# 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 will tolerate long dry periods and poor soils, and will produce 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.

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

## 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

### *1. 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.

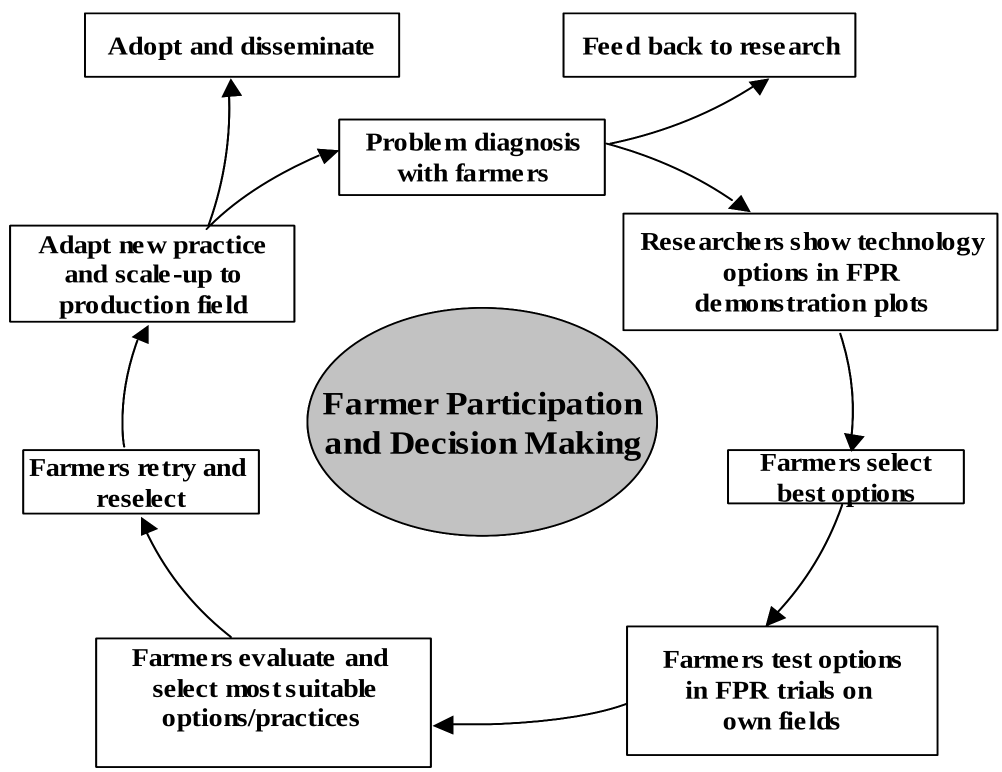


*Figure 1. Farmer participatory model used for the development of sustainable cassava-based cropping systems in Asia.*

*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), 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 subdistricts ) 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 experiment 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, for a total of 467 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).

***2. 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 being 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

### *1. 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).

**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) cassava | Yield (t/ha) peanut[1] | Gross income[2] (mil. dong/ha) | Product. costs[3] (mil. dong/ha) | Net income (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, *Tephrosia* 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., *Tephrosia* hedgerows | 40.0 | 3.3 | 21.7 | - | 8.68 | 3.04 | 5.64 |

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

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

[2] Cost fertilizers = 0.810 mil. dong/ha; cost of intercropping = 2.22 mil.dong/ha

*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).

### *2. 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.

Implementing the project in collaboration with many different institutions in China, Thailand and Vietnam, and with generous financial support from the Nippon Foundation, it was possible to expand the number of pilot sites each year. In 2001 the project was working in about 50 sites, and this 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.

