

Farmers decide: A participatory approach to the development and dissemination of improved cassava technologies that increase yields and prevent soil degradation

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Abstract. Farmers in Asia like to grow cassava because the crop tolerates long dry periods and poor soils, and produces reasonable yields with little inputs. Most farmers realize, however, that cassava production on slopes can cause severe erosion, while production without fertilizer inputs may lead to a decline in soil productivity. Research has shown that cassava yields can be maintained for many years with adequate application of fertilizers, 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 of these practices. To enhance the adoption of soil conserving practices and improve the sustainability of cassava production, a farmer participatory research (FPR) approach was used to develop not only the best soil conservation practices, but also to test new varieties, fertilization and cropping systems that tend to produce greater short-term benefits. The FPR methodology was initially developed in 2-3 sites each in China, Indonesia, Thailand and Vietnam, but has now extended to about 99 villages in Thailand, Vietnam 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 to

larger fields, and farmer participatory dissemination to neighbors and other communities. Based on the results of these trials, farmers have readily adopted better varieties, fertilization and intercropping practices, and many farmers have now adopted the planting of contour hedgerows to control erosion. The resulting increases in cassava yields in Asia over the past eight years have increased the annual gross income of cassava farmers by an estimated 150 million US dollars.

Introduction

Cassava (*Manihot esculenta* Crantz) is usually grown by smallholders in upland areas with poor soils and low or unpredictable rainfall. In some countries, the crop is grown on steep slopes, but in others it is grown mainly on gentle slopes; in both cases, soil erosion can be serious. Moreover, cassava farmers seldom apply adequate amounts of fertilizers or manures to replace the nutrients removed in the harvested products. Thus, both erosion and nutrient extraction can result in a decline in soil fertility and a gradual degradation of the soil resource.

The fact that farmers do not apply sufficient fertilizers and do not use soil conservation practices when the crop is grown on slopes is more a socio-economic rather than a technical problem. Research has

shown many ways to maintain or improve soil fertility and reduce erosion, but farmers usually consider these practices too costly or requiring too much labor. To overcome these obstacles to adoption, it is necessary to develop simple practices that are suitable for the local situation and that provide short-term benefits to the farmer as well as long-term benefits in terms of resource conservation. Being highly site specific these practices can best be developed by the farmers themselves, on their own fields, in collaboration with research and extension personnel.

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

Materials and Methods

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

(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

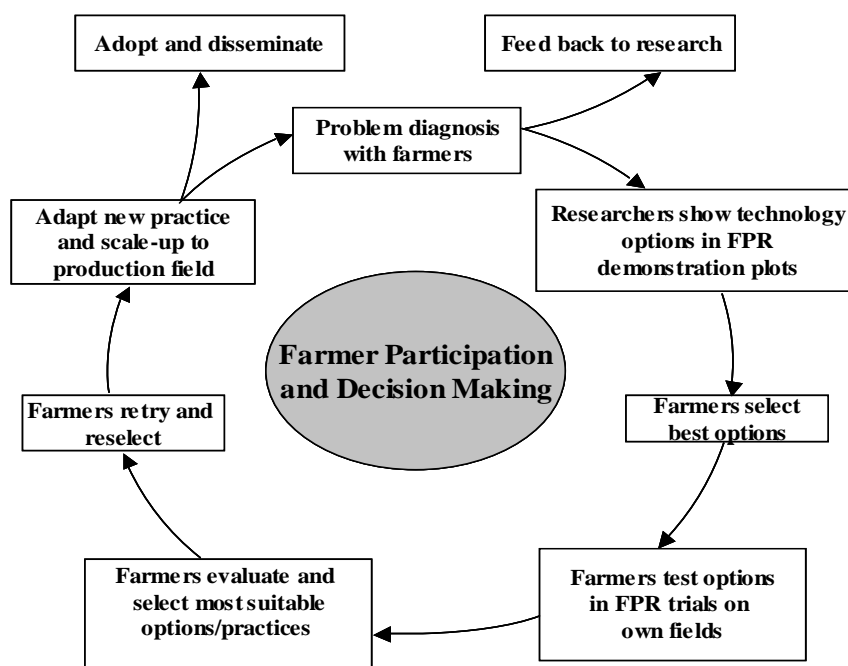


Figure 1: Farmer participatory model used for the development of sustainable cassava-based cropping systems in Asia.

Appraisals (RRA) in each site have been reported by Nguyen The Dang *et al.* (1998), Utomo *et al.* (1998), Vongkasem *et al.* (1998) and Zhang Weite *et al.* (1998). After conducting the RRAs, one or two suitable pilot sites (villages or sub districts) were selected to work with farmers in the development and dissemination of suitable varieties and production practices.

