 2003).

2. Second Phase (1999-2003)

The second phase of the project was implemented by five research and extension organizations in Thailand, six in Vietnam and three in China (**Table 3**). During this second phase, the emphasis shifted from development and use of farmer participatory research (FPR) methodologies to farmer participatory extension (FPE) in order to reach more farmers and achieve more widespread adoption. These include activities such as:

a. Cross-site visits

Farmers from a new site visit a village where the project had been conducted before and where new technologies had already been adopted.

b. Farmer field days at harvest

Local officials and farmers from the village and surrounding communities were invited to evaluate each treatment in the FPR trials, including the root yield and the amount of soil sediments eroded from each plot. In this way, the farmers learned and obtained information to make decisions about technologies suitable for their own conditions. They then discussed and planned for action in the following year.

c. District level field days

The purpose of these large-scale field days was to disseminate the selected technologies to nearby villages and sub-districts. During the field day, the experienced farmers shared their knowledge with other farmers.

d. Provincial level field days

At this level, approximately 1,000-1,500 farmers and officials from nearby provinces were invited to attend the field day. Reporters from newspapers and television stations were also invited in order to report the project activities through the wider mass media.

e. FPR training courses

Initial courses were organized by CIAT to train project staff in FPR methodologies. Additional courses were organized to train local extension workers and key farmers in cassava technologies and farmer participatory approaches. Furthermore, CIAT also supported the training of trainers in advanced courses abroad.

RESULTS AND DISCUSSION

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

a. FPR trials

Table 4 shows a typical example of an FPR erosion control trial conducted by six farmers having adjacent plots on about 40% slope. Contour hedgerows of vetiver grass, *Tephrosia candida* or pineapple reduced erosion to about 30% of that in the check plot, while intercropping with peanut and planting vetiver hedgerows also markedly increased net income. Farmers clearly preferred those treatments that were most effective in both increasing net income and reducing soil erosion, such as hedgerows of vetiver grass or pineapple. Results of many other FPR trials have been reported by Nguyen The Dang *et al.* (2001) and Vongkasem *et al.* (2001).

Table 3. Partner institutions collaborating in the second phase of the Nippon Foundation cassava project in Asia.

1. Research and extension organizations in Thailand
- -Department of Agriculture (DOA)
- -Department of Agricultural Extension (DOAE)
- -Land Development Department (LDD)
- -Kasetsart University (KU)
- -The Thai Tapioca Development Institute (TTDI)

2. Research and extension organizations in Vietnam
- -Thai Nguyen University of Agriculture and Forestry (TNUAF)
- -National Institute for Soils and Fertilizers (NISF)
- -Vietnam Agricultural Science Institute (VASI)
- -Hue University of Agriculture and Forestry (HUAF)
- -Institute of Agricultural Sciences of South Vietnam (IAS)
- -Tu Duc University of Agriculture and Forestry (TDUAF)

3. Research and extension organizations in China
- -Chinese Academy for Tropical Agricultural Sciences (CATAS)
- -Guangxi Subtropical Crops Research Institute (GSCRI)
- -Honghe Animal Husbandry Station of Yunnan

Table 4. 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 a FPR erosion control trial conducted by six farmers in Kieu Tung village of Thanh Ba district, Phu Tho province, Vietnam in 1997 (3rd year).

Treatment[1]	Slope (%)	Dry soil loss (t/ha)	Yield (t/ha) cassava[2]	peanut[2]	Gross income[3]	Product. costs	Net income	Farmers ranking
					—— (mil. dong/ha)		——	
1. C monocult., with fertilizer, no hedgerows(TP)	40.5	106.1	19.17	-	9.58	3.72	5.86	6
2. C+P, no fertilizer, no hedgerows	45.0	103.9	13.08	0.70	10.04	5.13	4.91	5
3. C+P, with fertilizer, no hedgerows	42.7	64.8	19.23	0.97	14.47	5.95	8.52	-
4. C+P, with fertilizer, *Tephrosia* hedgerows	39.7	40.1	14.67	0.85	11.58	5.95	5.63	3
5. C+P, with fertilizer, pineapple hedgerows	32.2	32.2	19.39	0.97	14.55	5.95	8.60	2
6. C+P, with fertilizer, vetiver hedgerows	37.7	32.0	23.71	0.85	16.10	5.95	10.15	1
7. C monocult, with fert., *Tephrosia* hedgerows	40.0	32.5	23.33	-	11.66	4.54	7.12	4

