



# Village Soil Fertility Maps

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## SUMMARY

Poor farmers in Northeast Bangladesh can readily tell which of their small plots are the most fertile, and which are the least. When we asked them to, they deftly drew maps showing three to six different levels of fertility. Building on this local knowledge, the Agricultural Advisory Society (AAS) and the Bangladesh Rice Research Institute (BRRI) identified farmer extension agents and gave them a two-day practical course on how to apply fertiliser in their rice fields, in a way that took into account farmers' own knowledge, and scientists'. We helped them set up a farmer-to-farmer extension programme for the poor. Poor farmers were comfortable working with other poor farmers in their own or neighbouring village. In each village, one farmer extension agent helped groups of about twenty people draw a village soil fertility map. Then with some help from AAS staff, the farmer extension agents used the soil fertility maps to locate small field experiments, in which farmers learnt to adjust fertiliser applications based on crop performance. Once they had the results from those trials, farmers held a result-sharing village meeting, and made recommendations for organic and chemical fertilisers, for each type of soil and each rice cropping season. In four seasons, volunteer farmer extension agents trained about 4,000 other poor farmers to apply balanced doses of nutrients in 216 villages. To further scale up the method, we held a three-day, hands-on training course for field staff of the Department of Agricultural Extension (DAE); experienced farmer extension agents acted as trainers. The government extension staff was shocked, but pleased to realise how much farmers knew, and had learnt, about soil fertility. In the future, if paid a small stipend, some farmers would make excellent extension agents and local coordinators.

## ACTORS AND NETWORKS

Recommending the right fertiliser dose for a village in Bangladesh is complicated. Even within a single village soil fertility is a mosaic of soil types, each of which respond best to a different dose of fertilisers. Farmers with less than 0.5 ha of land scattered in two to five plots may need a different recommendation for each tiny plot. Obviously, no one can test the soil in each field, but BRRRI and AAS recently developed a method that allows them to adjust specific recommendations for each field, without actually testing them all. It combines elements of farmer knowledge, farmer participatory research, selective soil sampling, farmer-to-farmer extension and participatory rural appraisal (PRA) exercises.

Although people elsewhere reported participatory exercises for ecological mapping (Gupta and IDS Workshop, 1989) and soil fertility management (Kanté and Defoer, 1994; Defoer and Budelman, 2000), none of these publications were available to the team in Bangladesh, illustrating the vacuum many researchers and NGOs in developing countries have to operate in.

The BRRRI Soil Science Division analysis soil fertility and develops fertiliser management packages. Through an exchange visit organised by the PETRRA project, one of the authors (Saleque) enrolled in a participatory crop improvement training course at the University of Wales in the UK. This course and literature on local knowledge (e.g. Murage et al., 2000) triggered the idea of mapping soil fertility with farmer colleagues, to develop their own nutrient management strategies. A partner organisation had to be found to help put these ideas into practice in the field.

AAS, a small national NGO described in previous chapters, works on about ten different rice projects with men and women farmers. AAS had previous experiences with agriculture, but not with participatory research in soil fertility. The director of AAS, Harun-Ar-Rashid, is an agronomist who once worked at BRRRI and is on good terms with their scientists, so collaboration was natural.

Twelve local NGOs and community-based organisations (CBOs)<sup>1</sup>, who have been working with AAS in other projects in Habiganj and Moulvibazar districts, in northeastern Bangladesh, helped identify and organise poor farmers.

Although Bangladesh has competent soil labs, in general, farmers have limited access to soil-testing services and depend on their own experience, advice from neighbours and DAE field staff (block supervisors), who have local soil maps, but not information at the individual field level.

## EVOLUTION OF THE METHOD

The first year (2002), AAS and their colleagues drew soil fertility maps with 12 villages. AAS started the meetings by asking the local people to draw a map showing the most fertile fields, the least fertile ones, and the in-between. Most of the

communities had made simple maps before, in other meetings with outsiders. The local people intuitively grasped the idea of the different grades of soil fertility and sketched maps from scratch with markers on white boards, showing the grades of soil in their village.