(b) Demonstration plots. Each year demonstration plots were laid out on an experimental station or a farmer's field to show the effect of many alternative treatments on yield, income and soil erosion. Farmers from the selected pilot sites visiting the trial were asked to discuss and score the usefulness of each treatment. From this range of many options farmers usually selected 3-4 treatments that they considered most useful for their own conditions. Some farmers then volunteered to test these treatments in FPR trials on their own fields.

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 along the contour on a uniform slope; 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 several 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 numerical indication of the effectiveness of the various practices in controlling erosion (Howeler, 2001; 2002).

(c) FPR trials. The FPR trials did not only involve soil conservation practices, but also new varieties, intercropping systems and fertilization, with the objective of developing a combination of practices that would increase farmers' income, reduce erosion and improve soil fertility.

During the first phase of the project, farmers in the four countries conducted a total of 177 FPR erosion control trials, 157 variety trials, 98 fertilizer trials and 35 intercropping trials. At time of harvest, field days were organized in each site to harvest the various trials by the participating farmers and their neighbors. The yields of cassava and intercrops, the dry soil loss due to erosion, as well as the gross income, production costs and net income were calculated for each treatment and presented in a joint meeting to the farmers. After one or more years of testing in small plots, farmers quickly identified the best varieties and production practices for their area and started using those on larger areas of their production fields (Howeler, 2002).

Second Phase (1999-2003). The second phase of the project was conducted in collaboration with five institutions in Thailand, six in Vietnam and three in China. During the second phase the emphasis shifted from participatory research (FPR) to extension (FPE) in order to reach more farmers and achieve more widespread adoption. These farmer participatory extension activities included the organization of cross-visits, in which farmers from a "new" site visited those from an "older" (already established) site where FPR trials were being conducted or where some selected practices had already been adopted. It also included training courses for key farmers and local extensionists; farmer field days at time of harvest as well as large-scale farmer field days with participation of many farmers from the district or province, and the establishment of community-based self-help groups. In addition, more conventional extension tools, such as a video, and booklets on various aspects of cassava production and utilization were prepared.

Once farmers had selected certain practices and wanted to adopt those on their fields, the project staff tried to help them; for instance, in setting out contour lines to plant hedgerows for erosion control, or to obtain

seed or vegetative planting material of the selected hedgerow species, intercrops or new cassava varieties.

Results and Discussion

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

(a) FPR trials. Table 1 shows a typical example of an FPR erosion control trial conducted by six farmers having adjacent plots on about 40% slope. It is clear that contour hedgerows of vetiver grass, *Tephrosia candida* or pineapple reduced erosion to less than 20% of that in the check plot, while intercropping with peanut and planting vetiver hedgerows markedly increased net income. Results of many other FPR trials have been reported by Nguyen The Dang *et al.* (2001), Huang Jie *et al.* (2001), Utomo *et al.* (2001) and Vongkasem *et al.* (2001).

(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).

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.

In subsequent years, the project was expanded. In 2001 the project was being implemented in about 50 sites. This was further increased to 99 sites by the end of the project in 2003 (Figure 2). Once the benefits of the new technologies became clear, the number of sites increased automatically, as neighboring villages also wanted to participate in order to increase their yields and income.

Whenever the project extended to a “new” site, the process outlined above was re-

Table 1: Results of an FPR erosion control trial conducted by six farmers in Kieu Tung village, Thanh Ba district, Phu Tho, Vietnam, in 1999.

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

¹ Fertilizers = 60 kg N + 40 P₂O₅ + 120 K₂O/ha; all plots received 10 t/ha pig manure.

² Prices: cassava dong 400/kg fresh roots, peanut 5500/kg dry pods. ³ Cost fertilizers = 0.810 mil. dong/ha; cost of intercropping = 2.22 mil.dong/ha.

