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Cover photograph:

Group of farmers in Piusilla, Bolivia, conducting crossings of potato germplasm. (Photo by Jaime Herbas.)

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Technical and Institutional Issues in Participatory Plant Breeding–Done from a Perspective of Farmer Plant Breeding

A Global Analysis of Issues and of Current Experience

PPB Monograph No. 2

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Contents

List of Tables and Boxes

Preface

The participation of farmers, especially women, in technology development is vital for achieving impact that benefits poor people. Household food security, and especially the well being of children in poor countries, is vitally affected by women's access to technology appropriate for their needs. This is why the CGIAR system has decided to strengthen, consolidate, and mainstream its participatory research and gender analysis in a high-priority, high-visibility program that recognizes farmer participation as an important strategic research issue, the Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (the PRGA Program).

The program's goal is to improve the ability of the CGIAR System and other collaborating institutions to develop technology which alleviates poverty, improves food security and protects the environment with greater equity. This goal will be accomplished through collaborative research to assess and develop methodologies and organizational innovations for gender-sensitive participatory research. The Program's overall strategy is to introduce and strengthen the appropriate use of PRGA approaches and methods in the CGIAR and partners' core research areas.

The Program focuses on participatory action research approaches to technology development and institutional innovation. Action research is defined as research conducted via hands on involvement in processes of developing technologies or institutional innovations, in contrast to only studying or documenting this development. Priority is given to two main thrusts: (1) participation of farmers and in particular rural women in **formal-led research**, and (2) participation of professional scientists in **farmer-led research**.

Over the last decade or more, substantial work has been done to introduce a user perspective into adaptive research. Recent evidence suggests that user participation can be critical in the **pre-adaptive** stages of certain types of research, when it brings users into the early stages of technology development as researchers and decision makers, who help set priorities, define criteria for success, and determine when an innovation is “ready” for release. This new role changes the division of labor between farmers and scientists, and may dramatically reduce the cost of applied research. We have some evidence that this novel approach can significantly improve the impact of research for poor farmers, especially women. However, evidence is patchy and it is not well understood how to replicate success on a large scale. A key contribution of this program is to develop clear guidelines on how to achieve this, and build capacity to operationalize novel approaches in practice.

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Executive Summary

Participatory Plant Breeding (PPB) denotes a range of approaches that involve users more closely in crop development or seed supply. For different perspectives in agriculture and development, which seek to improve crop development, conserve biodiversity, or empower farmers, PPB is seen to show much promise. This report considers work which seeks to support farmers' own systems of crop development and seed exchange (farmer-led PPB) in light of these different goals, and of the perspectives of the range of organisations promoting PPB. It presents an overview of farmer-breeding and a framework for support, and gives the first major comparative analysis of farmer-led PPB.

PPB is considered to have potential in situations where formal breeding and seed supply systems are unable to fulfil the needs of all users. Marginal areas are commonly mentioned, but in fact decentralisation may be valuable for any situation where the environment (agroecological and socio-economic) for crop growth and use is highly variable, or differs significantly from those anticipated and tested by formal breeding. Such variation also exists in high-potential areas where farmers and users want to pursue different options than those currently on offer. PPB is also seen to be valuable for 'minor crops', or in situations of dramatic change or crisis, where formal systems are not involved or not functioning. Finally, where formal seed systems fail to supply planting material on time, of suitable quality, at accessible prices, or of suitable diversity, farmers prefer their own sources (farm-saved seed, exchange, purchase), which still supply 80% of planting material each season: PPB can support and enhance this system.

This report broadly defines farmer-breeding to include both deliberate actions and those bound in farmers' practice, to consider collective as well as individual processes, and to include systems of seed storage and exchange. A review of current knowledge about farmer-breeding points to areas of similarity and difference from formal breeding. Farmers often bring a wider set of criteria to crop development than formal breeding. They also seek to balance maintenance with crop improvement, and local with broad adaptation, though details are sparse on the nature and success of such balances. Farmer-breeding can be considered as a series of processes for

managing gene flow, in parallel to formal breeding, which influence crop genetic structure and performance, as well as who receives germplasm and information. These processes include introduction of new diversity (and its testing), recombination, selection, storage, and exchange of planting material. Knowledge remains patchy on the biological and social impact of these processes. Farmers' actual interest in breeding may be supported by a range of socio-economic factors (failure of formal breeding, importance of crop, absence of policy barriers) as well as biological factors (visible diversity, self-pollination, environmental variation, experience with crop). As a social process, farmer-breeding and seed exchange involve particular groups differently, often giving roles particular to gender or wealth.

A framework, based on analysis of the case studies, outlines four broad approaches to support farmer-breeding.

1) Germplasm support to increase farmers' access to diversity can supply fixed or segregating lines and work with material with local or distant origins. Seed systems may also be directly supported.
2) Skills support in breeding, testing, or seed production can offer farmers new skills, or seek to extend best local practice.
3) Support in forming links may enhance the equity or sustainability of a PPB project, through helping establish two-way, flexible ties between individuals and institutions for germplasm or information.
4) Indirectsupportcouldconfrontbarrierstofarmer-breeding,orhel p promote it in other ways, such as market-development.

These approaches comprise a range of methodological options, with considerable implications for the ease of PPB and the nature of its impact.

The core of this report describes and analyses 11 case studies of projects that pioneer different aspects of farmer-led PPB. They represent activities in Africa, Asia, North and South America, initiated by institutions ranging from independent farmers' initiatives to the CGIAR, and involve crops from all breeding systems. PPB projects are active not just in marginal areas, but across a broad spread of agroecologies.

These cases address a range of goals, the most common being conservation and improvement of germplasm. Many of these cases also sought to expand farmers' crop options, though only a few cases made this a central goal, exclusive of interest in conservation. An additional goal in a number of cases was empowerment through promoting self-reliance. Finally, one case concentrated on helping post-disaster adjustment. Striking was the degree of overlap in most cases between crop conservation and development. Though goal-setting generally had local input, there was little discussion of this process or of problem diagnosis.

Choice of locations and methods for selection and evaluation reflected both the constraints of participants, and the type of information that was meaningful to them. Germplasm was a common approach, often combined with testing novel material and, in some cases, support to seed systems (usually community seed banks). Non-local germplasm was often Modern Varieties (MVs), though distant Farmer Varieties (FVs) were also introduced. Scale of collection was broadly related to organisation scale, with very local groups usually concentrating on local (but thorough) collection. Local seed storage generally seemed effective in the short-term, though there is scope for formal back-up.

Skills-development excited much enthusiasm, with external agents transferring new information, and extension of 'best practice' usually organised by farmers themselves. Similarly, when farmers initiated new links, it was generally with other farmers through informal networks. Links promoted by external agents could also be between farmers (through organising groups or workshops) or between farmers and formal institutions, usually over the transfer of germplasm. While valuable, impact from these approaches was difficult to assess, and more information on methods was needed. Focusing on basic issues and using flexible approaches appear to assist transfer of new skills to farmers.

Crop breeding system and division of labour are important issues for groups pursuing selection activities with farmers. Some cases confronted resource limitations, though they were able to address these by using local organisations to work collectively to isolate and select material. In training, farmers were taught modified selection methods based on mass selection, and generally appeared to grasp the principles. Testing methods, in selection or in germplasm screening, revealed different approaches between farmers and formal institutions, with farmer testing often on local, unreplicated plots. This raises the issue of variation in the ecological and socio-economic environment, which may affect particular users differently. Little is known of the quality of documentation in most cases, though it is one way to make germplasm and information more widely useful.

Impact on crop production generally appeared positive, with germplasm supply often expanding farmers' options significantly, overcoming bottlenecks, both biological and social, to diversity. Similarly, efforts in local storage and seed supply improved farmers' security of access to material. Impact on crop genetic development was less frequently quantified. Biodiversity appeared to be positively affected, though most cases lacked measures and baselines to confirm this. Furthermore, links between biodiversity, farmers' choices, and function are still poorly understood. Finally, cases offer useful indicators for empowerment, where farmers gain more control over seed supply and crop development, where roles may evolve to farmers, and where farmers may gain a critical awareness of research and policy arenas.

Users directly involved in PPB projects could be clustered into two broad profiles: experimenting farmers, and poorer, more seed-insecure farmers. The former profile correlated with more formal-sector projects aiming to introduce new germplasm or skills, while the latter often stemmed from local initiatives that worked on seed systems for security and diversity of access. Participants were self-selected, or in some cases, the community elected lead collaborators. Links with local institutions may in some cases help to reach broader groups of users. Despite an important role in farmer-breeding, direct involvement of women was often limited, though wealth/status of participants varied among cases. For both wealth and gender, targeting to particular groups, especially through consideration of special roles, may be one way to side-step barriers to participation. Some cases worked through farmers recognised as local experts, who may facilitate some activities, though broader consideration of their relationships to others, and roles in farmer-breeding may be needed. Technological approaches influence participation, including choice of species and testing site, and size/price of seed packets.

Farmer-led PPB involves different institutions, from social-movements to international research centres. Local groups of farmers were a common element, though little is known of internal structures of accountability within these groups, or their relationship with the surrounding community. Scale of activity was closely-linked to that of funding, which came through a variety of donor sources, though farmers supported most work themselves or through market sales. Some cases increased scale of impact through passing on tasks, such as training, to farmers as programmes evolved, or through linking to networks.

Particular types of institutions bring different strengths to farmer-led PPB, and complementary interactions show much promise in many areas, where local groups bring local knowledge and accountability, and more formal institutions offer technical support. However, such partnerships appear to be uncommon, or strained. This may be due to structural barriers to collaboration (policy and economics), or to barriers between the cultures of very different institutions, which undermines understanding and trust. Better collaboration may only come when these barriers and how to confront them are better understood.

Transfer of benefits between farmers could come through the exchange of germplasm or knowledge and skills. Though these processes occur among farmers already, projects tried to enhance exchange through workshops and other means to increase the visibility of new knowledge and materials to farmers. The nature of germplasm and information affects the ease and speed of transfer among farmers, while social relationships affect its pattern, though this aspect was usually not considered. Some cases also worked through formal systems to transfer benefits, though the limited reach of formal seed and extension systems, and perspectives hostile to farmers' practices and seed may limit scope for this. Finally, issues around Intellectual Property Rights (IPRs) need to be clarified, to establish where access and control over germplasm and information is vested, and who has rights to benefits. Current frameworks say nothing on material developed jointly between researchers and farmers' groups, or on collective systems of ownership. Openness and clarity on these issues are essential to maintain trust between institutions, and important for safeguarding rights to germplasm and benefits.

Major gaps in knowledge and practice in farmer-led PPB include:

- attention to 'minor crops', especially vegetables and regionally-important crops
- discussion and comparison of participatory methods, particularly those for diagnosing problems and setting goals, and for evaluating of progress
- discussion of training methods and topics for farmers in breeding and seed production
- involvement of National Agricultural Research Systems (NARS), including extension, in PPB
- collaboration between different types of institutions
- use of baselines and evaluations to assess impact
- development of indicators to measure impact for such goals as skills-development, biodiversity enhancement, strengthening links, and empowerment, and conceptual frameworks to analyse trade-offs between different goals
- attention to user differences in all areas, including goal-setting, methods, technologies, and overall impact
- explicit involvement of non-farmer users in PPB
- understanding, both historical and institutional, of the social movements that are initiating much PPB work
- for many, quantitative analysis of impact of different methods on crop genetic advance or biodiversity.

Suggestions for future work include:

- goals-setting which takes a broad consideration of supporting and limiting factors to farmer-breeding, such as the framework presented here
- more involvement of networks and organisations that work in a number of locations, enabling exchange of material and information, and scaling-up of work

- use and comparison of different methods for problem diagnosis, PPB support, and impact evaluation
- development and dissemination of materials on participatory training methods and breeding approaches
- more discussion of methods and approaches for establishing flexible, sustainable relationships between institutions
- process documentation of PPB efforts, especially for participatory methods, discussing decisions taken, and describing both successes and challenges encountered
- local or regional workshops or meetings among farmers to exchange experience
- encouragement and support to involve state-level research and seed supply systems, and help them to institutionalise PPB in their policies and practice
- more effort to understand barriers to institutional involvement and interaction, especially differences in institutional culture
- particular attention to policy, especially seed policy and IPRs; on an international and regional level, drafting model legislation and developing 'best practice' models
- consideration of other research on biodiversity which gives insight into the relation between diversity and performance, and which develops frameworks for farmers' decision-making around diversity more study of the farmers' intentions, practice, and impact in various processes of farmer-breeding, including introduction, recombination, selection, storage, and exchange.

1. Introduction

Perspectives on PPB

Recent years have witnessed an explosion of interest in participatory plant breeding (PPB). While some elements of this discussion are hardly new (e.g., Collins, 1914; Martin, 1936), and farmers' contributions to the development of formal breeding have been acknowledged elsewhere (Fowler, 1994; Kimmelmann, 1987)[1], the sustained international discussion of PPB has been quite recent (e.g., Sperling and Loevinsohn, 1996; Eyzaguirre and Iwanaga, 1996a). PPB has also become a central theme of international research and development programmes that focus on NGOs, NARS, or the CGIAR (CBDC, 1994; IPGRI, 1996a; SWP/PRGA, 1997).

In part, PPB's wide appeal stems from its resonance with current concerns in agriculture and development. Broadly, contemporary interest reflects three perspectives:

- improving the effectiveness of crop development and its reach of users
- supporting conservation and use of crop genetic diversity
- contributing to empowerment of farmers and other actors.