[1] Fertilizers = 60 kg N + 40 P_2O_5, + 120 K_2O/ha; all plots received 10 t/ha pig manure
TP=farmer traditional practice

[2] Cassava: fresh roots; peanut: dry pods

[3] Prices: cassava (C) dong 500/kg fresh roots
peanut (P) 5000/kg dry pods
1US$ = approx. 13.000 dong

b. Scaling-up and adoption

After having selected the most promising 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 sufficient planting material (like vetiver grass) or lack of markets for selling the products (like pumpkin or lemon grass). Also, to be effective, hedgerows need to follow the contour rather precisely; otherwise they can cause serious gulley erosion by channeling runoff water to the lowest spot. Contour hedgerows also force farmers to plow along the contour, which is more difficult and more costly; moreover it makes planting in neat straight lines, using tight strings as a guide, impossible. Thus, there are very practical reasons why farmers may be reluctant to adopt some of these soil conservation practices. **Table 5** shows the particular technologies that farmers had adopted in the two countries at the end of the first phase of the project. .

Table 5. Technological components selected and adopted by participating farmers from their FPR trials conducted from 1994 to 1998 in Thailand and Vietnam.

Technology	Thailand	Vietnam
Varieties	Kasetsart 50***	KM60***
	Rayong 5***	KM94*
	Rayong 90**	KM95-3***
		SM1717-12*
Fertilizer practices	15-15-15	FYM 10 t/ha (TP)+
	156 kg/ha***	80 N+40 P_2O_5+
		80 K_2O**
Intercropping	monoculture(TP)	monoculture(TP)
	C+pumpkin*	C+taro(TP)
	C+mungbean*	C+peanut***
Soil conservation	vetiver barrier***	*Tephrosia* barrier***
	sugarcane barrier*	vetiver barrier*
		pineapple barrier*

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

Second Phase (1999-2003): Farmer Participatory Research (FPR) and 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.

a. Farmer participatory research (FPR)

Whenever the project extended to a "new" site, the process outlined above was re-initiated, i.e. an RRA was conducted, interested farmers visited demonstration plots and/or made a cross-visit to an already established site, they conducted FPR trials, discussed results and eventually adopted those varieties or practices they had selected as most suitable for their own conditions. **Table 6** shows the number and types of FPR trials conducted in Thailand and Vietnam during the second phase of the project. While initially farmers were mainly interested in testing new varieties, fertilization, intercropping and erosion control practices, during the later part of the project they also wanted to test the use of organic or green manures, weed control, plant spacing and even leaf production and pig feeding. During the five years of the second phase of the project a total of 922 FPR trials were conducted by farmers on their own fields. **Tables 7** to **10** are just a few examples of the various types of FPR trials conducted by farmers in different sites in Thailand and Vietnam.

Table 6. Number of FPR trials conducted in the 2d phase of the Nippon Foundation Project in Thailand and Vietnam.

Country	Type of FPR trial	1999	2000	2001	2002	2003	**Total**
Thailand	Varieties	11	16	16	19	25	**87**
	Erosion control	14	10	6	-	11	**41**
	Chemical fertilizers	16	6	23	17	17	**79**
	Chem.+org fertilizers	-	-	10	11	11	**32**
	Green manures	-	-	13	11	15	**39**
	Weed control	-	-	17	5	10	**32**
	Plant spacing	-	-	3	-	2	**5**
	Intercropping	-	-	16	7	-	**23**
		41	**32**	**104**	**70**	**91**	**338**
Vietnam	Varieties	12	31	36	47	35	**161**
	Erosion control	16	28	29	30	23	**126**
	Fertilization	1	23	36	24	24	**108**
	Intercropping	-	14	32	31	26	**103**
	Weed control	-	3	-	-	3	**6**
	Plant spacing	-	1	7	19	8	**35**
	Leaf production	-	-	2	2	1	**5**
	Pig feeding	-	-	11	16	13	**40**
		29	**100**	**153**	**169**	**133**	**584**
Total		**70**	**132**	**257**	**239**	**224**	**922**

Table 7. Results of an FPR variety trial conducted by a farmer in Am Thang commune, Son Duong district, Tuyen Quang, Vietnam in 2002/03.