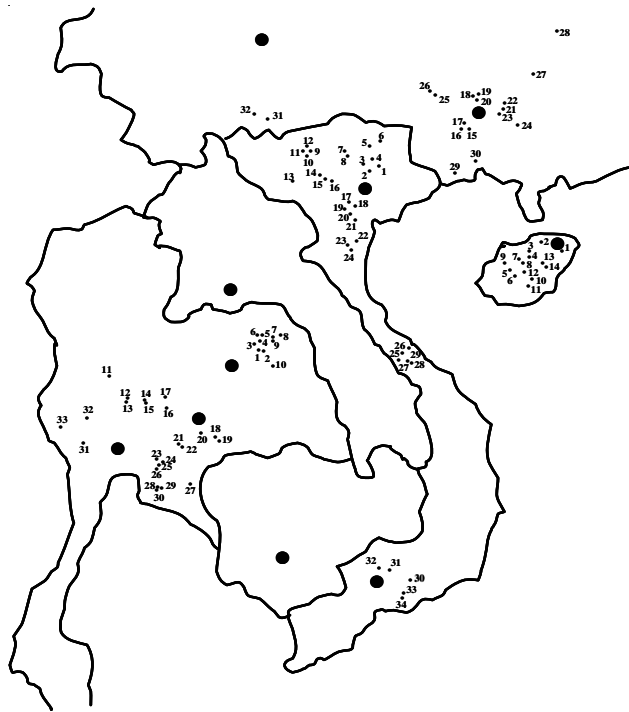


Figure 2: Location of FPR pilot sites in China, Thailand and Vietnam in the Nippon Foundation cassava project in 2003.

initiated, i.e. an RRA was conducted, interested farmers visited demonstration plots and/or made a cross-visit to an already established site, and they conducted FPR trials, discussed results and eventually adopted those varieties or practices they had selected as most suitable for their own conditions. Table 2 shows the number and type of FPR trials conducted in China, 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 second phase of the project a total of 1,154 FPR trials were conducted by farmers on their own fields.

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:

(a) 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 sub district extension staff, helped farmers to establish the trials, or they provided seed or planting materials required for the adoption of the new technologies.

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

Country	Type of FPR trial	1999	2000	2001	2002	2003	Total
China	Varieties	9	9	20	69	20	127
	Erosion control	3	5	8	17	-	33
	Fertilization	-	-	-	4	-	4
	Intercropping	-	-	-	9	-	9
	Pig feeding	-	-	-	59	-	59
		12	14	28	158	20	232
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		82	146	285	397	244	1,154

(b) 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 media. 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 literature about the project and the results obtained was distributed.

(c) 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.

(d) 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. In Thailand, farmers are encouraged farmers to set up these groups as a way of organizing themselves, to conduct FPR trials, to implement the selected practices, and to manage a rotating fund, from which members of the group can borrow money for production inputs. Thus, by 2003, a total of 21 “Cassava Development Villages” had been set up in the pilot sites. Each group needed to have at least 40 members, elect five officers to lead the group, and establish their own bylaws about membership requirements, election of officers, use of the rotating fund, etc. The formation of these groups helped to decide on collective action and to strengthen the community, 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.

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

In Thailand, 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. Table 3 indicates that by the end of 2003, about 865 farmers had planted a total of 1.65 million vetiver plants, corresponding to about 150 km of hedgerows.

Table 4 similarly summarizes the adoption of various new technologies in Vietnam. In 2001, over 1400 farmers in the FPR pilot sites were planting new cassava varieties (mainly KM 94), while hundreds were applying more balanced fertilization (usually pig manure in addition to chemical fertilizers), intercropped with peanut or black bean, and controlled erosion by the planting of contour hedgerows of *Tephrosia candida*, vetiver grass or *Paspalum atratum*. In some villages in Pho Yen district of Thai Nguyen province in North Vietnam, the gross income of many farmers in 2001 was 4-5 times higher than those reported in 1994/95 at the start of the project (CIAT, 2001). During 2002 and 2003 farmers in Van Yen district of Yen Bai province in North Vietnam planted a total of 500 km of double hedgerows of *Tephrosia candida* or *Paspalum atratum* to control erosion, and they planted about 3000 ha of new cassava varieties with improved fertilizer practices. This increased average yields from 10 t/ha to about 30 t/ha.

Table 3: Extent of adoption of vetiver grass contour hedgerows for erosion control in various FPR pilot sites in Thailand in 2003.