PPB may address limitations in formal, centralised breeding, by developing materials better adapted to farmers' local environmental conditions (Ceccarelli et al., 1994), or by giving attention to traits farmers value other than yield, such as maturity time, or market quality requirements (Kornegay et al., 1996). So-called 'minor crops' (cf. National Research Council, 1996) may also be better served by PPB. Similarly, *ex situ* conservation of crop genetic resources (FAO, 1996) also has limitations. Here, PPB could help on-farm conservation strategies, by 'adding value' to local diversity, enhancing its chances for local maintenance (Voss, 1996). Furthermore, farmers' management may be an evolutionarily important source of variation

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1. Formal breeders attention to and support of farmer selection is not limited to the USA. For a broader discussion of colonial science learning from farmers' practice, see Richards, 1985.

and continued adaptation (Eyzaguirre and Iwanaga, 1996b). Thirdly, PPB may have social justice effects, where needs, especially those of women and poorer users, receive more explicit attention. Empowerment may come through devolving choice and decision-making power from the agricultural research system to clients, or through enhancing farmers' own capacities in crop development. This empowerment perspective has been linked to expanding social movement activity in germplasm-related issues (Berg, 1996a). Though some movements do arise in 'marginal areas'[2], others occur in 'core' Green Revolution areas (Basillio, 1996) and in the North (Jongerden and Ruivenkamp, 1996). All, however, seek more control of crop development and seed supply to pursue different futures than those currently on offer.

These perspectives are not mutually-exclusive, but do indicate different hypotheses about the place of PPB, and suggest different programme objectives. Breeding is a major part of agricultural research[3], seen as valuable in poverty and hunger alleviation (Lipton, 1989), but it is also embedded in broader debates about impact in equity and genetic diversity. PPB includes these debates, and others, such as the relationship between farmers' and technical knowledge, access and ownership of genetic resources (RAFI, 1996) (reflecting that subject's very political history; Pistorius, 1997), and institutional relationships in agricultural research (Farrington, Bebbington et al., 1993). Though the technical and institutional issues in supporting farmer-breeding are at the core of this analysis, and are far from simple (Ashby and Sperling, 1995), we will point to some of these broader debates in our discussion.

Overview of Report

Two general approaches can be observed with PPB: when farmers join a formal-initiated process of crop breeding or seed supply ('formal-led PPB'), and when external agents seek to support farmers' own systems of crop development ('farmer-led PPB'). To date, much of our written knowledge of PPB come from the former approach. Though formal-led initiatives are important, and specifically addressed in a forthcoming report (Weltzien et al., 2003), this report focuses specifically on farmer-led PPB, as farmers' own breeding remains an important process in many areas and crops, for reasons outlined below.

We take a broad perspective on farmer-breeding and farmer-led PPB. We distinguish it from other farmer activity and innovation in

2. What is meant by marginal areas, and their potential impact on PPB and farmer-breeding is discussed more below.
3. For example, breeding occupies 65% of Ethiopian agricultural research spending (Institute of Agriculture Research, unpublished document).

crop development by local organisation and (frequently) by supporting links to institutions or external actors (scientists, development workers). Formal- and farmer-led approaches represent a continuum of options, distinguished by the degree that processes and institutional links are based in farmer, rather than formal institutions.[4] Understanding of farmer-breeding and genetic resource management remains patchy, and there is little systematic analysis of how best to support these systems (Franzen et al., 1996). As the first major comparative analysis of cases in farmer-led PPB, this report is an initial contribution to such an analysis.

The rest of the introduction briefly presents methods, and then explores some of the reasons why farmer breeding itself is an important force to be supported. Some issues of terminology are explored, to frame the rest of the paper. Chapter 2 gives an analytical overview of the current state of understanding of farmer breeding, while Chapter 3 presents a framework of diverse ways to support farmer-breeding, based on farmer-led PPB cases outlined here in Chapter 4. Chapter 5 enters into a comparative technical and institutional discussion of these examples, in light of the framework. Finally, Chapter 6 explores principal gaps in understanding, highlighting promising areas for further work and inquiry.

Methodology of Report

This report examines 11 pioneering cases that touch on some aspects of farmer-led PPB. While the authors conducted no original field work for this report, we had direct contact with many of those involved in the projects presented in Chapter 4. We identified cases and sources of information via extensive searches through published and unpublished documents (especially project evaluations) and queries to many newsletters and electronic discussion groups in related fields (e.g., ethnobotany, farming systems research, *in situ* conservation). Those chosen for in-depth study reflected the availability of information during the period of this consultancy. Farmer-led PPB is a new area, and few projects as yet refer to it as a central focus: other cases were also included, whose actions revealed important aspects of or insights into PPB. Though not exhaustive, the cases broadly represent the range of institutions, regions, crop types, and approaches to PPB currently found. E-mail discussions with a widely-dispersed and knowledgeable group, many of which are practitioners, were critical in identifying information sources and in commenting on our interpretations.

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4. As will be clear below, 'formal' and 'informal/farmer' make a distinction of institutions and modes of organisation, not necessarily of methods or approaches.

Importance of Farmer-Breeding

At least 80% of planting material each season comes from farmers' seed systems: farm-saved seed and local channels of gift, barter, and purchase (Cooper and Cromwell, 1994; Rabobank, 1994). Though the ratio of 'formal' to 'farmer' seed systems will certainly change (and this is not the place to debate how, or in what degree it **should** change) we argue that farmer-breeding, in the broad sense (defined in Chapter 2) will remain important. This is because formal breeding and seed[5] supply systems may not always meet the needs and preferences of farmers or other users. Some of the continuing challenges for centralised breeding are outlined below.

Breeding for variable environments: agroecology

Classically, formal breeders seek wide adaptation to maximise impact, minimising genotype-by-environment (GxE) interactions (Kang, 1990). This works best where ecological conditions are reasonably uniform, or optimised through management or inputs. However, many areas are highly variable in space or time, or have low input use, because other constraints restrict access to inputs or render their use uneconomic. These areas relate closely to the unfavourable farming regions described below. Input use may be low in favourable regions as well, especially among poorer farmers. This group appears to be expanding, as pricing changes, the declining impact of inputs, or rising environmental concerns move farmers towards lower input or organic approaches (Berg, 1996a). For all of these cases, GxE will have to be exploited, not minimised.

Crop varieties do not always perform well in all ecologies: genetic correlation may be low or negative, meaning that useful genes in good environments may have little value, or even be counter-productive in poor ones (Atlin, 1997; Ceccarelli et al., 1994). Compared to favourable environments, different varieties (including farmers' varieties, FVs) often excel in the worst conditions, an example of GxE 'crossover' (Ceccarelli et al., 1991).

Breeding for local adaptation is hardly simple (Ceccarelli, 1994; Simmonds, 1991): decentralisation to multiple testing sites is one approach (also pursued by some formal-led PPB projects). Difficult environments, however, may present multiple stresses. For barley, Ceccarelli et al. (1991) show that no single set of traits resists all the stresses a particularly difficult site can present, and argue that yield stability requires a population of varieties with different traits, an

5. We use 'seed' in this report to refer not just to botanical seed, but also to propagation material in general, thus tubers, grafts, and cuttings.

approach echoing wild plant ecology (Tillman, 1996). Diverse niches and varying environments challenge the ability of formal breeding to supply all the varieties that farmers need, for reasons of cost alone, and complementary or alternative strategies should be systematically explored. Farmer-breeding could potentially help in the development of a diverse range of materials.

Breeding for variable environments: socio-economic conditions

Uses and preferences are part of the 'social environment' and may also vary considerably with other factors. Farmers often have complex and varying sets of criteria for varieties to meet beyond yield, including maturity time, management needs, and quality for multiple end-uses. While some authors suggest that market involvement will reduce this set by substituting purchased inputs (Bellón, 1996a), the number of criteria could as easily increase for the growing numbers of farmers involved in specialised or niche markets in the North (Jongerden and Ruivenkamp, 1996) or the South (Berg, 1996a). Again farmers, and other users, may be better-placed than formal breeders at assessing these criteria.

Seed supply

Formal seed supply systems also have limited impact, particularly in unfavourable areas. For seed delivery, timing, quality, or limited choice often constrain use, especially for farmers distant from centralised seed production centres (Cromwell and Tripp, 1994). Fixed packet size and cash requirements may be a barrier for purchase, particularly for poorer farmers. Finally, formal seed certification requirements, especially uniformity, may not fit well with farmer systems that work with (and select among) diverse varieties (Tripp, 1997).

Thus, formal seed production in many places is a classic example of market failure (Cromwell et al., 1993). Though farmer demand has occasionally supported commercial supply (e.g., Pray et al., 1991, for sorghum in India), this has not been cost-effective for many crops. In a study of four African countries, Cromwell (1996) found seed enterprises sought economic efficiency by focusing on hybrid maize at the expense of less profitable vegetable and bean seeds, thus limiting choice. Formal-led initiatives working with farmers in decentralised multiplication have generally tried to imitate formal seed industry practices (roguing, cleaning), and have faced similar economic challenges (e.g., Seboka and Deressa, forthcoming).

In contrast, informal seed systems are often rapid and effective (Green, 1987), and more resilient than formal ones to short-term disruptions (Sperling, n.d.), though perhaps not with longer-term disasters (Richards, Ruivenkamp et al., 1997). While informal systems face their own limitations (e.g., geographical range, access to novel germplasm), their importance is unlikely to wane in the near future, in light of declining formal supply (Srivastava and Jaffee, 1993) and the increasing recognition of their potential in integrated seed supply (van Amstel et al., 1996; Almekinders et al., 1994; David and Sperling, n.d.).

Further reasons

Farmers manage many minor crop species exclusively, some of them significant in food security, like *Amaranthus* (Shiva et al., 1995). Also, farmer-breeding may assume greater importance when formal systems break down in crisis situations.

We stress that highlighting the challenges to formal breeding and seed supply systems does not negate the value of modern varieties (MVs) for many circumstances. There may be an unmet demand MV seeds (Cromwell, 1996), and even in unfavourable areas, farmers may overcome significant barriers to adopt new varieties or even cropping systems (Box 1). While some PPB proponents, especially those interested in conservation, refer to the **type** of germplasm involved, definitions of modern, farmer or traditional varieties pose difficulties (Box 2), and offer unclear implications for users and for biodiversity (see Box 3). Where possible, we specify where MV or FV material is being used. However, in this report, we place more emphasis on **processes** affecting germplasm, rather than on the **type** of germplasm itself, as this aspect is central to all social questions, and we feel we are on more solid ground, biologically. Boxes 1-3 raise some important conceptual issues associated with PPB and farmer-breeding.

Summary

In summary, we can begin to make a tentative indication of contexts where farmers' breeding and seed systems are important. Formal breeding programmes and seed supply systems may find it difficult and expensive to reach unfavourable and variable ecological and social environments. Farmer-breeding is also relevant in so-called favoured areas, where some farmers pursue paths different from those assumed by formal breeding programmes. In contexts of disaster or rapid change, formal systems may more vulnerable in some aspects than informal ones (see Sperling, 1997). For minor-crops, farmer-breeding is the main force available. These contexts are explored in the following chapters, following a summary of the areas of current understanding of farmer-breeding in Chapter 2.

Box 1

Issues of definition: marginality

The first two Boxes challenge dichotomous categories, such as marginal/favoured or traditional/modern. Their conceptualisation and use can vary greatly, and they risk over-polarising PPB discussions. Rather than completely discount their usefulness, these boxes simply point to areas of contradiction and make a plea for caution and clarity.

Categories of marginality such as “resource-poor farmers” (e.g., Chambers et al., 1989), or “complex, diverse, and risk-prone” (CDR) farming systems (Wellard et al., 1990) have wide currency in agricultural development discourse. These usually refer to areas with low or variable rainfall, hilly topographies, poor soils, and limited infrastructure. Typical CDR examples include the Andean region, semi-arid Africa, and tribal areas of Asia. Such categories have been used analytically in relation to farmer-breeding and seed systems (e.g., Cromwell et al., 1993).

Three salient points here reflect other rich debates:

1. Terminology. Almost all agriculture could in some way be described as complex, diverse and risky. Unambiguous definition is difficult, and masks considerable local diversity in marginal and non-marginal areas (Biggs and Farrington, 1991).

2. Context. Land is marginal if, under a given **management**, it cannot support production (cf. Bebbington et al., 1993). The ecological, economic, and political dimensions of marginality interact and often reinforce each other (Blaikie and Brookfield, 1987): a socially-marginal farmer may have little claim on resources, and because of her marginal economic situation, may have to put land to uses for which it is marginal. Thus marginality is, in part, structural.

3. Agency. Fortunately these conditions are not always fixed. Farmers can change land’s potential (Tiffen et al., 1994); these changes also occur in unfavourable areas, though perhaps more slowly (Goldman and Smith, 1995). These changes may be drive by population or factor prices (Boserup, 1965; Hayami and Ruttan, 1971), or endogenous social factors (van der Ploeg and van Dijk, 1995). Regardless of the theory, actors shape and change their own conditions of marginality.

Here, we use favourable/unfavourable to mainly refer to ecological potential for crop production.

Box 2

Issues of definition: types of varieties

In discussing farmer-breeding, it is sometimes tempting to describe practices, institutions, and planting material in terms such as 'traditional' or 'modern'. This can be useful where institutions are relatively distinct, as with seed supply systems (Almekinders et al., 1994*)*. However, as Tripp (1996) points out, distinctions between traditional (TVs) and modern varieties (MVs) tend to concentrate on a few aspects. In reality these identities become blurred, often usefully. For example, many successful MVs are actually pure line selections from local landraces (Richards, 1997). MVs are frequently incorporated as a component of farmers' mixtures (e.g., Scheidegger, 1993). Farmers may give special recognition to MVs that hybridise with local materials, such as 'criollo' maize in Mexico (Bellón and Brush, 1994), or come to consider MVs 'local', adopting them into the local genetic heritage (Smale et al., 1995**;** Budelman, 1983).

As with germplasm, so with systems themselves. Agricultural innovations originate from multiple sources (Biggs and Clay, 1981), and even Green Revolution technologies had local influences (Biggs and Farrington, 1990). Thus, to speak of purely 'traditional' or 'modern' systems runs the risk of blinding us to useful points of interaction that are central to farmer-led PPB (Cleveland and Murray, 1997) Though not ideal, farmer variety (FV) will be used here for materials not obviously from recent formal release. While we will continue using 'farmer' and 'formal' to denote the **institutions** (particularly for seed supply), we understand reality to involve various degrees of mixture.