Treatments[1)	Cassava yield (t/ha)	Gross income	Product. costs ('000 dong/ha)	Net income	B/C	Farmers' preference[2) (%)
1. Vinh Phu (local)	20.70	10,350	4,330	6,020	2.39	7.9
2. La Tre (SC205) (local)	21.40	10,700	4,330	6,370	2.47	10.5
3. KM60	29.20	14,600	4,330	10,270	3.37	21.0
4. KM94	37.50	18,750	4,330	14,420	4.33	94.7
5. KM95-3	32.80	16,400	4,330	12,070	3.79	26.3
6. KM98-7	25.40	12,700	4,330	8,370	2.93	10.5

1) fertilized with 1,100 kg/ha of 7-4-7 fertilizers = 1.43 mil. dong/ha

2) out of 38 farmers

Table 8. Average results of three FPR erosion control trials conducted by farmers in Suoi Rao and Son Binh villages, Chau Duc district, Baria-Vungtau, Vietnam in 2003/04.

Treatments	Dry soil loss (t/ha)	Cassava yield (t/ha)	Maize+ hedgerow yield (t/ha)	Gross income[1)	Product. costs[2) ('000 dong/ha)	Net income	Farmers' preference (%)
1. cassava monoculture, no hedgerows	77.12	26.34	-	10,536	6,079	4,457	20
2. C+ pineapple hedgerows	11.65	27.02	-	10,808	6,279	4,529	0
3. C+ *Paspalum atratum* hedgerows	12.18	30.13	11.40	12,052	6,279	5,773	65
4. C+ vetiver grass hedgerows	9.94	28.33	8.84	11,332	6,279	5,053	15
5. C+ maize intercrop	14.30	17.86	3.25	10,394	7,969	2,425	0

1) Prices: cassava — dong — 400/kg fresh roots
maize — 1,000/kg dry grain

2) Costs: labor — 20,000/manday
cassava fertilizers — 1,279,000 dong/ha
maize fertilizers — 550,000 dong/ha
cassava stakes — 500,000 dong/ha
maize seed — 440,000 dong/ha
labor for cassava without HR (210 md/ha) = 4.2 mil. dong/ha
labor for maize (40 md/ha) = 0.8 mil. dong/ha
labor for fertilizer application (5 md/ha) = 0.1 mil. dong/ha
labor for hedgerow cutting/maintenance = 0.2 mil. dong/ha

Table 9. Results of an FPR fertilizer and manure trial conducted in Khut Dook village, Baan Kaw, Daan Khun Thot, Nakhon Ratchasima, Thailand in 2002/03.

Treatments[1)	Root yield (t/ha)	Starch content (%)	Gross income[2)	Fertilizer cost[3) ('000 B/ha)	Production costs[3)	Net income
1. No fertilizers or manure	18.75	25.0	21.56	0	10.87	10.69
2. Chicken manure+rice hulls, 400 kg/rai	30.42	26.2	34.98	2.50	17.15	17.83
3. Pelleted chicken manure, 100 kg/rai	26.70	21.1	30.71	2.00	15.39	15.32
4. 15-7-18 fertilizer, 50kg/rai	29.68	24.1	34.13	2.66	16.73	17.40
5. 13-13-21 fertilizer, 50kg/rai	32.22	27.4	37.05	3.13	17.89	19.16
6. 16-20-0 fertilizer, 50kg/rai	26.08	25.9	29.99	2.50	15.61	14.38
7. 15-15-15 fertilizer, 50kg/rai	30.36	26.9	34.91	2.81	17.07	17.84

1) 1ha = 6.25 rai

2) Prices: cassava — baht — 1.15 /tonne irrespective of starch content

3) Costs: chicken manure — 1.0 /kg
pelleted chicken manure — 3.20 /kg
15-7-18 — 8.50 /kg
13-13-21 — 10.0 /kg
16-20-0 — 3.0 /kg
15-15-15 — 9.0 /kg
harvest + transport roots — 270 /tonne

cassava production without fertilizer or harvest 12,757 /ha

Table 10. Average results of five FPR pig feeding trials on adding ensiled cassava leaves to the diet, conducted by farmers in Huong Ha commune, A Luoi, Thua Thien-Hue, Vietnam in 2001/02.