Province		District	Sub district	Adoption of vetiver grass			
				Cassava		Vetiver	
				No. of farmers	area with vetiver (ha)	(no. of plants)	hedgerows (km) ¹⁾
1.	Kalasin	Mueang	Phuu Po	61	49.0	85,500	8.6
2.	Kalasin	Mueang	Khamin	-	-	-	-
3.	Kalasin	Nong Kungsri	Nong Bua	67	110.4	111,600	11.2
4.	Kalasin	Sahatsakhan	Noonburi	63	59.2	86,170	8.6
5.	Kalasin	Sahatsakhan	Noon Nam Kiang	47	40.6	128,330	12.8
7.	Kalasin	Naamon	Naamon	50	24.0	56,000	4.0
8.	Kalasin	Huay Phueng	Nikhom	50	24.0	216,000	20.0
9.	Kalasin	Don Chaan	Dong Phayung	50	24.0	28,500	2.2
10.	Roy Et	Phoo Chai	Khampha-ung	-	-	4,000	0.4
11.	Kamphaengphet	Khanuwaralakburi	Bo Tham	42	27.2	68,000	3.0
12.	Chayaphum	Thep Sathit	Naayaang Klak	42	27.2	83,000	5.5
14.	Nakhon Ratchasima	Thepharak	Bueng Prue	-	-	-	-
15.	Nakhon Ratchasima	Thepharak	Bueng Prue	26	34.2	80,000	11.0
16.	Nakhon Ratchasima	Sri Khiw	Paang Lako	-	-	-	-
17.	Nakhon Ratchasima	Daan Khun Thot	Baan Kaw	53	49.4	130,000	15.0
18.	Nakhon Ratchasima	Soeng Saang	Noon Sombuun	62	132.5	80,000	20.0
19.	Nakhon Ratchasima	Soeng Saaang	Sratakhan	-	4.8	20,000	2.0
20.	Nakhon Ratchasima	Khonburi	Tabaekbaan	27	24.0	100,000	5.0
21.	Prachinburi	Naadii	Kaeng Dinso	34	27.2	60,000	4.5
23.	Chachoengsao	SanaamChaikhet	Thung Prayaa	32	10.4	50,000	2.0
24.	Chachoengsao	Thaa Takiap	Khlong Takraw	42	27.2	100,000	5.3
27.	Sra Kaew	Wang Sombuun	Wang Sombuun	75	220.8	90,000	9.0
28.	Chonburi	Bo Thong	Kaset Suwan	-	-	-	-
31.	Ratchaburi	Baan Poong	Khaw Khalung	-	-	-	-
32.	Kanchanaburi	Law Khwan	Thung Krabam	42	27.2	80,000	3.0
33.	Kanchanaburi	Sai Yook	Sai Yook	-	-	-	-
Total	11	22	25	865	943.3	1,657,100	153.1

¹⁾Cassava area with hedgerows and hedgerow length are approximate, as some hedgerows were damaged by tractor while others needed to be partially replanted because of poor establishment due to drought.

Table 5 indicates the extent of adoption of new varieties in China, Thailand and Vietnam, both in terms of cassava area planted and the number of farmers planting these varieties. Only a fraction of the more than 800,000 farmers planting new varieties had actually participated in the project; the others must have heard about new varieties from extension agents, other farmers, starch factories or TV. In Thailand about 98% of the total cassava area is now planted with new varieties; in Vietnam this is about 40% and in China about 10%. Table 6 shows that during the past eight years the average cassava yields in all three

countries increased; this increase ranged from 0.83 t/ha in China to 4.16 t/ha in Vietnam. The increased yields resulted in annual increases in gross farmers' income by about 100 million US dollars in the three countries, and about 150 million US dollars in the whole of Asia. In addition, farmers in Thailand received higher prices due to the higher starch content of the new varieties. This was achieved by the collaborative effort of many researchers, extensionist, factory owners and farmers with strong support from national governments. The development of high yielding improved varieties and more efficient agronomic and soil

Table 4: The adoption of new technologies by farmers in various sites in Vietnam in 2001.

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

Table 5: Estimation of the number of farmers that have adopted and benefited from new cassava varieties in China, Thailand and Vietnam.

Country	Province	Average cassava areaper household(ha) ¹	Area undernew varieties (ha)	Average no.of farmers adopting new varieties ²
China	Guangxi	0.22	16,666	75,500
	Guangdong	0.53	~6,000	~11,320
	Hainan	0.53	1,333	2,500
Thailand		2.86	1,000,000	350,000
Vietnam		0.27	100,000	370,000
Total				~809,320

¹Data estimated from RRA (1994) and Vietnam Cassava Survey (1991/92)

²Assuming complete replacement of old by new varieties.

Table 6: 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	Cassava yield (t/ha) ¹⁾		Yield increase	Cassava price	Increased gross income due to higher yields
	(ha) ¹⁾	1994	2002	(t/ha)	(\$/tonne)	(mil. US \$)
China	240,100	15.21	16.04	0.83	24-30	5.4
Thailand	1,030,000	13.80	16.38	2.58	21-24	59.8 ²
Vietnam	329,900	8.44	12.60	4.16	22-29	35.0
Asia total	3,486,502	12.93	14.67	1.74	25	151.7

¹Data from FAOSTAT 2003.

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

conservation practices, as well as the use of a farmer participatory approach, all contributed to the widespread adoption of new varieties and improved practices in many countries in Asia resulting in improved livelihoods of cassava farmers.

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 quite effective in developing

locally appropriate and economically viable technologies, which in turn enhances their acceptance and adoption by farmers.

The conduct 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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