During the first three seasons, the two senior authors and other staff took several soil samples from each grade of soil that farmers identified in each village (see Table 8.1). Back in the lab, we were delighted to see that time after time, the soil that farmers said was the most fertile, actually was. Farmers had no trouble ranking local soils by fertility, and our scientific tests backed them up. In time, we began to trust the farmers more, and took fewer samples, only in those villages that had clearly different landscape and soil features from the ones we worked in previously. All villages had piedmont soil.

We learnt that farmers think that the most fertile soil is black, deep, clayey, with lots of earthworms; it retains water well. They think of the least fertile soil as thinner, whiter, sandy, with fewer earthworms, holding less water. Some farmers say that fertile soils have a distinct smell. On the other hand, we researchers perceived fertile soil as being high in organic matter and nutrients, especially nitrogen, potassium and phosphorous. In spite of our different perspectives, the results of our laboratory soil tests for organic carbon, total nitrogen, available phosphorous and exchangeable potassium correlated well with farmers' perception of soil fertility. But there was one problem (see Box 8.1).

In the villages, we learnt how farmers managed soil for each fertility grade. For example, farmers tended not to apply phosphorous or potassium, only urea, and not enough of that. By pooling scientific and farmer knowledge, we reached a consensus on which improved soil fertility management practices to test in each soil grade. This included the use of gobar cow manure, which everyone agreed was a good thing, higher doses of nitrogen than the farmers were using, and potassium. But because of what we had learnt with the farmers and laboratory tests, less phosphorous was suggested than we would have initially. Fertilisers were applied in split doses, each test plot receiving the same basal amount.

At first, the soil tests for phosphorous puzzled us. The tests showed that phosphorous was low, but when we asked farmers, they told us that in the past their crops hardly responded to phosphorous. Actually, our results turned out to be an artefact of the testing method. When we followed standard lab practice - drying soil and grinding it before measuring nutrients-phosphorous readings were low. But when we measured the phosphorous on waterlogged soil, which is where rice grows, there was a higher pH (6 instead of 5) and so more available phosphorous. This was a good lesson for us: we scientists need to be careful in validating local knowledge, as sometimes our tests are inappropriate. The new laboratory technique, which emerged from working with farmers, analyses soil samples in a way that is much closer to the actual field conditions (Saleque, 2004).

Box 8.1  
Farmers Lay  
Basis for New  
Lab Technique

Then, we tested the newly negotiated fertiliser applications in two or three fields per grade, comparing them side by side with farmer practices, in each of the 12 villages (Table 8.1). Farmers helped design the experiments, select the fields, decide on plot sizes and which rice varieties to plant. They did the trials on their own and took care of the fields like researchers, helped by field coordinators from AAS. Project staff recorded plant height and tiller number every 15 days. At the active growing stage, staff collected rice leaves to analyse them for nutrients.

By observing crop colour and growth at different stages, farmers adjusted the second and third doses, so that the total amount deviated slightly from what we had planned initially in the group meeting. From the training farmers had learnt that it was better to apply the last top dressing of urea at about seven days before flower initiation, rather than any time hereafter, and also that too vigorous crop growth could be slowed down with small amounts of potassium.

As our confidence in local knowledge grew, we took fewer soil samples. "As an agronomist, I felt very uncertain in the beginning of the project, but now I believe in my heart that farmers have the knowledge to correctly assess soil fertility and make a village map," says Mr. Ferdous, one of the enthusiastic young staff members from AAS.

Table 8.1 Evolution of farmer-to-farmer extension for soil fertility management

SEASON	VILLAGES (n)	FARMER EXTENSION AGENTS	SOIL TESTING	COMMUNITY LEARNING
Aus 2002	40	0	Randomly 2-3 samples from each fertility grade, in each village	3-4 field trials per fertility grade, comparing local practices with our recommended fertilisation
Aman 2002	80	0	Same as above	2-3 field trials per fertility grade
Boro 2003	10	17	Same as above	1 field trial per fertility grade
Aus 2003	33	35	Randomly 2-3 samples from each fertility grade, but only in villages that had distinct soil features	In 12 villages we compared local practices with our recommendations, and in the others we only did demonstrations of improved fertilisation
Aman 2003	79	79	Same as above	Demonstration plot only
Boro 2004	82	81	Same as above	Demonstration plot only
Total	216	212		

The farmers harvested the rice when it was ripe, and project staff recorded yield data. The plots with our negotiated fertiliser recommendations averaged higher yields than the ones that followed farmer practices, ranging from 12 to 49% in the minor rain-fed or *aus* season (April - August), 10 to 38% in the monsoon or *aman* season (July - November) and 35 to 40% in the dry *boro* season (November - May) (Table 8.2). Application of cow dung differed for each village and household, but farmers never applied during *aman*.