Treatments	No. of pigs	Life weight (kg) initial	Life weight (kg) 3 months	LWG[1] (g/day)	FCR[2] (kg DM/kg gain)	Feed cost[5] (VND/kg gain)
Control diet[3]	6	24.30	52.50	313.3	4.83	10,745
Control +13% ECL[4]	6	26.92	57.75	342.5	4.36	7,862
F test						*

[1] LWG = live weight gain
[2] FCR = feed conversion ratio
[3] Control diet of rice bran, ensiled cassava roots (32% as DM), fish meal and sweet potato (SP) vines
[4] 13% ensiled cassava leaves replaced part of fish meal, and all SP vines; cassava leaves had been ensiled with 20% fresh grated cassava roots
[5] Prices:

rice bran	dong	2,000/kg
fish meal		6,000/kg
cassava roots		320/kg
fresh SP vines		400/kg
cassava leaves		3,000/20 kg

b. Farmer participatory extension (FPE)

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

i. 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.

ii. 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 representatives 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, while extension pamphlets and booklets about the farmer-selected technologies were distributed.

iii. Training

Research and extension staff involved in the project had previously participated in Training-of-Trainers courses in FPR methodologies, including practical training sessions with farmers in some of the pilot sites. While some participants were initially skeptical, most course participants 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.

iv. Community-based self-help 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 "Land Care units", that have been very effective in promoting soil conservation in the Philippines and Australia. Subsequently, the Dept. of Agric. Extension in Thailand 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 credit fund, from which members of the group can borrow money for production inputs. Thus, by 2003, a total of 21 "Cassava Development Villages" had been set up in the pilot sites in Thailand. 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, while 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 planting material available when needed.

ADOPTION

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, practically all of the cassava area is now planted with new varieties 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, farmers started to apply more K, while the official fertilizer recommendation for cassava was 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. By the end of 2003, about 1,038 farmers had planted a total of 1.63 million vetiver plants, corresponding to about 145 km of hedgerows (Howeler *et al.*, 2003a, 2003b; 2004a, 2004b, 2005; Vongkasem *et al.*, 2003).

In Aug 2002 a participatory monitoring and evaluation (PM&E) was conducted in four pilot sites in Thailand where the project had been initiated at least four years earlier. Using focus group discussions and participatory evaluation methodologies, data were collected on the extent of adoption of the various technologies and the reasons for adoption or non-adoption. **Table 11** shows that new varieties had been adopted in 100% of the cassava growing areas in all four sites. Application of chemical fertilizers varied from 79-100%, vetiver hedgerows were planted in 22-55% of the cassava area, green manures in 0-50% and intercropping was not adopted at all, mainly due to lack of labor for managing intercrops.

Table 11. Extent of adoption[1)] of various cassava technology components in four pilot sites in Thailand in 2002 as a result of the Nippon Foundation project.

Technology component	Baan Khlong Ruam Sra Kaew		Thaa Chiwit Mai Chachoengsao		Sapphongphoot Nakhon Ratchasima		Huay Suea Ten Kalasin	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Varieties	480	100	469	100	396	100	228	100
Chemical fertilizers	480	100	469	100	364	92	180	79
Vetiver grass hedgerows	139	29	94	20	218	55	89	39
Green manures	72	15	0	0	0	0	114	50
Intercropping	0	0	0	0	0	0	0	0

[1)] Estimated by farmers in each site during Participatory Monitoring and Evaluation (PM&E) in Aug 2002

Figure 2 shows how the number of farmers in the pilot sites adopting various soil conservation measures increased year after year, initially mostly in Thailand but subsequently also in Vietnam.

Data in **Table 12** indicate that adoption of soil conservation practices in all sites in Vietnam increased yields, ranging from 13.5% in 2000 to 23.7% in 2002. As a result of the adoption of soil conservation practices, gross income, both per ha and per household, also increased very markedly over time. Results from both FPR trials and on-station research also indicate that the beneficial effect of contour hedgerows in terms of increasing yields and decreasing erosion increased over time (Howeler *et al.*, 2005). This is mainly because the planting of contour hedgerows, almost independent of the species used, will result in natural terrace formation, which over time reduces the slope and enhances water infiltration, thus reducing runoff and erosion. Well established hedgerows also become increasingly more effective in trapping eroded soil and fertilizers. Unfortunately, most FPR erosion control trials are conducted for only 1-2 years at the same site, so farmers do not quite appreciate the increases in beneficial effects that result over time. This, coupled with the fact that planting and maintaining hedgerows requires additional labor (and sometimes money for seed or planting material), while hedgerows take some land out of production and have initially little beneficial effect on yield, has hampered the more widespread acceptance and adoption of these soil conservation practices.