Box 3

Issues of definition: biodiversity

Support for farmer-breeding is often linked to conservation, and PPB's impact on biodiversity is a key concern. However, simply establishing meaningful definitions and measurements of biodiversity, let alone a conservation strategy, is a formidable goal. Biological diversity can be considered at ecosystem, species, or genetic scales. For genetic diversity, many measurement techniques (e.g., morphology, molecular markers: Ayad et al., 1997; Patterson, 1996; Harper and Hawkesworth, 1994) or analytical outputs exist (e.g., allele frequency, heterozygosity). This array of approaches can reveal divergent patterns (Frankel et al., 1995).

Assessing impact of biodiversity changes is even more challenging. For all measures of diversity, including morphological characters, functional relationships to crop performance need to be established (Milligan et al., 1994). Beyond measurement, there are considerations of spatial and temporal scale; e.g., diversity, even with uniform crops, can be enhanced over time through replacement (Witcombe and Joshi, 1996; Heisey, 1990). Any statement of biodiversity change (or claim to its impact on performance), especially one that does not specify time, scale, and measurement approach, should be treated with caution.

2. Current State of Knowledge of Farmer-Breeding

An analytical literature on farmer-breeding is only now starting to appear. Much of our knowledge about farmer management comes from studies of changes at the varietal level (see Box 4). Inquiry into biological impacts has been more recent, and some of the most significant comparative work (e.g., CBDC, 1994; IPGRI, 1996a) is still underway at the time of writing. Thus, this presentation should be regarded as preliminary.

We define 'farmer breeding' broadly, as actions by farmers, which lead to desired phenotypic expression, and affect crop genotype (though this may or may not entail genetic change). With this we include seed systems. Two propositions further shape this:

1. While deliberate activities like farmers' seed selection are important, farmer breeding be embedded in (individual or collective) farmer-practice, through social processes or norms (e.g., seed exchange).
2. While farmers may use particular traits to identify varieties, many 'varieties' may be, genetically, an open frame (Louette, 1994; Boster, 1985), and there may be many ways that farmers manage and shape gene flow, which can affect the genetic structure of these varieties.

Below, we outline four aspects of farmer-breeding, starting with goals, followed by an overview of the processes of farmer-breeding.

Box 4

Varietal demographics

Some generalisations from varietal demographics, the presence/absence of varietal diversity on-farm will help ground the discussion (e.g., Dennis, 1987; Louette, 1994; Brush, 1995; Scheidegger, 1993; Richards, 1986; Bellón, 1996a). Adoption of MVs is rarely total or sudden, but partial and gradual (Feder et al., 1985), as farmers balance different requirements and limit risk. Thus, in many regions, MVs and FVs are both found in varying degrees on farm. Studies over time reveal a dynamic, changing system, where the most constant element is farmers' interest in exploring new material.

Thirdly, we present hypotheses of where farmer breeding might flourish, followed by a brief discussion of the institutional and social context for farmer-breeding.

Goals in Farmers' Breeding

As in all breeding, the starting goals matter greatly. Studies generally focus on three major aspects: the holistic nature of farmers' goals, whether these are to maintain or improve traits, and whether they seek local or broad adaptation.

Holistic nature

Farmers' goals in breeding are frequently described as more holistic than in formal breeding (e.g., Amanor et al., 1993). Their choices reflect a wide range of criteria, including yield-stability (Ellis, 1993), biomass production (Haugerud and Collinson, 1990), feed (Ceccarelli et al., 1996) or food palatability (Smale et al., 1995), other quality traits (Ashby et al., 1995), maturity time (Bunting and Pickersgill, 1996), or soil fertility (Bellón and Taylor, 1993), among many others. Some goals are not readily reduced to functional characteristics—"cultural ecology" may play a role (Orlove and Brush, 1996) where crop varieties help construct social identities, especially identities based upon indigenousness (Cleveland and Murray, 1997). The very range of traits farmers seek is a major causal factor in the varietal diversity in their fields (Teshome, 1996; Bellón, 1996a; Brush, 1995).

Formal-breeding may pursue similar goals, though it may approach them differently, as with yield-stability (Cleveland, n.d.). For example, formal breeding has tended to pursue vertical disease resistance at the expense of horizontal resistance (Simmonds, 1991a), a bias re-enforced by privatisation (McGuire, 1997). However, there may also be situations where farmers seek a narrow range of criteria, such as meeting strict market requirements (Kitch et al., n.d.; Zimmermann, 1996).

Maintenance vs. improvement

There has been considerable discussion as to whether farmer-breeding seeks primarily to maintain or to improve characters.[6] For example, farmers may seek to maintain varieties true-to-type, preserving desire traits within familiar varieties. In most situations, neither goal exists

6. For instance, this question was posed at a recent workshop "Towards a synthesis between crop conservation and development", in, Baarlo, the Netherlands, July 1997.

exclusively, and some argue that both are necessary in promoting landrace enhancement, for instance (Berg, 1996b; Worede, 1993). While farmers often seek out new variation, they may also be reluctant to discard material, especially when environmental conditions or genetic supply are uncertain (Richards, 1995). We still know little about farmers' attitudes to diversity and risk, especially in the context of change (Brush, 1995), and actual genetic outcomes of farmer management require much more study.

Local vs. broad adaptation

The scale for which farmers seek adaptation is equally complex and controversial. In formal breeding, direct selection in target environments may achieve better results in stressed or heterogeneous environments (Atlin, 1997; Ceccarelli et al., 1996; Atlin and Frey, 1989; Ceccarelli, 1987; Simmonds, 1984). However, there is continued debate around scale and impact: some raise concerns that over-emphasis on site-specific adaptation comes at the expense of broad adaptation (Wood and Lenné, 1997). In breeding, as with PPB, effort and impact bear much more critical attention.

References to farmer-breeding sometimes stress its continual, dynamic adaptation of FVs to local conditions (Worede and Mekbib, 1993), while some suggest that, because of management and genetic heterogeneity, adaptation over wider areas may also occur (Berg, 1996b; Hardon and de Boef, 1993). Farmers' intentions on scale of adaptation remain poorly-known, so we draw insights from practice. Cosmopolitan varieties (FV or MV) suggests that farmers can identify and disseminate varieties adapted to a broadly-dispersed environmental niche (Green, 1987; Dennis, 1987; Richards, 1986). Gene flow is important here: in the Andes, exchange and regeneration of potato planting material helps form a common, plastic gene-pool at the valley scale (Quiros et al., 1992), which may contribute to adaptation at that level (Zimmerer, 1991a; Zimmerer and Douches, 1991). Material with very local circulation may be quite distinct (Johannessen, 1982), but may lack the diversity to adapt to varied or changing conditions (Wood and Lenné, 1997). It is to this perspective of gene flow that we now turn.

Processes of Farmer-Breeding

We can draw parallels between farmer- and formal breeding, as a process of introducing, recombining, selecting, and conserving diversity. The presentation of separate processes is indicative: in reality, these stages are very **integrated**, and distinction among them is slightly artificial.

Introduction: bringing novel diversity to the farm

A basic process is the introduction of new varieties or species to a locality. Farmers have an important role in this by actively seeking or opportunistically including new material.

Many intercontinental exchanges involving farmers are largely unchronicled. For instance, the spread of cassava or maize from the New World to Africa (Wood and Lenné, 1992), or of rice and sorghum in the other direction, involved slaves and small farmers far more in transporting knowledge and material than colonial botanical agencies (see Vernon, 1993; Martin, 1936).

Variety turnover is rapid in farmer systems: the average Rwandan farmer sees and evaluates some 100 different bean varieties in her lifetime (Sperling et al., 1993). Richards (1995) found Sierra-Leonian farmers had substituted nearly half of their rice varieties over an 8-year period. New varieties come through diverse means: informal exchange, formal release, travelling merchants, 'theft' of lines from a research trial (e.g., Salazar, 1992; Maurya, 1989), as volunteer seedlings from neighbours' fields (Ferguson and Sprecher, 1987: one named such a variety "uninvited guest"), or even animal droppings (Richards, 1986). We know little of the relative significance of these sources of novelty, or how often novel materials are recognised and tested as such.

An historical understanding is also important. War, colonial borders, and formalised seed policy may greatly restrict gene flow (Richards, Ruivenkamp et al., 1997; van Oosterhout, 1996). However, in some cases colonial agriculture has stirred new material into local gene pools for farmers to select (Budelman, 1983). An understanding of how important sources of germplasm have changed over time is also important.

Recombination: generating new assortments

Like formal breeding, farmers generate new possibilities for selection through recombination. Again planned or opportunistic practices exploit, and sometimes direct, this process. The breeding system is obviously important here, affecting the distribution of genetic diversity and the ease and frequency of hybridisation.

Open-pollinated crops, such as maize and millet, cross readily, and typically show much variation within varieties or individual seed lots. Useful characters can be transferred between different types, as described by Worede (1993) for deliberate mixtures of *Brassica* in Ethiopia. However, 'genetic contamination' by unwanted characters can cause serious problems: Friis-Hansen (1987) demonstrated that cross-pollination from long-season maize MVs to faster FVs increased their maturity time, causing crop losses. In such cases, isolation of desired types is important: farmers do this both through temporal isolation of flowering time and through spatial isolation (though some lack sufficient land to do this, ibid.).

Self-pollinated crops (most cereals and grain legumes) produce reasonably uniform types, making selection—and the roguing of off-types—more straightforward. Management may mix varieties, deliberately or otherwise, and a low out-crossing rate can present new combinations for farmers to isolate and study (Martin and Adams, 1987), as with beans in East Africa (Ferguson and Sprecher, 1987; Voss, 1992). Richards (1986) notes that single panicle harvest and special attention to field margins help some West African rice farmers identify new crosses. Furthermore, while formal research has only recently crossed Asian and African rice, there is evidence that farmers in Sierra Leone have already isolated and disseminated such species hybrids (Richards, 1997).

Most vegetative crops will occasionally produce offspring from seed, thus allowing recombination. These may be passively included, as Johns and Keen (1986) found with potatoes in Bolivia. Enset (*Musa ensete*), southern Ethiopia's staple, flowers after seven years, though farmers rarely wait that long to harvest it (Habte-Wold et al., 1994). Shigeta (1990) found that farmers carefully tend any chance seedlings they find, knowing that they might acquire new types in this manner.

Introgression of genes from wild and weedy crop relatives into domesticated crops can be seen genetically over large geographical and evolutionary scales for some crops (e.g., Cui et al., 1996; de Oliveira et al., 1996) though the immediate level of importance for farmers is controversial. Some suggest that farmers encourage hybridisation by tolerating wild and weedy crop relatives in field margins (Worede and Mekbib, 1993) or by preserving wild areas (Dorm-Adzobu et al., 1991; Shigeta, 1990), and repeatedly backcross such hybrids into their crop population to 'refresh' it (Benz et al, 1990). However, the degree (e.g., Doebley et al., 1987), and value of introgression to farmers is still inconclusive (Wood and Lenné, 1997), and more study is sorely needed.

Selection

Selection of seed is a crucial process, though distinctions between human and natural selection can be overdrawn, as these interact (Salick, 1995). The strength of farmers' **cultures** of selection varies (see p.15), and is sometimes taken as an indicator of the local strength of farmer-breeding (Berg, 1996a), e.g., selection from threshing piles reflecting farmers' loss of interest in breeding (Brac de la Perrière, 1982). On the other hand, farmers may select based on observations of individual plants' progress through the season (Berg, 1992; 1993).

Farmers often identify local varieties through a 'folk taxonomy' (Berlin, 1992) which may correlate well with formal scientific taxonomic classification (Teshome et al., 1997), or may simply distinguish varieties for social use (Boster, 1985). Selection of varieties for true-to-type may help fix desired traits in the face of gene flow from different populations or varieties (Louette, 1994; Bellón and Brush, 1994), or help farmers identify new types, and assign new names for new combinations (Alemu and Sandford, 1994; Shigeta, 1990; Box, 1986; Boster, 1985). However, we still know very little about the actual impacts of farmers' selection, in part due to on-farm environmental variation. Closer study of farmers' selection, however, is beginning (CBDC, 1994; IPGRI, 1996a).

Storage of planting material

On-farm and local storage are significant sources for farmers' seed systems. Local methods may vary considerably within a community, especially where some use purchased inputs. Available evidence suggests that local storage limits large losses from harvest to planting (Janssen et al., 1992; Tetlay et al., 1990), though it remains difficult to draw general conclusions (Friis-Hansen, 1996). Farmers' storage systems can also experience significant losses, especially for large-seeds and humid regions (Cromwell et al., 1993).

Exchange of planting material

While seed exchange is important in the introduction and dissemination of genetic variation, it also must be understood as a **social** system. Gift-exchange relationships can be a means of constructing social ties (Brush et al., 1992; Box, 1986; Boster, 1985). Local exchange also has greater potential for accountability (and thus trust) than formal or commercial supply (Cromwell, 1996).

Certainly, local exchange has limitations. While small amounts of gene flow can theoretically blur distinctions between two separate populations (Lawrence and Marshall, 1997), farmer-exchange can be very local, cut off from other pools of diversity (Zimmerer and Douches, 1991; Tetlay et al., 1990). There are equity concerns if these networks exclude certain farmers. Studies of bean seed channels in the African Great Lakes region show that variety access differed quantitatively and qualitatively with wealth (David and Sperling, n.d.; Sperling, 1996b). Poor farmers who completely consume seed stocks may lack access to neighbour or family seed channels, with little choice but accept material and the terms of exchange available in the market. Wealthier farmers generally used markets to add particular varieties to their mixtures. Furthermore, the social fabric supporting seed systems may be among the main casualties of war or other social disruptions (Richards, Ruivenkamp et al., 1997). As with genetic bottlenecks, there clearly are also 'social bottlenecks' that are not well understood.