After each harvest we held a village training workshop. According to the farmers even the lowest yield increase of 9.5% in *aman* season still justified the additional fertiliser cost of Tk 880 (US\$ 15) per ha, their net profit being Tk 1,820 (US\$ 32) per ha. Based on the soil fertility maps and results of the field experiments, we refined our nutrient management packages for each soil fertility grade (Table 8.3).

Both the village map preparation and encouraging results of the soil fertility management experiments created great interest among the farmers. The ground had

Table 8.2 Response of rice to different soil fertility management packages in Habiganj and Moulvibazar, 2002-2003

Fertility grade <sup>1</sup>	Grain yield (ton per ha) <sup>2</sup>		% increase
	Farmer practice	Improved practice	
Aus season (variety 539)			
I	3.07	3.50	14.0
II	3.41	3.81	11.6
III	3.16	3.77	19.4
IV	2.88	4.02	39.6
V	2.53	3.77	48.8
Aman season (BR11)			
I	3.04	3.58	17.6
II	3.08	4.23	37.3
III	3.80	4.16	9.5
Boro season (BRRI dhan 28 & 29)			
I	4.55	6.13	34.7
II	4.01	5.54	38.0
III	3.90	5.46	39.9

<sup>1</sup> Soil fertility grade according to farmers, I indicating the most fertile soils

<sup>2</sup> FP = farmers' fertiliser dose, IP = improved fertiliser dose

been prepared to introduce farmer-to-farmer extension.

When we realised that the method was scientifically sound and farmers were keen on it, the project team brainstormed on how to scale it up with limited funding and staff time. AAS pioneered farmer-to-farmer extension in various other projects, such as the one on women-led group extension, described in Chapter 3. The following extension method can be used not only for soil fertility management, but for any topic on which farmers, men or women, have developed a deep local knowledge.

## THE FARMER-TO-FARMER EXTENSION METHOD

Explore strengths in local knowledge

In this project, local knowledge on soil fertility was the starting point to develop training and field research.

Identify innovative resource-poor farmer extension agents

Once farmers had drawn a village soil fertility map and set up field experiments or demonstration plots for comparison, it became easy to find and train three to four volunteer farmer extension agents from each village. This was especially true for women. Some poor women extension agents in the Women-led Group Extension sub-

Table 8.3 Fertiliser use in farmers' practice (FP) and improved practice (IP) plots in Srimongal upazila, Moulvibazar, 2002-2003

Fertility grade <sup>1</sup>	N (kg per ha)		P (kg per ha)		K (kg per ha)		S (kg per ha)	
	FP	IP	FP	IP	FP	IP	FP	IP
Aus (April - August)								
I	15	56	4	15	5	40	0	9
II	35	52	9	17	10	46	1	10
III	41	43	8	15	35	47	0	8
Aman (July - November)								
I	37	80	3	22	5	69	0	9
II	35	75	2	21	10	66	0	9
III	47	66	5	18	28	47	1	9
Boro (November - May)								
I	49	70	4	19	7	58	2	9
II	32	90	4	16	8	59	0	8
III	57	92	5	18	16	62	0	10

<sup>1</sup>Soil fertility grade according to farmers, I indicating the most fertile soils

project, described in Chapter 3, were even going to more villages than those required by the project. They appreciated the benefits of the project so much that they wanted other poor women to get the same benefits. Solidarity and a desire to serve the community are often the motivation for farmer-to-farmer extension.

Farmer extension agents should be willing to work in their own or a neighbouring village to develop a village map and soil fertility management packages. During the last year of the project (2003-2004), we trained 212 farmer extension agents who were selected for their educational level, leadership ability, and enthusiasm.