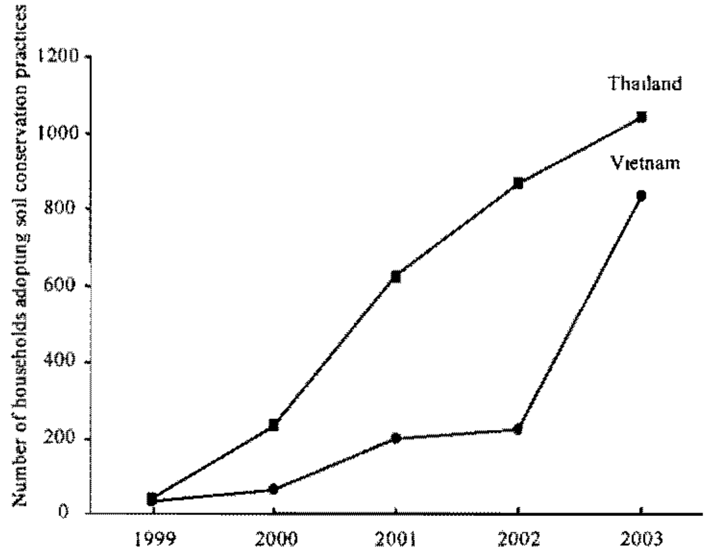

Figure 2. Number of farmers adopting soil conservation measures in their cassava Fields in FPR pilot sites in Thailand and Vietnam from 1999 to 2003.

Table 12. Extent of adoption of soil conservation practices and the estimated increase in yield and gross income of farmers in the FPR pilot sites in Vietnam from 2000 to 2003.

Year	Number of households	Area with soil conser. (ha)	Cassava yield (t/ha) Farmers' practice[1]	With soil conservation	Percent yield increase	Increase in gross income (US$) total	per household	per ha
2000	62	21.12	12.11	13.75	13.5	865	13.95	41.00
2001	200	59.87	16.50	19.95	20.9	592	22.96	76.70
2002	222	88.85	20.60	25.48	23.7	11,582	52.17	130.35
2003	831	612.00	20.60[3]	25.48[3]		61,658	74.20	100.75
Total	**831**	**612.00**				**77,944**		

[1] Farmers' practice includes most new technologies except soil conservation

[2] Fresh root price: in 2000 350 VND/kg
in 2001 350 VND/kg in north, 200 in central and 290 in south
in 2002 400 VND/kg
in 2003 320 VND/kg (estimated)
1US$ = 14,000 VND in 2000 and 15,500 VND in 2003

[3] Yields estimated from 2002

Source: *Tran Ngoc Ngoan, 2003*

Table 13 shows in more detail how the adoption of various technologies increased over time in one commune in Pho Yen district of Thai Nguyen province where the project first started working in 1994. Since 1995 farmers have conducted FPR trials on new varieties, more balanced fertilization, intercropping, and erosion control. After some years of testing farmers initially adopted new varieties and intercropping in small areas of their land. This was followed by better fertilization and erosion control; the latter was adopted by only a small number of farmers as most cassava fields in the commune are on gentle slopes or on terraced land. It is clear that the adoption of new technologies increased yields significantly, of both the local variety Vinh Phu and the new varieties, mainly KM 95-3 and KM 98-7. The gradual increases in yield, from 8.5 t/ha in 1994 to 36.8 t/ha in 2003 was accompanied by an increase in area planted using new technologies, resulting in about a 20-fold increase in net income and marked improvements in the livelihood of farmers in this commune.

Table 13. Impact of the adoption of new cassava varieties and improved production practices on the livelihood of farmers in Tien Phong commune, Pho Yen districtl of Thai Nguyen, Vietnam.