Context: Where Is Farmer-Breeding?

Farmer-led PPB aims to support and enhance farmer-breeding, or even restore a level of farmer control over breeding and seed supply. Levels of involvement, knowledge, and interest in modifying crops vary greatly among farmers, and this could influence PPB's direction, or even its chance of success. However, comparative study on the nature of farmers' **interest** in breeding is sparse. We advance several hypotheses about factors related to farmers' potential interest, based on theory and available information. These issues were first raised in the introductory discussion of challenges to formal breeding and seed supply. Now, we outline possible supporting contexts for farmer-breeding in more detail. Of course, the actual **effectiveness** depends as well on genetic diversity, environmental variation, knowledge, and skills, as discussed above.

Hypotheses

Where might we expect to see more interest in farmer-breeding? Hypotheses 1-3 refer to situations where formal breeding and seed supply systems may not reach farmers, while 4-6 address factors that may more generally support innovation.

1. Conditions of dramatic change, such as conflict or natural disaster. From the case studies in the next chapter, this includes REST and SOH.
2. Unfavourable regions, where MV seed may have little impact. REST, and PTA's activities in Northeast Brazil are examples of this.
3. Market failure, where farmers' isolation and/or poor infrastructure prevent MV seed or other inputs from reaching farmers in a cost-effective or timely manner.
4. When the crop (or farming in general) is economically important. Where farming is considered less economically-lucrative than other activities (e.g., labour migration), there may be less interest in innovation (Sumberg and Okali, 1997). Similarly, secondary crops may receive less attention than cash crops or staples: Honduran farmers actively select maize, but give little attention to selecting beans (L. Meitzner, pers. comm., 1997). Most cited cases worked with staple food crops, though CIAL and SAVE farmers displayed great interest in screening cash crops, peas and oil palm, respectively.
5. Wealth. Richer farmers have a wider margin for experimentation (Friis-Hansen, 1996), or simply can afford to cultivate full-time, when poorer farmers may need to allocate labour to other income-generating activities (Rice et al., 1997; Zimmerer, 1991b). However, poorer farmers could also be more interested in breeding, especially if they seek to avoid costly inputs, or have to adapt to poorer or more complex conditions. The wealthier village in the Guanxi case was able to organise selection and seed production;

for PTA or CONSERVE however, poorer farmers are more interested in innovating with FVs.

6. The absence of barriers. Institutional and policy factors can be barriers to farmer-breeding, especially restrictive seed policy (Tripp, 1997; Friis-Hansen, 1995; Zeleke, 1993).

Berg (1996a) stresses two important points about the re-emergence of farmer-breeding. Professionalisation of breeding is not a one-way path: farmers sometimes seek to (re-) establish their role over a process. Secondly, this can occur both in CDR areas, and in the heartland of industrial agriculture. Institutional and political barriers may mask a much wider interest in farmer breeding, both in the North and South.

Hypotheses 7-11 consider biological factors, especially of the crop itself:

7. Genetic diversity. Greater genetic diversity within a crop may offer more visible variation to manipulate and a greater potential response to selection, though the optimal **amount** of diversity is a point of debate. BBA or CONSERVE, for instance, work with considerable diversity.
8. Visibility of diversity to farmers. For instance, selecting among long-cycle (e.g., tree crops) or small-grained crops (e.g., teff) would be difficult, regardless of the variation.
9. Low rates of outcrossing. New and interesting individuals are easier to isolate and maintain in self-pollinated crops like rice than in cross-pollinated species like millet. Also, inter-population outcrossing is more likely to dilute gains from selection for the latter group (though greater genetic diversity could well offset this).
10. Highly variable agroecology, available resources, or crop uses. This may spur interest in seeking different types to fill specific niches (Bellón, 1996a). SAVE farmers were especially interested in filling ecological niches and the hungry season gap in food.
11. Long historical association with a crop. Long experience can lead to detailed folk-taxonomies and to many cultural uses (e.g., the Hoor in Ethiopia make 15 different foods from sorghum; Miyawaki, 1996), which may relate to greater knowledge/interest in breeding it. Long association often correlates with diversity (hyp. 7). Examples include CONSERVE, UPWARD, and BBA.

Most of these potential contexts are present to some degree in the case studies below. No project worked on tree crops, for instance (hyp. 8). Hypotheses interact: several PPB projects work with maize, an outbreeder, which, hyp. 9 suggests could be challenging. However, maize was the most important staple crop in these cases (hyp. 4), with a long history (hyp. 11) and considerable genetic diversity in each region (hyp. 7). The USDA, and to some extent SAVE and CIAL, provided farmers with new and unfamiliar crops (counter to hyp. 11), or tree-crops (counter to hyp. 8), but interest was high because these filled new niches (hyp. 10), or offered new market options (hyp. 4).

Context: Who Does Farmer-Breeding?

The processes described above are **social**, and may involve specific groups differently. Gender is a central factor, though not always well addressed in research and development (cf. Howard-Borjas and Wisseborn, 1997). Women often possess specific knowledge and skills in crop development (Bunning and Hill, 1996), and frequently are responsible for maintaining seeds and varieties (van Oosterhout, 1996). Women also have a key role in establishing selection criteria and in fostering the social relations around seed exchange. In many places they do the majority of cultivation. Doing an activity is not always coterminous with having control over it, however.

Status and wealth are also important distinctions, often overlapping with gender. Richer or poorer farmers may be more active in breeding, depending on the context, as mentioned above. However, better-off farmers are often seed sources for others (Cromwell, 1996; Green, 1987; Richards, 1986), while poorer or lower-status farmers may be isolated from access channels (Sperling, 1996b; Boster, 1986).

Studies sometimes portray farmer-breeding as essentially an individual activity, reflecting researchers' own methodological individualism, or perhaps echoing common perceptions about formal breeding[7]. However, community-level processes can be important, e.g., for shaping genetic flow through seed exchange (Louette, 1994). Associated knowledge, taxonomies, and use criteria are, to some extent, products of social interaction. Moreover, the **institutional** context shapes practices in breeding, whether formal or farmer. This can be seen in norms of planting, experimentation, exchange, and other actions that reflect cultural identity, as C. Longley (pers. comm., 1997) observed in the contrasting approaches that neighbouring ethnic groups take to rice selection in Sierra Leone. Collective identity may also be expressed through farmer-breeding in opposition to 'foreign' Green Revolution technologies (e.g., Shiva et al., 1995): some NGO work resonates with these strongly felt social and political identities. Furthermore, arguments supporting farmers' and communities' claims to Intellectual Property Rights (IPRs) on FVs hinge on understanding farmer breeding as a collective, community process (Cleveland and Murray, 1997; Brush, 1994). Thus, collective processes in farmer-breeding merit deeper attention.

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7. Formal breeding may also be more of a collective process than commonly portrayed. We concur with Cleveland (n.d.) that an ethnographic approach to studying formal breeding is sorely needed.

3. PPB to Support Farmer-Breeding: A Framework

This chapter presents a preliminary framework, developed from case studies, for describing and analysing different approaches to farmer-led PPB. We group these broadly as support in:

- germplasm
- skills
- forming new links
- indirect support

This list is presented in terms on factors that might constrain farmer-breeding. As such, any could be a starting point for stimulating farmer-breeding. A stakeholder diagnosis of the seed system could help prioritise possible approaches. Such a list will certainly be refined, and possibly expanded, with experience and with a richer understanding of farmer-breeding in context.

Germplasm Support

Farmers may have limited exposure or access to genetic variation, constraining their ability to attain their goals in crop development. We term germplasm support all efforts to increase available diversity, and draw two distinctions: between working with segregating or fixed lines, and with local or non-local material. Support to seed storage and exchange systems can also enhance available diversity.

Segregating vs. fixed

This has received considerable attention in PPB discussions. Witcombe et al. (1996) usefully distinguish between working with segregating or stable lines. They term work involving farmers in evaluating stable lines “participatory variety selection” (PVS), reserving “PPB” for work with still-segregating material. For PPB itself, they outline a continuum of methodological options for the division of labour, ranging from giving late- to early-generation material to farmers, to farmers making their own crosses. This continuum reflects self-pollinated crops, and does not apply as well to cross-pollinated or vegetative species. For simplicity, they recognise 'PPB' as a general term, an approach we follow[8].

The range of options between fixed and segregating lines also relates to the division of labour between farmers and breeders in screening, and multiplying (self-pollinated) materials. Furthermore, it has implications for the degree of local adaptation, the level of farmer skills required, the number of lines and farmers that can be involved, and the ease and speed of multiplication and dissemination. Thus it is an important factor in weighing trade-offs, in both formal- and farmer-led PPB approaches.

Local vs. non-local

Stable vs. segregating implies different stages of cultivar development in a formal seed system. However, the uniformity and stability usually required for formal release may not be necessary for **farmers'** seed systems. Local material (FV or MV) may be useful, but inaccessible to some farmers, due to social or economic barriers to its access, or simply because some local seed systems are fragile. For example, valuable support can come through re-supplying local material that had been lost, or through supporting particular groups in accessing local germplasm. Thus, we distinguish between segregating and non-segregating, as well as between local and non-local germplasm support.

Seed systems

The type of seed storage system may restrict the level of diversity available, especially material not immediately used. Also, absent or restrictive supply systems may prevent some farmers from accessing seed. Direct support to farmers' seed storage and exchange systems could be another way to enhance **access** to diversity. This support could be material, such as establishing community seed banks. However, much seed system support probably relates to skills or to building linkages. Both these approaches are introduced below.

Skills Support

Another approach with considerable potential is supporting farmers to develop their own skills in crossing, selection, or seed production.

8. Other terms have been employed: Plant selection and varietal choice by farmers: implications for Collaborative Plant Breeding, from biological and sociocultural perspectives. (Cleveland et al., 1998), Participatory Crop Improvement (Atlin, 1997), and Participatory Variety Selection (PVS), which Witcombe et al. (1996) employ to distinguish work with stabilised lines. For the sake of simplicity we use PPB as a general term.

Skills-development may be necessary when working with processes that are difficult or unfamiliar, such as segregating materials or new crops. This can take two broad starting points. One recognises that some farmers may have exceptional knowledge and skills that are unknown or unappreciated by others. Support here seeks horizontal extension of 'best practice' among farmers, making it more widely known.

A second approach seeks to develop skills in "what farmers don't know" (Bentley, 1989) about crop development. Examples include how to select for heritable traits, promote crossing, or isolate outcrossing varieties. A practical understanding of basic processes can spur a burst of innovation among farmers.

Support in Forming Links

Links between institutions and individuals—to exchange material or information—are important for any type of crop development. Promoting and reinforcing links can help expand the scope and sustainability of work. This can be conceived at different levels: links among farmers or between institutions.

Promoting farmer-farmer links can facilitate horizontal exchange. Links between farmers and other institutions are also important in exchanging germplasm or information. For example, ties between farmers and genebanks were valuable in germplasm restoration (Worede and Mekbib, 1993), and conservation (Eyzaguirre and Iwanaga, 1996b). "Opening the genebanks" does not guarantee equity: links among farmers and institutions still shape access. Institutional relationships and roles can evolve, especially as farmers gain confidence. Long-term goals for capacity-building or farmer empowerment require that links evolve beyond simple supply-channels, and become a stable, flexible inter-relationship, possibly within entirely new institutions (Ashby and Sperling, 1995). While such interactions help shape formal-sector work through extended farmer contact, they also can strengthen farmers' (or other stakeholders') voice in research and development, as has been attempted in other situations (Commandeur, 1997; Collion, 1994). Thus, building links can have a number of meanings in PPB.

Indirect Support

Hypothesis 6 suggested that political or economic barriers may limit farmers' engagement or even their interest in breeding. Indirect support to farmer-breeding includes confronting such barriers. Supporting markets for grain or seed can stimulate farmers' innovation (Goldman and Smith, 1995). Challenging restrictive seed laws (Tripp, 1997), especially those requiring DUS or hybrid material (e.g., Zimbabwe; Friis-Hansen, 1995), can also help. Any support that empowers marginalised, but important actors in farmer-breeding, such as women, may significantly help breeding itself.

In the face of heavy promotion of external technologies, some groups use education and advocacy to strengthen awareness and respect for local practice and varieties, especially among the young. For instance, local seed fairs in India (BBA case), and the Andes (Tapia and Rosas, 1993), have been effective. Mokuwa (1997) argues that rural schools could also play a role by adopting problem-based curricula in natural resource management, crop development, and biodiversity. Large-scale urban migration, as occurs in much of Africa, may be moderated through promoting breeding—or more generally agrarian/rural lifestyles—as a way of fostering a "new agrarianism".

Table 1 summarises this preliminary framework of farmer-led PPB approaches, listing some examples under the four categories described above. Germplasm support may come through direct inputs of material, or through supporting seed systems for supply and storage. Skills-development can address skills new to farmers or work to extend current good practice. Linkages can be supported among farmers or across different types of institutions, and indirect support can involve stimulating markets, or promotion through education and advocacy. In practice, these categories interact. Arrows show two such examples: work with seed systems also involves skills-development and support for linkages, and working with segregating material may require new skills for farmers. Preliminary work, namely baseline studies and stakeholder analyses of seed systems, tie in to all approaches, and are not listed here. Choice of approaches in a farmer-led PPB programme should ideally reflect such a diagnosis of constraints. However, institutions shape how problems are framed and support is offered. We return to this point following a discussion of the case studies.

Table 1. Simple framework describing approaches to supporting farmer-breeding.

Germplasm	Skills	Linkages	Indirect
non	new skills	among farmers	Markets
segregating/segregating	extending best	between	Education
non local/local	practice	institutions	Advocacy
seed systems			

4. Case Studies

This chapter presents 11 cases where farmer-breeding has been supported in some manner. We describe them briefly here, to give substantive background to analysis and discussion in Chapter 5. Each of the cases below is in its own right innovative and unique, and is truly a pioneer in this field. The generosity of those involved with these cases in sharing information and further insights has contributed to a richer discussion that, we hope, will help others to learn from the experiences described below.