Young, illiterate farmers also emerged as excellent extension agents, being able to mobilise poor farmers quickly. "I can't read," admits 18-year-old Ramiz Ali from Mirzapur, "but I have many good friends in my village and they help me to write and read whenever I organise a group meeting."

As AAS implemented six PETRRA sub-projects on seed, fertiliser and crop management in northeastern Bangladesh, many farmers had already received training on various topics. Especially when seed producers under Farmseed (see Chapter 18) were trained to become farmer extension agents, they became increasingly recognised as a reliable source of quality seed and agricultural knowledge. The principle of reducing transaction costs by combining multiple services by the same people is further discussed in the final chapter of this volume.

### Train extension agents

All farmer extension agents received a two-day training in the AAS office, in which the first day dealt with soil fertility and the second day with the actual extension method. During their first attempt to prepare a village map, the project staff supported these new extension agents.

Training becomes easier once farmer-extensionists have undergone the whole process in their own village. By organising training-of-trainer courses, an exponential growth in number of villages trained can be achieved.

Later on in the project, DAE block supervisors were also trained. This time the training had to convince people who were entirely new to the concept. The training was essential for institutionalising the method among the government's extension service, who have the country's greatest human resource. AAS developed a three-day curriculum, with experienced farmer extension agents as trainers. Classroom exercises

Farmer extension agents in Bondaue village learnt about soil fertility and helped the project by drawing soil maps in neighbouring villages. They also learnt other farmers to adjust their fertiliser application based on crop colour and growth. Once local suggestions for fertilisation were validated, they kept on visiting farmers about once a month, often in the teashop.



were supplemented by village group discussions and drawing soil fertility maps.

### Form farmer groups

As they are poor themselves, farmer extension agents face few problems in selecting and motivating other poor participants in their own or neighbouring village. In general, the project selected farmers with less than eight months of rice provision ability. For block supervisors it may be more difficult to keep away the wealthier farmers, who hire labour instead of working the land, and who inhibit poor farmers from speaking up.

Each group, should consist of about 20 real farmers, who plough the land and know it intimately. Women farmers should be included in the group if possible.

### Visualise local knowledge

"Visualisation is key to learning and is very useful in group decision-making, especially when farmers are illiterate," says Ranadhir Datta, one of the first farmer extension agents. A good map can indeed explain a lot, and when developed by farmers it creates pride and ownership.

Village soil fertility maps have to show village borders, main roads, rivers and crop fields. Different fields need to be identified and named with their local place names on the map by participating farmers, who then identify the most fertile fields and mark these as fertility grade I, the next as fertility grade II and the least fertile fields as grade III or higher.

Village soil fertility map drawn by farmers and extension agents.



### Elicit farmers' own terms for soil

In the future, it would be interesting to elicit farmers' own terms for soil, e.g. black soil, sandy soil, asking them to rank these ethno-soil types by fertility, test them, make broad ranges of recommendations. These local categories of soil would have to be measured periodically, since they may vary somewhat geographically, but extensionists could then suggest other farmers "apply between such-and-such in black soil, so much in sandy soil" (see also Box 8.2).

Of course, unravelling local terms is easier said than done. In his book *Indigenous Knowledge Development in Bangladesh*, Paul Sillitoe (2000) mentions several characteristics farmers use to describe soil. Farmers talk about *jore* or strength of a soil. Strong soils give good yields, but 'strength' is complex and is influenced by several pedological factors. Folk terms may have several related meanings. For example, farmers talk about *ras* or what is left behind after flood waters recede. But *ras* also comes from rain



and groundwater. For some farmers *ras* means soil moisture, for others what is taken up by plants. A soil that expresses the benefit of organic matter has *quyat*, which is not visible but adds to the *jore*, the 'strength' or fertility of the soil.

### Explore ways of improving local practices

For each fertility grade, we identified the farmer's soil fertility management practice that gave the best yield, recorded the other farmers' practices and discussed the yield difference with them.