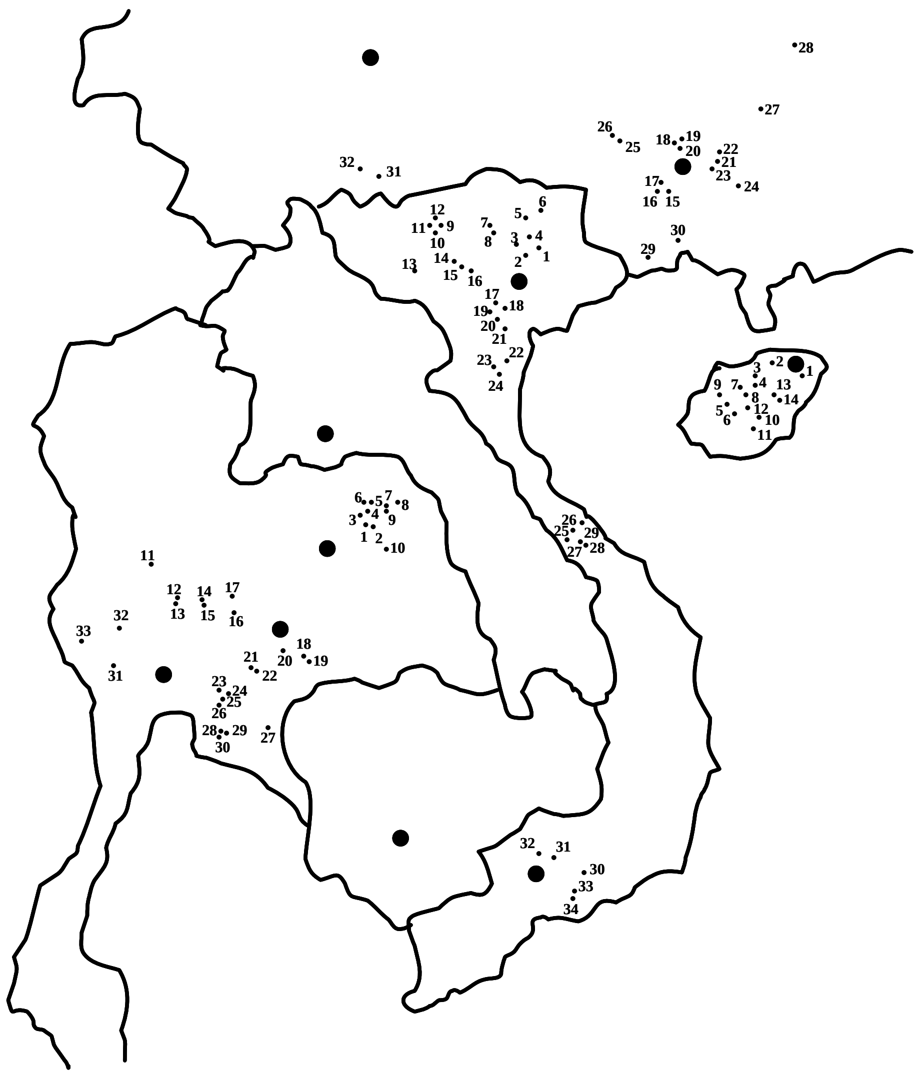

*Figure 2. Location of FPR pilot sites in China, Thailand and Vietnam in the Nippon Foundation cassava project in 2003.*

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 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.

**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** |

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 subdistrict extension staff, helped farmers to establish the trials, or they provided seed or planting materials required for the adoption of the new technologies.

*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 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 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, the Dept. of Agric. Extension has encouraged farmers to set up these groups as a way of organizing themselves, to conduct FPR trials, to implement the selected practices, and to manage a rotating fund, from which members of the group 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.

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

| | | | | Adoption of vetiver grass | | | |
|---|---|---|---|---|---|---|---|
| | Province | District | Subdistrict | No. of farmers | Cassava area with vetiver(ha) | Vetiver (no. of plants) | Vetiver 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 Kliang | 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 Khiiw | 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 | Sratakhian | - | 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** | **1,657,10(** | **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 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 4. The adoption of new technologies by farmers in various sites in Vietnam in 2001.**

| Province | District | Commune | 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 | - | - | - | - |
| Tuyen Quang | Son Duong | Thuong Am | Am Thang | 16/2.0 | 15/0.5 | 15/6.0 | - | - |
| | | | Hong Tien | 18/1.2 | 18/0.6 | 8/4.0 | - | - |
| Yen Bai | Van Yen | | Yen Hung | 5/2.0 | - | 5/2.0 | - | - |
| | | | Yen Thai | 4/2.0 | - | 4/2.0 | - | - |
| | | | Yen Hop | 6/2.0 | - | 6/2.0 | - | - |
| | | | Mau Dong | 9/4.0 | - | 9/2.0 | - | - |
| | | | Dong Cuong | 7/2.0 | - | 7/2.0 | - | - |
| | | | Tan Hop | 5/2.0 | - | 5/2.0 | - | - |
| | | | Dong An | 6/2.0 | - | 6/2.0 | - | - |
| | | | Lam Giang | 4/2.0 | - | 4/2.0 | - | - |
| | | | An Binh | 7/2.0 | - | 7/2.0 | - | - |
| Phu Tho | Thanh Ba | Phong Linh | Kieu Tung | 13 | - | 25 | - | - |
| | Phu Ninh | Thong Nhat | Thong Nhat | 32/2.0 | - | 25/3.5 | - | - |
| | | | Bao Thanh | 5 | - | - | 2 | - |
| Hao Binh | Luong Son | Dong Xuan | Dong Rang | - | 12 | 45 | 9 | - |
| Ha Tay | Thach That | | Thach Hoa | 1000/100 | 10 | 15 | 4 | - |
| | Chuong My | Tran Phu | Tran Phu | 40 | - | - | 60 | - |
| Thua Thien-Hue | A Luoi | | Hong Ha | >19 | 12 | 25 | >20 | 15 |
| | Nam Dong | | Thuong Long | 10 | - | - | - | 20 |
| | Huong Tra | | Huong Van | - | - | - | - | 40 |
| Dong Nai | Thong Nhat | | An Vien | >30 | 2 | - | 5 | - |
| Binh Phuoc | Dong Xoai | | Dong Tam | - | 5 | - | 5 | - |
| | | | Minh Lap | - | 10 | - | 5 | - |
| Baria Vungtau | Chau Duc | | Suoi Rao | 7/1.4 | - | 5/2.0 | - | - |
| **Total** | | | **30** | **>1,435** | **169** | **226** | **>183** | **75** |

**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 income

received by farmers of about 100 million US dollars in the three countries, and about 150 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 by the collaborative effort of many researchers, extensionists, factory owners and farmers with strong support from national governments. The development of high yielding improved varieties and more efficient agronomic and soil 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.

**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 area per household (ha)[1] | Area under new 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** |

[1]Data estimated from RRA (1994) and Vietnam Cassava Survey (1991/92)
[2]Assuming 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 (ha)[1] | Cassava yield (t/ha)[1] 1994 | Cassava yield (t/ha)[1] 2002 | Yield increase (t/ha) | Cassava price ($/tonne) | Increased gross income due to higher yields (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 |

[1]Data from FAOSTAT 2003
[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 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 at large.

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