REST: Community Seed Banks and Expert Seed Selection in Tigray, Ethiopia[9]

This project is administered by the Relief Society of Tigray (REST), an NGO co-ordinating development work in this northern Ethiopian region, with close ties to the government. This project began in 1988, toward the end of the long civil war, as an emergency programme for areas under Tigrayan rebel control. Tigray was disconnected from most sources of support, including foreign aid, during this period (Clay, 1991), and had been hard-hit by drought. Though the focus has evolved links to biodiversity conservation, this project was born of necessity, focusing on self-reliance and seed security. It offered good-quality seeds at seasonal credit, particularly emphasising poorer farmers. The focus was mainly on staple cereal crops (barley, wheat, sorghum, and maize), though grain legumes have received recent attention. To provide the highest quality seed, the best traditional seed selectors were mobilised. It is this aspect which particularly distinguishes this project, as it points to the potential for locally linking biodiversity conservation with seed supply and crop improvement.

Overview of methods

From 1988-93, there were 42 genebanks operating at the *Woreda* level (a sub-district comprising around 15 *Tabias*, local units of around 2000 people each), which covered most of Tigray. Following

9. Information drawn mainly from Berg (1996b, 1992); Abay (1996); and Mekbib et al. (1993).

the end of the war in 1991, the programme placed additional emphasis on conserving FVs (especially landraces), and has maintained 17 genebanks since 1993, concentrating on 10 *Woredas* in central Tigray. Some of the former REST genebanks are now managed by the Board of Agriculture of Tigray Region (BoA), but others have ceased operation. The number of farmers receiving seed loans varies, depending on the quality of the previous harvest (see Table 2).

Table 2. Additional funds added to seed bank project each year by REST, calculated from data in Berg (1996b).

Year	Number of beneficiaries	Cash inputs by REST[a]	Inputs/beneficiary
1993	24,959	294,000	11.7
1994	20,848	190,000	9.1
1995	15,455	120,000	7.7

a. Calculations in US$, with exchange rate of 7 Ethiopian Birr/$.

Oversight and financial management for each genebank is at the *Woreda* level, through a Seed Committee. Two elected *Woreda* representatives sit on this Committee, as does a BoA member and two elected farmers. Seed purchase and selection occurs at the *Tabia* level, organised by a local committee comprised of two elected officials (for *Tabia* council), one or two “model farmers” who promote development projects, and one or two expert farmers known for selection abilities. This committee selects and purchases seed before harvest, appointing two to four farmer-curators (there are 386 in total) to store the seed on-farm using traditional granaries and practices (drying, with ash and peppers as insect repellent, occasionally supplemented with chemical pesticides). Each curator stores 10 to 20 varieties (FVs), each one separately, and reported seed loss was remarkably low (1%-3%). During planting, needy farmers receive seed on credit, which they must repay at season’s end, at the harvest price plus an average interest of 6%.

Each *Tabia* committee decides which varieties to purchase. Though the major varieties are well-represented, less common ones are being increasingly included, as well as some grain legumes. Seed selection uses traditional mass selection, according to multiple criteria. For maize and sorghum, cobs and panicles are directly selected and purchased. The traditional system of selection for barley and wheat is a 2-year cycle, the *mingas* system (literally meaning ‘ennoble’ in Tigrinya). In the first year, individual panicles are selected from a normal field; these are multiplied the next year in a special, fertile field, and seed is bulk harvested. The committee purchases seed from these fields. In both systems, seed may be selected that performs well under moderately fertile conditions.

Overview of results

The programme supports local seed and variety security, providing seed that is cheaper and better than commercial traders. Though no yield evaluations were available, farmers agree that seed from the programme is superior in performance than unselected FVs, or compares favourably to MV seed provided by formal sources. These aspects, and the timely provision of seed to those who would otherwise resort to expensive or lower-quality sources, suggest that this project has important benefits for production. Effects on yield stability are not known, though selection methods seem biased to broad adaptation, and resources saved from avoiding commercial seed purchase may be re-invested in the ongoing land rehabilitation programmes, thus lowering environmental variation. Also, the continued improvement of FVs, their secure supply, and apparent fertiliser-responsiveness increase the chance that this local diversity will continue to be valued and actively used by farmers. Owing to the mass selection methods employed, and to the large quantities selected, Berg (1996b) considered that genetic diversity was not being unduly restricted in selected populations, citing long-term experiments (Dudley, 1977).

Though mainly poorer farmers benefit (35% of seed recipients were female), there is a reported resurgence of interest across all groups of farmers in seed selection. Berg (1996b) suggests that this revival of interest in seed selection, a practice that some feared was in decline, was precisely because the production advantages of carefully selected seed became apparent. This project suggests that biodiversity, and skills, are being maintained **and** enhanced, thus offering a fruitful combination of development and conservation.

Some reflections

The decentralisation of decision-making is remarkable, as are ties to local government development programmes. These local government ties, seen in other projects, may facilitate integration with other activities, though it does raise questions about independence. Seed supply is much faster and offers more choice than the long formal supply chain in Ethiopia. The characteristics of the expert farmers involved in selection are not mentioned. This may be of concern, given that elsewhere elected officials and ‘model farmers’ have tended to be male and better-off. More to the point, it is not clear if selection criteria reflect the needs/conditions of all users.

Though local storage is effective in the short-term, it is still subject to risk of loss, and may benefit from long-term backup from the central seed stores (at *Woreda* level) which are being planned. Raising the formal system’s regard for farmers’ seed selection and storage may have important empowerment results, particularly for the expert farmers. This work raises policy questions, especially around seed legislation and ownership. It also implicitly contradicts the high input/high output messages promoted by the Sasakowa/Global 2000 Programme and the Ministry of Agriculture's Package Programme, and it may face growing conflict with this approach in the future.

Cost efficiency is not easily calculated given the lack of direct measures of impact. Annual inputs from REST were still needed, though less so following good harvests (Table 2). The desire to first limit financial inputs from REST on established seed banks may also limit possibilities for scaling-up, at least for the time being. Given the growing interest across Tigray in learning seed selection, there may be scope for expanding training. It may be justifiable to increase the (low) seed prices or interest to cover costs of honoraria for committee members and seed curators. However, subsidised seed is economically justified in some situations (Cromwell et al., 1993).

There was no mention of horizontal exchanges across seed banks of information or material, or any specific input from national genebanks, though this was recommended (Mekbib et al., 1993). Information on change in performance or germination over time, in comparison to MVs or unselected materials was not available, though this would be extremely interesting and useful. The project shows that farmers are capable of delivering high-quality seed: it may be able to fruitfully complement the formal supply system, by also supplying (and selecting) MVs. Many questions remain about the types of germplasm inputs that may be useful (uniform MVs, landrace selections, or population varieties), given the difficult ecological and risk-averse conditions of the primary beneficiaries, and the conservation goals of the project. The impressive level of local activity could serve as an excellent basis for linking farmers and other institutions.

PTA: Community Seed Banks and Maize Selection in Brazil[10]

The PTA network is a coalition of Brazilian NGOs promoting alternative technology development in conjunction with small farmers' and with trade unions of rural labourers. This currently involves 23 NGOs. operating in 12 States in Southeast, South, and Northeast Brazil. Initiative came partly from farmers' groups themselves. In the more favourable South and Southeast areas, farmers sought access to affordable seed for maize, their main crop. A generation of promotion of F_1 hybrids, often tying credit access to

10. Information drawn from PTA Network (1996); Cordeiro (1993); Cordeiro and de Mello (1994); and discussions with people involved in the Network.

adoption, had meant that the materials and skills for local seed production were becoming rare in those areas. To save money, some farmers were replanting hybrid seed for several generations, but suffering declining yields as a result. Some communities, such as in the Zona de Mata region of Minas Gerais, had been organising on their own for seed selection, but had been encountering difficulties. For instance, cross-pollination between different seed lots, perhaps a minor issue for dispersed holdings in the past, had become important as land shortages brought farmers adjacent to their neighbours: issues of isolation distance were unknown to many farmers. Some of these groups approached the PTA Network for support. In the same period, the Network found a few farmers who were saving their own seed and obtaining good results on poor land, and, following a seminar in 1990, developed a joint strategy that would focus on seeds.

Overview of methods

Their goal was self-sufficiency in maize seed supply for small farmers, with specific activities reflecting regional priorities. In more marginal Northeast areas, emphasis was on security of supply in the face of recurrent drought, with 250 Communal Seed Banks involving 9250 families of small farmers.

In higher-potential areas, emphasis has also been placed on screening and improvement of materials: seed production groups (150 in 1993/94) have been organised, involving 10,000 families. Work involved four areas:

- farmer-varieties of maize still grown were collected and stored in community seed banks.
- formal- and farmer-managed trials evaluated these varieties.
- farmers received training in crop selection, and some undertook crossing and selection on these varieties.
- finally, communities organised for seed production.

In PTA's vision, these areas are not considered as separate stages, but as intimately-linked activities that may run concurrently. Also, through annual seminars and other means, PTA helped farming communities to gain a critical understanding of relevant political issues, particularly of seed laws (see below).

The Seeds Network sought to co-operate with EMBRAPA, Brazil's agricultural research service, and developed the National Criollo Maize Trails (ENMC) with them, to evaluate varieties recovered through collection work. Though recovered FVs compared favourably to commercial or public MVs in these multi-locational trials, farmers found the small (10 m^2) high-management plots unrepresentative of local conditions, and ran local trials under more typical management levels.

Some communities were interested to learn selection methods. Previously, the predominant practice was selection from bulk stores. Seminars covered such issues as ear selection, isolation distance, and stratified mass selection (i.e. grid-selection: select the best ears at regular intervals, to control for environmental effects). This was supported through considerable local organisation and activity, where farmers started to select recovered FVs, or recent crosses given to them by EMBRAPA. Farmers' approaches are highly innovative, especially given their limited resources. To obtain enough land to isolate varieties from cross-pollination, some communities designated a collective plot, with families gaining access to seed on the basis of labour contributions. Selection of sites may have been an issue where environment or land quality was highly variable. For instance, in one community, seed was selected from a relatively infertile community plot, but the farmers discovered that progeny planted on more fertile land had extensive vegetative growth and no grain-set. The community responded by selecting from poor and fertile plots in parallel, pooling the seed.

Overview of results

Unfortunately, there was little detail available specific to the Communal Seed Banks in the Northeast. Across all regions, the Network identified more than 200 types of maize, now conserved in the local seed banks, and widely evaluated and promoted. Seed storage generally uses locally-available materials and structures. Maize seed is quite robust to storage, provided conditions are dry; though details are unavailable, it is thus quite possible that viability is effectively maintained, at least for short periods. PTA is reportedly considering detailed investigation of effective local storage methods, with a staff member recently returned from advanced study in genetic resources.

For the seed production groups, evidence suggests that benefits to farmers (quality seed without cash payment) out-weigh the labour input costs of community-produced seed. The selection approach taught enables more dependable genetic advance than simple mass selection (M. Smith, pers. comm., 1997), though as yet there is little known about the effectiveness in improving traits of value to farmers under their different conditions of genetic and environmental variation. PTA is monitoring and analysing yield trials across locations, and presumably will be able to note changes in the future.

The National Criollo Maize Trials show that many FVs perform well across different environments, and that some out-yield the best MV varieties. National yield trials may have been important in building support within EMBRAPA, though this may have been short-lived (see below). However, multi-location trials may reject material with good performance in particular ecologies, or with valued characteristics other than yield, as Joshi and Witcombe (1996) noted for rice in India.

Thus, local farmer-managed trials were important, and revealed that farmers may seek area-specific criteria, and have a different approach to extracting information. Farmers preferred larger plots with no replication in their own trials: they may be interpreting yield in the context of micro-environmental variation, as seen elsewhere (Brouwer and Bouma, 1997). Though there were no details on the methods used to exchange material and information among communities, local trial results may facilitate such an exchange and help scale up results.

Some reflections

Institutionally, what is most striking is the role of community-level organisations and social movements (in alternative agriculture, in rural labourers' labour unions) in initiating and supporting the work. The degree of involvement and direction from farmers is impressive, as are efforts to involve them in national policy debates. More information about the farmer/community organisations themselves, their evolution, and about the facilitating role played by PTA would be very valuable for other organisations to gain insights to the strengths, and potential challenges, of such institutional arrangements. Empowerment is a clear outcome where farmers learn selection skills and communities become self-reliant in seed production. Though participants are described generally as "small farmers", it is unclear if differences among users, especially by gender, are a factor.

As with REST and Guanxi, concern for seed security in the Northeast is different than for seed quality elsewhere; communities in highly unfavourable areas may face chronic seed insecurity (Cromwell et al., 1993). In its outset, PTA suggested an interesting division of roles: NGOs in a service role to community groups that organise and conduct most of the work, with EMBRAPA technicians offering technical training and backstopping. However, it appears that much of EMBRAPA remained unsupportive, and that policy issues have further soured this relationship. These issues include biases to MV use (such as tied credit), and especially Brazil's new intellectual property laws. These may limit farmers' access to formal germplasm sources, and restrict seed saving and exchange where communities are multiplying MV seed for themselves. Network members and farmers also fear that Intellectual Property Rights (IPRs) over farmers' materials could be exploited by a third-party without compensation. Consequently, PTA Network members have been prominent advocates for the recognition of Farmers' Rights in national and international policy. These issues are far from being resolved, and the climate of PTA-formal collaboration is somewhat strained.

BBA: Collection and Screening of FVs in India[11]

The Beej Bachao Andolan (BBA: Save the Seeds Movement) is a self-organised farmers' movement active in the Garahwal Himalaya of Uttar Pradesh, northern India. Their goal is the maintenance of the *barahnaja*, or "12 seeds" intercropping system practised in the region, seen to be threatened by official promotion of MV soybeans, with an additional goal of promoting organic production methods. Members collect, screen, and promote a wide range of FVs from across the region. They espouse a Ghandian self-help philosophy, and do not accept funds attached to specific conditions (i.e. from institutional donors).