In Chiapas, southern Mexico, researchers found that smallholder farmers had their own names for five local soil types: *tierra negra* (black earth), *tierra baya* (yellowish white earth), *tierra colorada* (red earth), *tierra colorada arenosa* (red sandy earth), and *tierra cascajosa* (earth that resembles subsoil or exposed bedrock). Researchers sampled 104 fields. An analysis of variance using the soil classes as the grouping factor indicated that farmers' soil taxonomy discriminated among the objective properties in the soil (organic matter, pH, % sand, % clay) and that objective properties were consistent with farmers' perceptions. However, ethno-soil names and their physical properties vary from village to village, and researchers must check them anew in each community where they work.

Source: Adapted from Bellon (2001)

Box 8.2  
Mexican  
Smallholders  
also  
Understand  
Soil

Through group consensus building, an optimum soil fertility management package for each fertility grade and each season is developed. In each grade, a collaborating farmer tries the recommendation in a whole field (about 0.1 to 0.2 ha), adjusts applications based on crop colour and growth, and the group compares the results with three neighbouring farmers' fields. After harvesting the crop, the recommendation for each soil fertility grade is discussed and fine-tuned in a village workshop.

In three years, we conducted 1,177 field trials of which about 1,000 were led by farmer extension agents. Many of the farmers who were initially reluctant to apply phosphorous, potassium and sulphur to their rice field, became motivated by observing farmer-led demonstration plots.

### Share findings with wider farming community

While fine-tuning the fertiliser recommendations in the village workshop, farmers get motivated by their peers. With the map, each family can see to which fertility grades each of their plots belong, and how to apply plot-specific fertilisers.

Later, we helped farmers summarise the recommendations and copy the soil maps onto an A4-sheet, and make ten photocopies for the village.

Chatting with farmers, we came up with some ideas for improving the method. Farmers often discuss political, social and agriculture-related issues with their colleagues in the village teashop. "As I often go to Kashipur village, about 1 km from

my home, and discuss with other farmers in the teashop, it would be very good to have a copy of their village soil fertility map in there," said Nonishil, a farmer extension agent from Nischintapur who visits his extension village each month. This idea was suggested by one of the authors (Harun-Ar-Rashid) and Nonishil immediately agreed. Later on, we thought of giving laminated village soil maps with fertiliser recommendations to local fertiliser retailers, to display in their shops.

### Create incentives for farmer extension agents

Training and capacity building are the initial incentives for farmer extension agents, while later increased social recognition becomes more important. However, recognition by peers is harder to achieve for farmer extension agents who work in a neighbouring village. Nonishil stressed that his social recognition would be enhanced by writing his name and address on the village map that is displayed in the teashop of his extension village. In this way, everybody would know him and know where to seek advice. Despite this, farmer extension agents would need a financial incentive to initiate activities in new villages.

If all farmer extension agents could be trained as seed producers, they could also use their enhanced social standing to make a bit of money, by selling quality seed, as is already taking place in those villages where AAS trained farmer seed producers.

Getting the balance right. By observing farmer-led demonstration plots in Northeast Bangladesh, many farmers started to apply phosphorous, potassium and sulphur to their rice field, not just urea. In more lowland areas, characterised by excessive fertiliser use, experiments led to reduced inputs.

### KEYS FOR SUCCESS

Farmers learnt to better observe their crop to assess crop fertiliser requirements. These acquired skills also helped them to monitor soil fertility over time.

Preparing village soil fertility maps with poor farmers created great confidence among them and scientists. This was further enhanced when we realised that their knowledge of soil fertility was confirmed by laboratory tests and the results of field experiments. Their confidence got another boost when, in a village workshop, they presented their soil fertility maps, yield data of their experimental plots, and fertiliser advice in front of researchers, DAE and NGO staff, and private sector input suppliers.

Pride, social recognition, the desire to escape poverty, and solidarity make this farmer-to-farmer extension work. Poor farmers more readily accept new information from their peers, working as extension agents.



Block supervisors can gain a lot of credit from the community by listening to them and building on their local knowledge. Training block supervisors through hands-on exercises helps to institutionalise this innovative approach in DAE. Block supervisors can easily apply this method if they collaborate with farmers who work the land and know the 'language of their soil'. With these local experts, and by building on previous experiments and topographical similarities, soil tests are not needed in each new village.