Year	Variety or practice[1]	No. of farmers	Cassava area (ha)	Cassava yield (t/ha)	Peanut yield (t/ha)	Gross income[2]	Production costs	Net income	Total net income (mil.dong)[5]
						(mil. dong/ha)			
1994[3]	Vinh Phu	115	50	8.5	-	3.40	2.93	0.47	23.50
	New varieties	0	-	-	-	-	-	-	-
			50						**23.50**
2000	Vinh Phu	NA[4]	NA	21.5	-	NA	NA	NA	NA
	New varieties	25	1.31	30.9	-	15.45	4.36	11.10	14.54
	Intercropping	37	2.59	29.3	0.81	18.70	6.16	12.54	32.48
	Erosion control	4	0.20	24.7	-	12.35	4.66	7.69	1.54
			>4.10						**>48.56**
2001	Vinh Phu	61	2.17	22.7	-	11.35	4.36	6.99	15.17
	New varieties	122	4.70	29.0	-	14.50	4.36	10.14	47.66
	Intercropping	40	3.38	26.2	0.77	16.94	6.16	10.78	36.44
	Erosion control	4	0.20	NA	-	NA	NA	NA	NA
			10.45						**>99.27**
2002	Vinh Phu	18	0.64	25.4	-	12.70	4.33	8.37	5.36
	New varieties	100	5.16	33.7	-	16.85	4.33	12.52	64.60
	Intercropping	118	3.69	32.3	1.73	24.80	6.13	18.67	68.89
	Balanced fert.	48	2.95	33.4	-	16.70	4.83	11.87	35.02
	Erosion control	5	0.18	25.4	-	12.70	4.63	8.07	1.45
			12.62						**175.32**
2003	Vinh Phu	NA	NA	NA	-	NA	NA	NA	NA
	New varieties	225	17.00	36.8	-	18.40	4.33	14.07	239.19
	Intercropping	120	11.00	36.0	0.67	21.35	6.13	15.22	167.42
	Balanced fert.	54	3.40	33.6	-	16.80	4.83	11.97	40.70
	Erosion control	5	0.60	27.0	-	13.5	4.63	8.87	5.32
			>32.00						**>452.63**

[1] In Tien Phong farmers traditionally grow mainly Vinh Phu variety but have now largely changed to KM 95-3 and KM 98-7; the new practices include intercropping with peanut, balanced fertilization of 10 t/ha of pig manure plus 80N-40P_2O_5-80 K_2O, and erosion control by contour hedgerows of *Tephosia candida*

[2] Price of cassava in 1994: 400 VND/kg fresh roots
Price of cassava in 2000-2003: 500 VND/kg fresh roots
Price of peanut in 2000-3003: 5,000 VND/kg dry pods

[3] Data from RRA at the start of project

[4] NA = data not available

[5] 1US$ = 11,000 dong in 1994, about 15,500 dong in 2003

Table 14 summarizes the extent of adoption of new cassava technologies in FPR pilot sites in 15 provinces of Vietnam in 2003 and the resulting increase in gross income due to higher yields obtained. Although balanced fertilization produced the greatest yield increase, it was not adopted over a very wide area. New varieties were most widely adopted resulting in the greatest increase in gross income. The total annual increase in gross income due to adoption of new technologies in the FPR sites was estimated at 1.67 million US dollars or $72.92 per household.

Table 14. Extent of adoption of new cassava production technologies in FPR pilot sites in 15 provinces of Vietnam in 2003/04, the effect on cassava yields, and the increase in gross income resulting from the yield increase in those sites.

Technology component	No. of households	Area (ha)	Cassava yield (t/ha) Farmers' practice[1)]	Improved technology	Increase in gross income total ('000US$)[2)]	per hh (US$)	per ha (US$)
1. New varieties	14,820	7,849	19.93	28.95	1,462	98.65	186
2. Balanced fertilization	1,710	607	21.37	30.50	114	66.67	188
3. Soil conservation practices	831	612	20.60	25.48	62	74.19	101
4. Intercropping	4,250	160	29.95	28.94	15 [4)]	-17.32	94
5. Root and leaf silage for pig feeding	1,172	-[3)]	-	-	12	10.24	-
Total	**22,833**	**9,228**			**1,665**	**72.92**	-

[1)] Farmers' practice usually includes most new technologies except the technology being tested
[2)] based on a price of 320 VND/kg fresh roots in 2003/04; 1 US$ = 15,500 VND
[3)] 3,370 pigs
[4)] increase in gross income from the harvest of intercrops
Source: *Tran Ngoc Ngoan, 2003.*