Overview of methods

At the core of BBA are six to eight farmers, the catalyst being Vijay Jardhari, a long-time activist with the *Chipko* Movement, an environmental movement famous for its actions, especially by women, to protect trees from destruction. He has ties to other environmental NGOs, and with others has travelled widely in the region, collecting varieties of a range of crops for storage, screening, and dissemination. At least 130 varieties of rice, 110 of beans, 40 of finger millet, and a range of other crops have been collected and evaluated (mainly on one plot) noting agronomic performance, pest and disease-resistance and quality factors. The identified traits are very diverse: for instance, black-stemmed rice that can be occasionally planted to identify and remove weeds, an example of "auxiliary selection" (see also p. 66). An herbarium is kept with detailed records. Given the diversity they have collected, there is probably still much to gain from introduction and screening, and making crosses would consume much of their limited time and resources (cf. Witcombe et al., 1996). There are no details on seed selection, however. Promising lines are multiplied for distribution and promoted to the neighbouring farmers. Of the 285 families in the village, 100 are estimated to be trying varieties provided by BBA, loaned to them on terms commonly used in many countries (e.g., 1.5 x return at harvest).

Overview of results

There appears to be growing interest in organic agriculture in the region, due at least in part to rising costs of chemical inputs. Some farmers adopting BBA varieties are confident of economic savings. However, effects on production and diversity are difficult to specify without baseline studies and detailed analyses. A review of available data on varietal mixtures suggests they offer a yield advantage, and slightly more yield stability, compared with monocultures (Smithson

11. Drawn from Kothari (1997; 1994); Sperling (n.d.); and Shiva et al. (1995).

and Lenné, 1996), but these relationships are not guaranteed. Reports suggest that regional diversity, and farmers' interest in maintaining it, still may be high. BBA's most important contribution may not be preventing a given variety from disappearing completely from the region, but rather their increase to the information base on FVs, and their movement of material between different local genepools.

Principally the core group of men does their collection and screening work. This omission has limited the input of women, who are usually in charge of seed selection and storage, and may have limited promotion of varieties of particular use to women. This evaluation is mainly in one site, though materials originate from a diversity of ecologies. While community plots may involve more farmers and thus transfer material more quickly or more broadly, testing in multiple environments may help identify materials for specific niches.

As with other cases, empowerment and self-reliance are important to farmers involved, and they focus on the transfer of information and materials to do this. Also similar to some other cases are the links to grassroots social movements, with which BBA members have extensive activist experience. This appears to have been valuable in giving them the confidence, skills, and contacts to pursue an ambitious project with limited financial support. However, the same self-help philosophy may also preclude close ties with formal sector institutions. Both these aspects of social movements are seen in other cases; we return to this significant issue in the discussion below. In this case, direct support from outside agencies, including NGOs, may not be possible. However, BBA is seeking, in partnership with Kalpavriksh, an environmental NGO, outlets to sell local wild products as a means of supporting their seed nursery work. Thus, this case points to a range of possibilities for indirect support of farmer-breeding that have been relatively unexplored until now.

SOH: Re-Supply of Beans After the Genocide in Rwanda[12]

Rwanda's continuing civil strife disrupted areas of the countryside starting in 1991-92, and exploded into genocide for an intense period between mid-April and June 1994, affecting the entire country. This was an acute tragedy, resulting in the death of perhaps 1 million people and the displacement of another 2 million. As agencies rushed to assist in relief and rehabilitation for Rwanda's agricultural production systems, there was concern that this effort be sensitive to crop diversity and informal seed channels, as well as to formal capacity-building. Extensive previous documentation had identified

12. Sperling (1996a; n.d.) was a primary source, though see SOH Documents 1-9 for details. Also, personal communications with L. Sperling and comments from R. Kirkby (both Sept., 1997).

incredible diversity for common beans (*Phaseolus*), and considerable sorghum diversity in farmers' fields. Formal and informal agencies were concerned to support diversity, both for its importance to meeting farmers' needs, and for the global community. Seeds of Hope (SOH) was one of the first large-scale relief efforts that systematically addressed issues of seed and variety restoration, and post-war institutional development. Though its primary goal was not participatory research, the programme offers insights into farmers' seed channels and situations of dramatic change.

The short, intense nature of the genocide meant that farmers' genetic management were not as severely disrupted as initially feared. While farmers in many places were displaced for long periods, most were away from their farms for only a few weeks, and 30% of farmers in Rwanda by the end of 1995 had never left their farms. Many those displaced returned to their former communities. Because of this, and because most farmers had planted beans before the genocide had started, half the farmers surveyed had been able to reap at least some of what they had sown during the genocide/war periods (Sperling, 1996a; n.d.). Most locations had someone able to harvest beans, so total loss of local varieties did not occur. During the first season post-war, nation-wide surveys showed much diversity was still present and available, a situation quite different from some long-term, low-intensity conflicts, such as in West Africa (Richards, Ruivenkamp et al., 1997). However, this case merits discussion here as it shows both the resilience—and the limits—of farmers' seed systems, and gives some valuable insights into how this can be supported, both in an emergency situation, and in the long-term. While the full SOH programme addressed sorghum, potatoes, maize, and cassava, this analysis will focus on beans, the most diverse crop addressed by SOH, and the main protein source to rural Rwandans.

Overview of methods

SOH involved a broad spectrum of institutions, including International Agricultural Research Centres (IARCs) of the CGIAR, African NARS, and NGOs.[13] Emergency seed and food aid started entering arriving

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13. This spectrum included African NARS that contributed germplasm, field space, and advice to the initiative: Burundi, Ethiopia, Kenya, Malawi, Tanzania, Uganda, Zaïre. Also officially involved were eight IARCs, including: the International Center for Tropical Agriculture (CIAT), the International Maize and Wheat Improvement Center (CIMMYT), the International Potato Center (CIP) and its network PRAPACE, the International Center for Research in Agroforestry (ICRAF), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Institute of Tropical Agriculture (IITA), the International Livestock Research Institute (ILRI), and the International Plant Genetic Resources Institute (IPGRI). These worked closely with a number of NGOs, including World Vision and Médecins Sans Frontières.

immediately after the genocide. The goal in this period was to make seed aid more responsive to farmers' needs. Given enormous time/logistic constraints, NGOs, with technical advice from SOH, made huge efforts to distribute a range of crops, including beans, maize, and sorghum during the first two post-war seasons. While some previously-grown varieties were multiplied for release in later seasons, NGOs were guided to purchase material as much as possible from similar ecologies from border markets in countries like Uganda. Seed relief attempted to target particular packages of varieties to specific regions. Emergency distribution for beans was, at the suggestion of SOH, first of varietal mixtures, which variously included FVs and MVs as available. SOH later sought to evaluate the impact of this aid together with the NGOs. They attempted to identify gaps in seed or varietal introductions, and special needs around access. SOH also worked to sensitise the reconstructed NARS to farmers' management and use of crop diversity.

For beans, SOH could make use of extensive studies of local seed systems and varietal diversity, (e.g., Voss, 1992; Scheidegger, 1993; Sperling, 1996b), making it one of the only cases to have baseline assessments, as well as impact analyses. The initial impact assessment was a survey following the first post-war season (there are two to three seasons a year for beans in Rwanda). SOH and NGOs working in co-operation surveyed 143 households in scattered regions of the country (i.e. the particular NGOs' areas of activity). By the third post-war season, conditions had calmed enough to enable a nation-wide and more detailed survey of how farmers have re-supplied their systems. SOH worked with ISAR, Rwanda's NARS, randomly sampling 884 households across all of Rwanda's agro-ecological and political zones. In the future, molecular studies will be combined with farmers' evaluations to assess the actual level of variety loss, if any: it is notable that SOH places equal weight on both types of assessments.

Overview of results

As mentioned above, local disappearance of specific varieties did not appear to be widespread. Harvests were better than first expected and farmers' seed channels, especially local markets, worked well in most regions and allowed recovered local varieties to be sold and disseminated. Farmers were considerably poorer and more vulnerable than before the war. Having something to eat in that time gave them space to pursue multiplication of adapted seeds. The evaluations show the role indirect relief aided support played here in providing farmers that space. In this sense, the food/seed aid rapidly provided by NGOs, along with restoration of relative security, gave farmers enough of a cushion to plant, rather than consume, their adapted stocks. The distribution of varietal mixtures was a novel move in relief work. This, and the targeting of mixtures to certain ecological zones, gave relatively good production results (and thus larger cushion for farmers). Though farmers sold much aid seed as grain, they also pulled out familiar or novel varieties for continued use.

Presence of diversity is not the same as access to it: though efficient, local seed systems are not always equitable. Many poor farmers knew where they could obtain particular varieties missing from their mixtures, but could not afford to purchase them. This same class of farmers often consume their entire harvest, and must seek out planting material every year, often not getting preferred varieties. Thus, the poverty of certain users needs to be specifically addressed—they lack access to desired varieties (low 'variety security') and chronically lack planting material (low 'seed security').

In thinking about support strategies, it is important to consider how farmers normally obtain seed—and how these seed channels would change with disruptions. Community seed bank approaches would not be easily workable in a Rwandan situation: farmers' variety needs for beans are much more diverse, and (pre- and post-war) social solidarity is considerably less than in other seed bank cases (e.g., Tigray). "Seed vouchers" have been suggested to enable poorer farmers to purchase desired seed types from the market, though this may entail considerable logistical organisation. It is also important to remember that farmers' needs change. Rwandan farmers had increasingly demanded MV material in the 10 years previous to the war, especially for climbing or disease-resistant bean varieties. Such demands were not particularly met in the first relief-aid distributions, as much of the seed came from markets across the borders with Uganda and Burundi, and not from formal sectors. This highlights two further points:

- formal seed systems may be slower to recover links than informal systems.
- needs may change, and may not easily be met from currently existing genepools.

Some reflections

While massive bean germplasm restoration proved unnecessary in Rwanda, it is interesting to reflect on the strategy proposed for varietal introduction. Its intention was to build on the well-known skills of Rwandan farmers, particularly of women, who normally take seed and varietal management decisions. With NGOs taking the lead, SOH planned to facilitate widespread community-level varietal screening. Local varieties, 170 key ones, had been multiplied from initial NARS stocks through East and Central Africa. Communities with varietal deficits were to receive 25-50 different entries, broadly adapted to the agro-ecological zone, for farmers to evaluate and eventually access—if they found useful materials. SOH was not designed as a PPB project, but should one follow now, the baseline information shows how a broad consideration of constraints may be useful, following the framework of approaches to support farmer breeding. The proposed strategy is a good example of a germplasm input approach to support farmer-breeding. The survey information confirmed that some farmers were not constrained by local availability, but by access to germplasm. Thus, PPB work would do well to emphasise links, both for poor farmers who lack access to local varieties, and for formal supply, to improve access to new varieties of interest to farmers.

The above issues all point to possible roles for outside support to play. They also indicate that "opening the genebanks" may not be a solution in itself. Most genebank (and breeding) materials lack evaluation information relevant to farmers that would enable some degree of targeting, and access issues and changing needs still need to be confronted. New, flexible relationships for exchange and technology development need to be forged in the long run, requiring institutional changes. Thus, SOH's attention to building new linkages and changing perceptions, both with NGOs and with the NARS, is appropriate and laudable, echoed by the initial intentions of the PTA Seed Network and the recent proposal for a "Seed Security Unit" from UK NGOs (C. Longley, pers. comm., 1997). Striking with SOH was the level of emphasis on sensitising the NARS, and the need for novel (though diverse) material, beyond conserving local diversity. It will be interesting to see if such attention helps mitigate some of the formal-informal distrust or policy conflicts frequently seen in other cases. As other cases show, it may be equally fruitful to seek to empower farmers, through education and action, to actively search for new seed/cropping options themselves, and to articulate their needs for formal sector support.

SAVE: Farmer Screening and Multiplication of New Varieties in Sierra Leone[14]

This project, the Sustainable Agriculture and Village Extension programme (SAVE) occurred from 1990-95 in southern Sierra Leone, and was implemented by CARE, an international NGO. The goal was to supply new planting material for this variable and risk-prone environment, facilitate farmer-to-farmer linkages, and strengthen ties between farmers and formal researchers. The assumption was that farmers' breeding was limited by their access to new planting material, and not by their level of interest or skills.

14. Main sources are George et al. (1992); Okali et al. (1994); and CARE-Sierra Leone (1994a; 1994b).

Overview of methods

Farmers were organised into Clubs, with the sole project purpose to facilitate distribution of planting material. Through these, farmers received small amounts of planting material, and were encouraged to engage in “creative play” experiments to fill gaps in their farming systems, and to share their material and findings with others. Club membership, 750 in the first year, swelled to 4500 by the end as the project added new villages (totalling 75). After two and a half years, 1800 packets had been distributed for testing. Farmers could choose from 54 different varieties from upland and swamp rice, cassava, sweet potato, oil palm, mango, and maize, with 5-15 varieties available for most species. SAVE followed a strict, and controversial, policy of not offering extension advice, even for crops unfamiliar to the farmers. Field agents also documented farmers’ agricultural practices, with the original intent to help inform researchers at the NARS stations, and re-orient their research agenda. They also organised field days and workshops for farmers from different villages to share their experience and materials. At these, farmers representing each Club would present their testing approaches and observations to other farmers, who asked questions. These were very popular and had enthusiastic farmer involvement.