## DIFFICULTIES, RISKS AND ASSUMPTIONS

Initially, the participatory experiments were divided into two plots, one that followed the farmer's practice and the other with the suggestions based on the soil samples and consensus building exercise. Some farmers took it as a competition and started adding extra fertiliser to their 'farmer' plot, masking potential impact of the experiment. From then onwards, we decided to have a whole field under improved practice and compare this with neighbouring fields of non-participating farmers. So non-participants became part of the experiment without knowing it.

It is an important lesson. As Graham Thiele and colleagues point out, a farmer field school or any other method should not try to force through a pre-determined result (Thiele et al., 2001). Because the researcher's technology may not always 'win', especially if farmers treat the experiment like a contest, and stack the deck in their own favour.

We believe that those farmer extension agents who have been equally trained as seed producers have a vested interest in providing multiple services to the community. Others will need a small stipend in future to keep up the motivation to train new villages, organise meetings and field days, and monitor field activities.

## SCALING UP

In Habiganj and Moulvibazar districts in northeastern Bangladesh, up to 4,000 poor farmers are now applying balanced doses of nutrients in 216 villages.

After attending a farmers' workshop, the Integrated Crop Management sub-project under PETRRA started preparing village soil fertility maps in Kurigram district in northwestern Bangladesh. Although the method was developed in piedmont soils, it can be replicated in any soil type after initial backstopping by soil tests.

Nationwide adoption of the method will depend largely on the understanding of the method and acceptance by the senior DAE management. Many DAE block supervisors, upazila and district level officials already appreciate this new approach and have implemented it in 19 more villages in Srimongal and Habiganj districts. Potentially, each block supervisor, once trained by AAS and BRRI, could supervise 10-



How green is green? Integrating village soil fertility maps with other visual tools such as the leaf colour chart would further improve accuracy of timing and reduce dosage of fertiliser applications. In some villages, AAS initiated both approaches side-by-side and farmers are eagerly observing each others' experiments.

15 farmer extension agents, to act as local group coordinators and resource persons.

After the training course organised for block supervisors, one of them said: "Poor farmers rarely adopt our fertiliser recommendations, so it is very important for us to learn this new method. With some initial training, it is not so difficult to do and the maps can be drawn in a new village within only two to three hours. Once recommendations are known for a given village, only one trial in each fertility grade is needed to validate or fine-tune them in neighbouring villages."

When asked how the new method could benefit national agencies, Mr. Ferdous from AAS said: "At the national level a lot of money can be saved and soil testing can become more accurate if use is made of participatory soil fertility mapping." The soil testing service provided at national level by the Soil Resource Development Institute, the National Agricultural Research Services, and some NGOs have gone to a great effort to make site-specific fertiliser recommendations, but they can reach only a few farms. Both for logistic and technical reasons Hugh Brammer, long-term

soil expert in Bangladesh, also invariably advises against the use of soil test kits and suggests to rely on simple fertiliser trials in farmers' fields (Brammer, 2002).

The methods described in this chapter add to a number of other methods being tested across the world, and after having read this case study, scientists from the International Centre of Tropical Agriculture (CIAT) expressed their intention to explore its potential for scaling-up site-specific soil fertility management in East Africa (Vanlauwe, personal communication).

## CONCLUSION

Soil fertility knowledge and management is determined by a complex set of ecological dynamics, socio-cultural factors, institutional arrangements and policies of various sorts (Kerven et al., 1995; Scoones, 2001; Brammer, 2002). Responding to the non-adoption of blue-print recommendations by farmers, Defoer and Budelman (2000) compiled a resource guide for participatory learning and action research on soil fertility in the tropics. But the senior author of this work also admitted that resource flow maps and nutrient balance calculations are complex, and as such limiting their scope for being scaled up (Defoer, 2000). The general lack of ready to use methods for teaching many beneficiaries about soil fertility management was further emphasised by Snapp and Heong (2003).