ASSESSMENT OF IMPACT

In order to determine more precisely the effect of this project on adoption of new technologies, an impact assessment was made by an outside consultant. He organized focus group discussions and collected data from farmers in eight representative project sites, four sites in Thailand and four in Vietnam, as well as from farmers living within 10 km of those sites, who had not participated in the project. **Table 15** shows the percent of households (out of 767) who had adopted various technologies. New varieties were adopted[1] by nearly all cassava farmers in the eight sites in Thailand and by 70% of farmers in Vietnam; the use of chemical fertilizers had been adopted by 85-90% of households in the eight sites in each country; intercropping by nearly 60% of households in Vietnam, but by only 13% in Thailand. Contour ridging was adopted by about 30% of households in both Vietnam and Thailand, while contour hedgerows were adopted by 23% of households in Thailand and 25% in Vietnam; in Thailand these hedgerows were almost exclusively vetiver grass, while in Vietnam most farmers preferred the planting of *Tephrosia candida* or *Paspalum atratum*, as these are easier to plant (from seed) and can also serve as a green manure and animal feed, respectively. Thus, it is clear that adoption of specific practices varies from site to site, depending on local conditions and traditional practices. **Table 15** also indicates that there were highly significant differences in the adoption of almost all the technologies between participating and non-participating farmers (with the exception of contour ridging and the use of chemical fertilizers in Vietnam), with participating farmers having a greater extent of adoption than non-participating farmers. In this case, "participants" were defined as farmers who had conducted at least one FPR trial and/or had participated in an FPR training course, while "non-participants" had done neither, but may have attended a farmer field day organized by the project. It can be seen that new varieties and the use of chemical fertilizers were readily adopted by both participants and non-participants, while adoption of soil conservation practices and intercropping was both less widespread and largely limited to participating farmers. This clearly points to the difficulty of achieving spontaneous and widespread adoption of soil conservation practices.

But how does adoption of these new technologies translate into higher yields and income? **Figure 3** shows the cassava yields that farmers reported before and after the project, corresponding more or less to the second phase of the project, or from 1999 to 2003. In Thailand the yields of participating farmers increased from 19.4 to 25.8 t/ha (33%), while yields of non-participating farmers increased from 15.5 to 20.3 t/ha (31%); in Vietnam project participants increased yield from 13.7 to 28.2 t/ha (106%) while non-participants increased their yields from 14.3 to 23.9 t/ha (67%) (Lilja *et al.*, 2005). Thus, in both countries yields increased very markedly, but these increases were greater for participants than for non-participants, especially in Vietnam. For comparison, **Figure 3** also shows the increase in yield for the whole country, as reported by FAO during approximately the same time period. Yields for the whole of Vietnam are considerably below those reported by the farmers in the focus groups; but the yield

[1] Planted in 50% or more of the farmer's total cassava area

increases are similar to those reported by the non-participants. In Thailand the initial yields in the country were similar to those of non-participating farmers, but after-project yields were much higher for participants as well as nearby non-participants than for the country as a whole. This indicates that participating farmers benefited most from their experiences but that nearby farmers also benefited indirectly from the project.

Table 15. Extent of adoption (percent of households)[1] of new technologies by participating and non-participating farmers in the cassava project in Thailand and Vietnam in 2003 (n=767).

	Thailand			Vietnam			Full sample		
	Partic.	Non-partic.	Total	Partic.	Non-partic.	Total	Partic.	Non-partic.	Total
Varieties									
-100% improved varieties	100	88.0	91.1***	50.0	38.8	42.9***	73.2	67.3	69.1***[2]
-75% improved varieties	0	11.7	8.6	5.6	6.7	6.3	3.0	9.6	7.6
-50% improved varieties	0	0.3	0.2	26.2	18.3	21.1	14.0	7.9	9.8
-25% improved varieties	0	0	0	4.0	5.4	4.9	2.1	2.3	2.2
-No improved varieties	0	0	0	14.3	30.8	24.9	7.7	13.0	11.3
Soil conservation practices									
-contour ridging	52	22	30***	35	31	33	43	26	31***
-hedgerows	60	10	23***	50	12	25***	54	11	24***
-vetiver grass	60	10	23***	10	3	5**	33	7	15***
-*Tephrosia condida*	0	0	0	38	6	18***	20	3	8***
-*Paspalum atratum*	1	0	0*	12	2	6***	7	1	3***
-Pineapple	0	0	0	2	1	1	1	0	1
-sugarcane	2	1	1	0	0	0	1	0	1
-other hedgerows	3	0	1*	7	1	3***	5	1	2***
-no soil conservation	21	72	59***	23	58	45***	22	67	53***
Intercropping	28	8	13***	79	49	59***	55	25	34***
-with peanut	1	1	1	47	33	38***	26	14	18***
-with beans	0	0	0	27	29	29	14	12	13
-with maize	3	10	5***	2	3	3	6	3	4*
-with green manures	19	4	8***	0	0	0	9	2	4***
-with other species	3	2	2	39	15	24***	22	7	12***
Fertilization									
-chemical fertilizers	98	86	89***	85	86	86	91	86	87***
-farm-yard or green manure	55	25	33***	74	60	65**	65	40	48***
-no fertilizer	0	13	9***	12	8	9	6	11	9*