Overview of results

Given that there were no direct financial incentives, farmers’ responses were enthusiastic, and SAVE expanded to involve more farmers and communities, though staff numbers limited scaling up. This showed the effectiveness of distribution of small ‘experimental’ packets, and highlighted the fact that their access to novel material had been poor. At least 18 varieties had been identified at the end, and there were hopes that farmers would be trained to carry on multiplying these for local supply at the end of the project. The most notable success, an early-maturing sweet potato, filled a gap in the hungry season (see hypothesis 10, above). SAVE linked impact with sustainability, arguing that there is a trade-off between readily visible impact for some, and smaller (and less risky) gains in income and production for a wide group of farmers. This is a significant point, suggesting that some PPB projects, by focusing on a limited range of technologies with readily measurable impact, could be sacrificing sustainability or equity. It is relevant to mention here that SAVE’s annual budget was US$250,000, and that its donor, a mining company required to fund local development work as a condition of operating in the area, put relatively little pressure on SAVE for immediate results. Unfortunately, the resurgence of war at the end of the project, and the lack of a systematic baseline at the start (despite plans in the proposal), mean that impact cannot be measured, nor SAVE’s arguments assessed.

The channelling of material through Clubs meant that farmers controlled who assessed new packets, as well as how testing was done. Except for unfamiliar crops, the no-extension policy appeared to work very well, though there was no systematic analysis of the form of folk experimentation, despite extensive documentation by staff (see below). Passing control to farmers also was empowering, though in some cases Farmers' Club membership and seed distribution were slightly biased to particular families and villages. Also, women were not treated as a specific client group. In the later phase, SAVE gave more attention to equitable participation, especially that of women, and increased focus on vegetables. SAVE's decision to focus on accessible, low cost technologies minimised barriers to involvement. However, tree-crops, especially oil palm, which attracted much interest, were less accessible to tenant-farmers than for those who owned land. Land tenure was confronted directly in CONSERVE's project.

Though Richards (1985; 1986) has documented extensive gift exchange of rice varieties, farmers reported that informal exchange of material and information was sometimes restricted to kin or Club-members. Thus, the workshops and open days played an important role for horizontal transfer, as well as for skills-sharing. As with Farmer Field Schools for Integrated Pest Management, and with CIALs, using farmers as trainers was effective. The degree of horizontal dissemination of material was not measured, though it was quite rapid in some cases. For exchange, the amounts and breeding system mattered. The small amount distributed, though enabling many farmers to benefit, did slow multiplication and exchange. However, vegetative crops (cassava, sweet potato) were able to be spread more quickly than seed crops like rice.

Documentation of farmer practices by SAVE staff was intended to influence and change research agendas. Station scientists welcomed informal feedback on adoption, and planned to work on material that was more appropriate to farmers' needs, most notably FVs. Written documentation varied in format, and was not compiled and analysed, a factor which probably contributed to the eventual shift in project goals away from reorienting research agendas to improving germplasm supply. This may have been a lost opportunity to contribute to fertile debates on farmers' experimentation (cf. Sumberg and Okali, 1997). Nevertheless, SAVE staff kept abreast of current research and had constant communication with NARS workers, thus enhancing the NGOs' role in research and development. Near the end of the project's five-year period, there was concern to maintain these links, especially for continued supply of new materials, perhaps through having a small sub-station in the area. However, the resurgence of civil war in the region prevented this from happening, and has made the continuation of Farmers' Clubs, which had no other purpose, highly unlikely.

USDA: Free Seed Distribution to Farmers in USA[15]

From the 1840s until 1924, the largest government programme anywhere to directly supply farmers with diverse planting materials occurred in the US through the US Department of Agriculture (USDA). Though the conditions in the US in this period—new land being opened for agriculture, high urban demand, a responsive and well-funded research system, to name but a few—were hardly typical of Southern countries, the experience still offers some important lessons. It also points to the critical need to examine the historical origins of formal plant breeding, and to look at similar experiences of facilitating farmer access to seed that may have happened on smaller scales in Southern countries.

While breeding techniques such as hybridisation and pure-line selection were known and employed by some formal breeders (and farmers) in the 19th century, it was only in the 1920s that central breeding programmes could be seen to have a greater impact than the selection and screening actions of countless farmers. For instance, in the mid-1910s, the vast majority of varieties on Recommended Lists of the USA (Fowler, 1994) and the UK (Palladino, 1990) were still introductions or selections from FVs, and not products of formal breeding programmes. Formal breeding eventually hit its stride through applying the new science of genetics (Palladino, 1994), and through advances in experimental and statistical methods, particularly those from Fisher, enabling replicated trials to screen for quantitative traits (Gigerenzer et al., 1989).

Overview of methods and results

Before this period, farmers were the main forces in crop development and seed production. Plant introduction and distribution were crucial for a country like the USA, which had relatively few genetic resources that farmers could exploit[16]. Though seeds entered through immigrants or wealthy individuals (e.g., most of the 70 sorghum varieties grown in the 1930s could be traced to the introductions of one entrepreneur; Martin, 1936), the US government also became involved. In the 19th century, the Navy and diplomatic offices scoured the globe to bring planting material to the US. In the 1840s, the Commissioner of Patents convinced Congress to fund collection and evaluation work

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15. Most of this discussion draws on Fowler (1994); Kloppenburg (1989); and Martin (1936).
16. However, the US had many potentially significant plants domesticated by the Native Peoples which were lost in the disruption and devastation of their cultures. Nabhan (e.g., 1989) is an important starting point for the taxonomy and ethnobotany of Native agriculture.

and distribute free seed to farmers for experimentation. This became the main task of the USDA, established in 1862, which annually sent millions of parcels to growers, each usually several packets of different varieties. A wide range of species was distributed, many being quite diverse populations which offered potential for continued farmer selection. In the words of the Commissioner of Patents in 1855, the small packet size was to place "the opportunity of experimenting... within the reach of several hundred times as many persons as would be if distributed by the bushel" (Fowler, 1994, p. 18).

The programme grew enormously in scale (Table 3). Farmers could request seed via elected representatives, making use of government seed catalogues with enormously detailed passport, provenance and husbandry information. The programme was popular with Congress members for dispensing patronage to their constituents. Before 1897, any farmer who wanted could obtain seed, though they increasingly sought well-known or ornamental varieties also available through the seed industry, preferring the USDA as its supply was high-quality and free. By 1897, the focus on screening novel material was diluted. Commercial seed companies, fearing depressed prices, pressured Congress to scale back the programme: distribution was more strictly for experimentation following this period. The section of Seed and Plant Introduction, established in 1898, took over collection and distribution, funding systematic collecting expeditions, and distributing "new and rare" planting materials to experiment stations and *bona fide* farmer-breeders, still sending hundreds of thousands of packets to farmers (Kloppenburg, 1989). There was still considerable interaction between farmers and breeders and contemporary accounts pay homage to the "observing but unknown and unsung" efforts of farmers in their work in isolating valuable new varieties (Martin, 1936).

Though costly, the programme was considered a public service whose commercial impact far outweighed its costs. For instance, a few crops so introduced were cited in 1912 as having collection costs of a few thousand, but annual values of many millions of (1912) dollars (Fowler, 1994). This period saw an explosion of diversity in farmers'

Table 3. Numbers of seed packages sent to US growers since establishment of USDA.

Period	Seed packages	Yearly average
1862-69	6,600,000	825,000
1870-79	12,890,000	1,290,000
1880-89	34,950,000	3,495,000
1890-99	81,560,000	10,195,000

Adapted from Fowler (1994), data from Klose (1950).

fields, and the selection by farmers of many still-popular varieties. Though, as shown above, farmers were still regarded as important members of the breeding community into the 20th century, free seed distribution was opposed by seed and breeding companies, and the programme ended in 1924.

Some reflections

Widespread enrichment of farmers' genetic repertoires, given proper support, may stimulate innovation and provide new options for farmers. Though the USDA programme was very deliberate, we should consider other cases where colonial agencies, bringing in material for breeding programmes, have also enriched farmers' genepools, albeit less intentionally. In situations where formal breeding faces complex and diverse situations, where it needs to respond to rapid change, or where it does not operate at all, broad-based supply of material to farmers may be extremely useful and cost-effective. For instance, FAO's Global Plant of Action, from the International Technical Conference on Plant Genetic Resources in Leipzig, makes reference to the USDA experience in its discussion of germplasm restoration. However, a generalised genetic enrichment programme to farmers may not be appropriate in an emergency situation: SOH shows the value of a targeted response.

US farmers had considerable access to information in the late 19th century: extension and a flood of farmers' magazines, newsletters, and bulletins helped spread information on breeding and crop husbandry techniques, encouraging innovation. Significantly, contemporary movements display these aspects: the Indian-based Honeybee Network documents and publishes farmers' innovations, while local-scale projects are creating their own passport information to pass on to farmers (e.g., BBA, SAVE). However, public financial support for agriculture was high in the US, and through transport and communication links, farmers there enjoyed good access to the rapidly-expanding urban markets. Southern farmers, especially small farmers, may not be able to realise profits from their innovations to the same degree. Finally, one of the contributing factors to the demise of the US programme, the rise of IPRs over planting materials, may restrict such an approach now. Still, there are many situations where direct supply to farmers could have huge potential. The main limiting factor for farmer-breeding in many cases may be supply of germplasm, as shown by SAVE: generalised genetic enrichment programmes such as this one and the US case need much more attention and exploration.

Zamorano: Small Farmer Conservation and Enhancement of Maize in Honduras[17]

This case offers an example of a project, which places considerable attention on developing farmers' skills in crop improvement. Of particular interest with this case is the production of a manual for this farmer-training (Gómez et al., 1995) and evaluations of its effectiveness (Gómez and Smith, 1996; Bueso, 1994). The project began in 1993, and still continues, organised by the Escuela Agrícola Panamericana Zamorano in Honduras, with ties to local NGOs, and supported by the Cornell International Institute for Food, Agriculture and Development (CIIFAD). The work developed from trying to find better ways to benefit farmers with genetic improvement, as well as enhance and improve local ("criollo") maize, thus increasing its value and continued local use. This is accomplished through:

- surveying farmers' needs and selecting FVs on-station.
- on-farm selection of FVs with farmers choosing the plants.
- workshop training of farmers to better do this themselves.

Participating farmers were also encouraged to flexibly adapt their new knowledge to their home conditions, and to share these skills with their neighbours.

Overview of methods

The agricultural school hosts an annual workshop to transfer to farmers skills in maize breeding techniques, as well as stress the potential value of local materials and the importance of *in situ* conservation. Small farmers were invited from various regions of the country to attend the intensive 3-day course, generally with NGO sponsorship, training 43 farmers between 1993 and 1995. Though the specific criteria for choosing farmers were not described, (male) farmers were invited, with varying experience and place of origin. For example, the 1995 workshop involved farmers ranging from 18 to 82 (mean 39) years old. In another year, it appears that farmers who had a special local role in rural extension were invited. The on-station selection closely involved four local farmers, doing joint selection and long-terms trials on their farms over a number of years.

For the intensive 3-day course, the approach involved hands-on learning with group discussion and reflection. Farmers outlined their problems and particular goals with maize, and discussion of different

17. Sources for this case-study include Gómez and Smith (1996); Bueso Uclés (1994); Gómez et al. (1995); and discussions with Laura Meitzner, Aug., 1997, and Margaret Smith, Oct., 1997.

criteria ensued, where staff stressed the value of using local landraces for this. The crop improvement training concentrates on "what farmers don't know" (Bentley, 1989; he helped design the original course), particularly key processes which farmers may not perceive, such as pollination. Thus, training addressed the basics of pollination, and how to control it to control crosses between particular parent plants. They also discussed the relative heritability of their selection criteria, emphasising controlled, in-field selection and deliberate crosses. Farmers were encouraged to innovate, adapting local materials and selection methods to their home situations (e.g., to bag ears in pollination control), and to pass on their skills to others in their community. It was impressed upon farmers that enhancement of their maize is a gradual process, and they were told to expect results only after a few seasons.

Overview of results

At the end of each workshop, the participating farmers evaluate the training, generally with a very positive response. Researchers visited past participants observe how they implement techniques back home. There was also an evaluation workshop, where several former students returned to discuss the course and how they were proceeding since. This group of eight former trainees had shared their knowledge with 28 farmers, on average, in the 2 years following the training. The farmers discussed how they employed and adapted the selection techniques learned in their course. Furthermore, they discussed the effectiveness of the course itself, and made recommendations for materials and approaches for further training programmes.

From the evaluation workshop and from direct observations, almost all farmers surveyed made use of some selection techniques upon their return home. Among farmers there was considerable variation in the starting material used—some used FVs, while others worked on selecting from MVs. They sought a large number of criteria, many selecting for health-related traits, height, and vigour, with less attention to selection for grain characteristics. Most had adapted techniques, some conducting trials to assess the effectiveness of using local materials (e.g., testing the effectiveness of paper bags to isolate pollen). Most passed taught these skills to neighbouring farmers. Finally, most farmers accepted a small financial investment in materials without immediate payoff, having learned that crop improvement is gradual and requires a number of cycles of selection.

On-station trials in 1995 showed an increase of 31% in yield potential over three selection cycles for the landraces (though there was no indication of variance over time or space). A study that compared the intensive workshop approach with the continuing on-farm work with the farmers near the university (Bueso Uclés, 1994) suggested that the latter fostered a sense of paternalism among the farmers. The latter felt that they were simply playing host to a researcher-managed experiment. By contrast, the short courses were more open-ended, giving farmers basic knowledge, but encouraging them to apply it creatively to their home situations. This suggests that, when training is attuned to gaps in farmers' knowledge, is conveyed in a comprehensible manner, and is open-ended (allowing farmers flexibility and control), it can support new lines of innovation by farmers.

Some reflections

Like other cases, this innovative programme is reflective and continues to develop. There were some concerns raised about the intensive university course: while sudden rescheduling may be normal (and necessary) for university and staff, due to sudden time conflicts, farmers are not so flexible with their time, especially when their presence requires several days' travel. Such differences may undermine trust. There was no mention of whether gender or specific user issues were addressed. The work strongly encourages using local materials in maize improvement, which is a promising approach to linking conservation and use. However, if diversity is restricted in some locales, either in the initial materials or through intensive selection, inbreeding could depress performance. This, or counter-productive activities developed by farmers in good faith (such as cutting off maize tassels to mark plants for selection) may dampen farmers' enthusiasm, or even harm their production. As observed by Zamorano, a certain degree of monitoring and follow-up is thus important. However, clear farmer interest, flexible methods, and the capacity of local materials for increased yield all suggest that this approach has much long-term potential.