The adaptive method described in this chapter builds on farmers' soil fertility knowledge to grade soils, and is relatively simple and easy to learn. Farmers draw a village soil fertility map as a starting point to develop and test improved locally-specific fertiliser guidelines. Farmer extension agents help other farmers to understand the recommendations, to test these in their own fields and modify them if needed.

The method also offers the government extension system a great opportunity to appreciate local knowledge more. Coordinated by DAE staff, farmer extension agents may work on many topics and increase the overall impact at the community level.

## REFERENCES

- Bellon, M. R. (2001) *Participatory Research Methods for Technology Evaluation: A Manual for Scientists Working with Farmers*. CIMMYT, Mexico DF.
- Brammer, H. (2002) *How to Help Small Farmers in Bangladesh*. The University Press Limited, Dhaka.
- Defoer, T. (2000) *Methodology on the move: case studies from Mali and Kenya on methodology development for improved soil fertility management*. In: Guijt, I., Berdegue, J. A., Loevinsohn, M. and Hall, F. (eds) *Deepening the Basis of Rural Resource Management*. RIMISP and ISNAR, 56-72.
- Defoer, T. and Budelman, A. (eds) (2000) *Managing Soil Fertility in the Tropics. A Resource Guide for Participatory Learning and Action Research*. Royal Tropical Institute (KIT), Amsterdam.
- Gupta, A. K. and IDS Workshop (1989) *Maps drawn by farmers and extensionists*. In: Chambers, R., Pacey, A. and Thrupp, L. A. (eds) *Farmer First. Farmer Innovation and Agricultural Research*. Intermediate Technology Publications, London, pp. 86-92.
- Kanté, S. and Defoer, T. (1994) *How farmers classify and manage their land*. IIED Issue Paper 51
- Kerven, C., Dolva, H. and Renna, R. (1995) *Indigenous soil classification systems in northern Zambia*. In: Warren, D. M., Slikkerveer, L. J. and Brokensha, D. (eds) *The Cultural Dimension of Development: Indigenous Knowledge Systems*. Intermediate Technology Publications, London, pp. 82-87.
- Murage, E. W., Karanja, N. K., Smithson, P. C. and Woomer, P. L. (2000) *Diagnostic indicators of soil quality in productive and non-productive smallholders' fields of Kenya's Central Highlands*. *Agriculture, Ecosystems & Environment* 79, pp. 1-8.
- Saleque, M. A. (2004) *An alternative method of soil phosphorus analysis for rice growing acid soils*. BRRRI Seminar Paper, April 1 2004. Gazipur, Bangladesh.

- Scoones, I. (ed.) (2001) *Dynamics and Diversity: Soil Fertility and Farming Livelihoods in Africa*. Earthscan Publications, London.
- Sillitoe, P. (2000) *Cultivating indigenous knowledge on Bangladesh soil: An essay in definition*. In: Sillitoe, P. (ed) *Indigenous Knowledge Development in Bangladesh. Present and Future*. Intermediate Technology Publications, London, pp. 145-160.
- Snapp, S. and Heong, K. L. (2003) *Scaling up and out*. In: Pound, B., Snapp, S., McDougall, C. and Braun, A. (eds) *Managing Natural Resources for Sustainable Livelihoods: Uniting Science and Participation*. Earthscan Publications, London, pp. 67-87.
- Thiele, G., Nelson, R., Ortiz, O. and Sherwood, S. (2001) *Participatory research and training: Ten lessons from the farmer field schools (FFS) in the Andes*. *Currents* 27, pp. 4-11.

<sup>1</sup>The partner organisations involved in this study were Mac Bangladesh, Prantik, Nishchitapur Krishak Samabai Samity (NKSS), Uttar Varaura Bahumukhi Krishok Samabay Samity (UVBKSS), Association for Socio- Economic Development (ASED), Social welfare Advancement Brilliant Association (SABA), Pragoti Samaj Unnayan Sangstha (PSUS), Madhabpur Bahumukhi Nari Mukti Sangstha (MBNMS), Bahubal Agrani Samaj-Kalyan Sangstha (BASS), Bangladesh Association For Social Advancement (BASA), Rural Agriculture and Social Development of Bangladesh (RASD) and Manab Kalyan Sangstha (MKS).