[1]Percentages may total more than 100 % as households can adopt more than one type of technology simultaneously
Significant differences between participants and non-participants: * P<=0.10 ** P<=0.05 *** P<=0.01
[2]Level of significance in this case refers to differences between participants and non-participants in terms of the categorical distribution, not the adoption levels

Table 16 shows that during the past ten years the average cassava yields in both countries increased; this increase was 5.62 t/ha in Thailand and 6.05 t/ha in Vietnam. The increased yields resulted in annual increases in gross income received by farmers of about 203 million US dollars in the two countries, and about 325 million US dollars in all of Asia. In addition, farmers in Thailand received higher prices due to the higher starch content of the new varieties. This was achieved not only by this project, but by the collaborative effort of many researchers, extensionists, factory owners and farmers, with strong support from national governments.

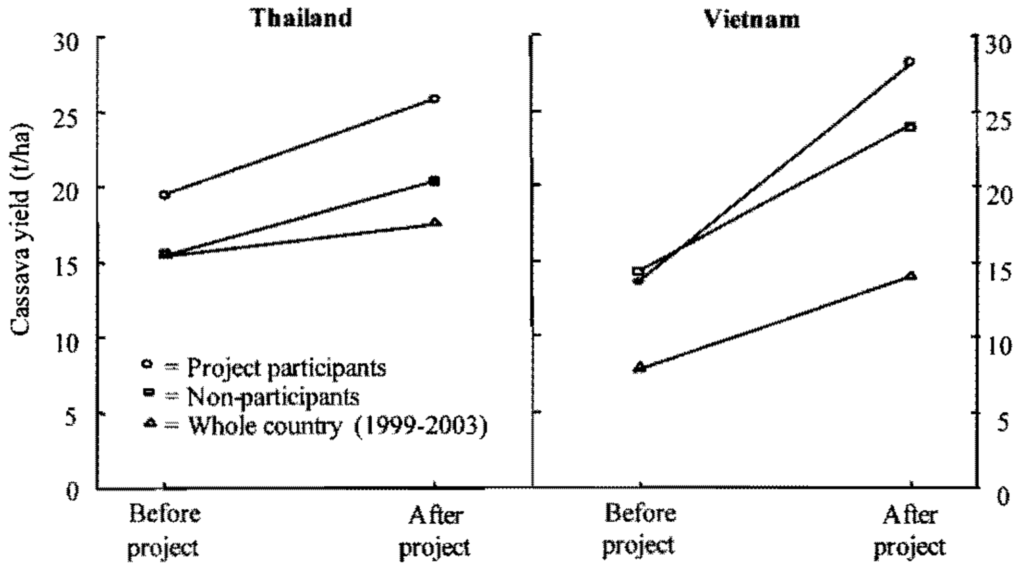

Figure 3. Average cassava yields of farmers participating in the Nippon Foundation cassava projec or of near–by but non-participating farmers, before the project started and at the end of the project. Data are from PRRA census forms collected from 417 households in Thailand and 350 households in Vietnam. For comparison the national average cassava yields in 1999 (before) and 2003 (after) are also shown.

Table 16. Estimation of the annual increase in gross income due to higher cassava yields resulting from the adoption of new cassava varieties and improved practices, in China, Thailand and Vietnam, as well as in Asia as a whole.

Country	Total cassava area (ha)[1]	Cassava yield (t/ha)[1] 1994	Cassava yield (t/ha)[1] 2004	Yield increase (t/ha)	Cassava price ($/tonne)	Increased gross income due to higher yields (mil. US $)
Thailand	1,050,000	13.81	19.43	5.62	25	147.5[2]
Vietnam	370,500	8.44	14.49	6.05	25	56.0
Total Asia	3,508,103	12.93	16.64	3.71	25	325.4

[1]Data from FAOSTAT for 2004

[2]In addition, farmers also benefited from higher prices due to higher starch content

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 was found to be very 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 at large.

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