CONSERVE: Rice Conservation and Improvement by Farmers in the Philippines[18]

The Community-Based Native Seeds Research Centre (CONSERVE) is an NGO which received initial technical and policy support from the South-East Asia Regional Institute for Community Education (SEARICE), and works with the Santa Catalina Multi-Purpose Co-operative (SCMPC), a farmers' co-operative in Cotabato, Philippines. Since 1992 the project aims to collect, conserve, disseminate, and improve rice varieties, the main staple in the region, linking this work with farmer empowerment, and rejecting the monoculture approaches promoted by the Green Revolution. Work is linked to political education on aspects of plant genetic resources.

18. This analysis draws from Berg and Alcid (1994); Magnifico (1996; n.d.); and discussions with T. Berg, 1997.

CONSERVE claims that MVs are unsuitable under organic farming practices, and works with FVs. The economic rationale for reduced input use was recognised as a strong motivation for many CONSERVE farmers to switch to FVs (Berg and Alcid, 1994).

Overview of methods

CONSERVE works deliberately with poor, mainly tenant, farmers. The SCMPC, the largest co-operative in Cotabato province, selected curators for CONSERVE from within their members. Over 250 farmers practice organic agriculture, with 106 curators from 23 villages, 146 farmers received technical training, 16 farmers trained as trainers, and 13 trained in crop improvement (there may be an overlap).

A preliminary survey identified diverse ecological and ethnic sources for collection in six southern provinces in Mindanao. To the over 300 FVs so collected, CONSERVE added samples from the International Rice Research Institute's (IRRI's) 137 rice accessions from Mindanao. Currently, CONSERVE maintains 485 rice accessions, 271 of which were characterised by staff and farmers by 1994. Farmers developed simplified (morphological and agronomic) characterisation, which Berg and Alcid (1994) considered up to international standards, though passport samples were not described. Analysed data served as a guide for further evaluation of crops and their improvement.

Evaluation occurs at the CONSERVE centre, assessing yield and agronomic performance under organic cultivation on unreplicated plots. Documentation on evaluation was considered poor (ibid.). Farmer curators screen about 10 different accessions on-farm. A total of 123 accessions for upland and lowland sites were distributed in 1993, though no data are provided on screening methods.

A preliminary evaluation identified 20 accessions with good food quality and yield without chemical inputs, the highest yield being 5.8 t/ha, compared to 4 t/ha for MVs. Eventually farmers select a few varieties for their farms, based on pest and disease resistance, maturity time, production, food quality and high milling recovery. They preferred heterogeneous varieties, as these provide more opportunities for selection.

Crop improvement also occurs both at the CONSERVE centre and on-farm. Farmers define breeding objectives based on the general criteria mentioned above. From crosses, mainly using FV parents, CONSERVE staff has produced 18 F4 lines and four lines at the F2 generation. Furthermore, 26 pure lines selected from FVs are being evaluated. Farmers receive F3 and F4 crosses for further improvement. Farmers received training on the detailed manual crossing needed for rice, and on selection. However, there are no details on the training or the teaching methods used.

Seed storage is both at CONSERVE's centre seed bank and *in situ* on curators' fields. Seed bank accessions are dried, cleaned, and stored at room temperature in wax-sealed glasses with silica gel, sufficient for short-term storage of a small number. In 1997, CONSERVE made a "black box" arrangement with the Philippine Rice Research Institute's (Philrice) genebank. In this arrangement, CONSERVE has exclusive access to the replicates of their accessions kept by Philrice.

Overview of results

Though still early for assessing yield or stability impact, it is likely that moves toward organic production, and a low-cost supply of seeds, has lowered production costs. New germplasm inputs may benefit production goals, as well as enhance locally-available biodiversity, at least in the short term: before 1992, farmers depended only on a couple of modern varieties. A baseline survey on socio-economic conditions, farming practices, and genetic resources for rice might enable better assessment of impact, though the preliminary survey documentation was unavailable.

The project is entirely dependent on grants (largely from the Development Fund, a Norwegian NGO), although income from rice sales and rental of the CONSERVE training facilities was mentioned. Cost-benefit analysis is difficult without access to the financial reports, though costs were presumably modest, with six staff on local salaries, and maintenance of the CONSERVE's centre.

Some reflections

Complementary roles in collection and storage of germplasm show considerable potential: NGOs may have better access to a particular area and people, and may be able to better collect samples and information. Moreover, since all accessions are still grown in source communities there is back-up source of seeds and information. However, formal institutions can complement this with *ex-situ* storage, valuable for large collections or long periods. Considering the political rivalries between community-based and formal genebanks, CONSERVE's arrangement with Philrice is a breakthrough in institutional co-operation. It would be interesting to monitor these developments.

Secondly, IPR issues remain potential obstacles to further institutional collaboration. CONSERVE's farmers are willing to share their seeds with others, provided that the openness remains mutual. However, as with PTA, there are concerns that others outside the communities may claim monopoly benefits. This echoes problems of co-operation among partners within CBDC (Manicad, 1996), but it is uncertain whether these concerns truly reflect empowered communities' or NGO views (T. Berg, pers. comm., 1997). CONSERVE is considering linking with other NGO networks (e.g., MASIPAG) to improve seed distribution, though, since CONSERVE improved seeds would fail Philippine Seed Board certification, formal, commercial options could be problematic.

Third, farmers' organisations may help in scaling-up. To reach more communities, and further improve such links, farmers might be trained to take a lead role in extension. While SCMPC as a starting social base was effective, a more specialised farmers' organisation may need to be formed.

Fourth, CONSERVE sought the most socio-economically marginalised group, the tenant farmers. Tenants do not have sole control over production objectives, as they have to share crops with their landlord. Generally, these prefer high-yielding technologies, restricting tenants' choices. The low participation of women tribal communities (the main source of CONSERVE's accessions) also needs addressing.

Finally, building trust between farmers and CONSERVE was important for the project's success. According to CONSERVE, farmers are treated as equals, as sources of FVs and related knowledge. The project aims to institutionalise farmers' participation. For instance, two farmer curators are board members. This case highlights some useful indicators of empowerment, enhanced:

- access to germplasm.
- skills to conduct germplasm collection and plant improvement, and thus
- decision making power and control of local resources.

Guanxi: Women's Self-Initiative to Regenerate Maize in China[19]

Overview of methods

This case represents an initiative of women farmers in two villages in China's Guanxi province (Wenteng and Zhichen) to regenerate preferred maize varieties. The villages represent contrasting environmental and economic conditions. Zhichen has a harsh environment: water is a serious constrain, while rains easily flood the

19. The source for this case study is Song (1998).

land and wash away the crops. With no roads and limited market access, maize is produced for consumption. In contrast, Wenteng's environment is favourable, with relatively educated, well-off residents who are integrated into the market economy. Pig raising is the main source of income and maize is mainly used as pig feed. However, common to both villages is:

- women's domination of farming, as most men have migrated to urban areas for employment.
- Tuxpenos are the most popular maize types.

Tuxpenos (Tuxpeno 1 and Tuxpeno PBcC15) are open-pollinated varieties developed by CIMMYT from a landrace originating in Tuxpe, Mexico. These were introduced in Southwest China in 1978 originally as constituents for variety improvement and hybrid combination. However, Tuxpenos rapidly disseminated through three provinces mainly via informal exchange; currently planting is 1.6 million hectares.

In Zhichen, 90% surveyed said that lodging-resistance and higher yield are the most important criteria for their selection of Tuxpenos, though they cited other traits, including lower input (seed, fertiliser) requirements than other varieties. From 20 local maize varieties, Zhichen villagers only planted Tuxpeno along with three others.

Wenteng villagers replaced their hybrids with Tuxpenos, largely due to the favourable characteristics of Tuxpeno and the unreliable quality of hybrid seeds. Since their introduction in 1978, both villages have received no additional input of Tuxpeno from outside sources.

However, Tuxpenos have greatly degenerated from out-crossing in the last 15 years. Average plant height has become higher, yield greatly decreased and lodging resistance has been lost. In addition, the three other local varieties in Zhichen have also degenerated by crossing. While both Wenteng and Zhichen villages prefer Tuxpenos, only Wenteng has sought to maintain them exclusively, while Zhichen has chosen to maintain their local varieties.

Overview of results

The initiatives of both villages to regenerate their maize varieties reflect the inadequacy of the formal system to meet their requirements. In China, formal seeds systems are centralised and dominant: the few private seed companies are not allowed to breed, and the government distributes seeds with input packages. There are quotas for areas planted to hybrid maize, though this policy is widely disregarded by villagers and local officials. Despite subsidies, many farmers still find hybrid seeds (or the inputs needed for optimal performance) too expensive. Moreover, seed quality has become unreliable since the start of privatisation. In Zhichen, maize production is completely with open-pollinated varieties (OPV); in Wenteng, only 7%-8% of maize area is cultivated with hybrids.

While scientific breeders, government officials, and CIMMYT have also observed degeneration of Tuxpeno varieties, they have not responded to many villages' request for improving them. Since Tuxpeno is an OPV, there is no financial incentive for Chinese officials to act on farmers' request for seed supply. Government officials and CIMMYT only became aware of the village-level successes of Wenteng and Zhichen through Song Yiching's research, though it is not known if they are interested in supporting or scientifically validating these initiatives.

Women in Wenteng village have organised to regenerate the Tuxpeno varieties, isolating selected plots through field dispersal and temporal isolation. Seed selection involves selecting the

- best plants: those with big ears in the middle of the field, then
- best ears: cob size, length and number of seed rows, and then
- best grains: from the middle of the ears, based on size, shape, quality, and colour.

They claim that they have conducted similar techniques on landraces in the past, and that such skills have been passed on for generations.

Zhichen villagers, on the other hand, felt that Tuxpeno varieties had degenerated beyond their skills to improve them, and have hoped that the government will eventually step in, since they consider Tuxpeno a government variety. However, they know they must maintain their local varieties, as no outside agency is interested. Thus they choose to maintain the three local varieties based on their characteristics and usage. Some farmers maintain 'local white' for its sweet stalk. 'Local sticky' is a waxy variety used for local festivals; despite low yield, almost every household maintains a small plot in their vegetable garden. Lastly, 'Duan 1', an improved OPV from the 1960s, is maintained due to its strong drought resistance. The women organise themselves to maintain the three local varieties through spatial separation (grown in isolated gardens or separate valleys) and seed selection (select best cobs and then best seeds). Similar to Wenteng, Zhichen villagers claim that their ancestors have passed on this knowledge.

Some reflections

Farmers' breeding objectives reflect environmental conditions, market and institutional relations, socio-economic positions, and attitudes to risk. Zhichen farmers chose risk-averse strategies with their main consumption crop. Despite Tuxpeno's agronomic popularity, Zhichen farmers in highly unfavourable environments regenerated other varieties for nutritional value, cultural practices, and reliable production in the worst conditions. On the other hand, Tuxpeno serves Weteng's commercial crop requirements. Their production surplus extends their level of risk-taking. In addition, their more advanced skills of varietal regeneration may also reflect more land availability as compared with Zhichen, or better education.

Four issues arise in this study:

- gender should become an important factor in technology design as "feminisation of agriculture" is an obvious phenomenon here.
- informal seed systems and local knowledge show great potential, and merit more formal appreciation, especially if inter-institutional relationships are to improve.
- policy and privatisation limit scope for formal-sector support of farmer-breeding.
- relationships between farmer-breeding and risk-management needs further study in the context of varying environments.

UPWARD: Social Dynamics of Two Community Genebanks in the Philippines[20]

This project was initiated by the User's Perspective in Genetic Resources Research (UPWARD), a consortium of Asian agricultural researchers and development workers, with CIP involvement. Two community genebanks were set up in 1992 in Maambong and Dalwangan villages in Bukidnon, Philippines. These focus on root crops, which are the main staple food of poor communities. The main collection is sweet potato, although cassava, yams, taro and lutia were also collected. Aside from conservation, the project has two other objectives:

1. to determine the type of community dynamics that support or undermine conservation of germplasm and indigenous knowledge at local level, and
2. to transform household-level conservation into a more explicit group or communal activity, with more secure and widely-distributed benefits (Prain and Piniero, 1994).

Overview of methods

In Maambong and Dalwangan villages, UPWARD conducted "memory banking", interdisciplinary teams sought to complement genebanks in

20. This discussion draws from Prain and Piniero (1994), and Sandoval (1994).

recording and conserving genetic and cultural diversity (Sandoval, 1994). Collection and preservation of specimens, Rapid Rural Appraisals (RRAs), and benchmark socio-economic data were used to gather ethnobotanical information. However, it is unclear how this information was used in relation to the collections and project planning.

Following consultation, each village established a community genebank to be managed by a newly formed community organisation. For Maambong, the “Industrious Mothers” is an all-woman group with an informal structure. Dalwangan’s “Livelihood for the People” group originally involved men in the tribal community, having a formal structure with the tribal chief (man) acting as leader of the genebank. In total, there are about 35 farmer curators.

For both genebanks, site selection depended on land donation, and size was not planned. However, size was reduced, particularly for Dalwangan, as voluntary labour became limiting. For the “Industrious Mothers” in Maambong, each curator maintained one or two long beds laid out side by side in a single plot. Each bed was planted to cultivars of different root crops, with women planting individual collections from their farms. The source agroecolological diversity was not specified. This resulted in several duplications, while only one or two curators planted some rare types. Overall, the sweet potato collection increased from eight in the first planting to 19 in the second. Some collections were added from the Dalwangan collection and the research centre.

For Dalwangan’s “Livelihood for the People”, the curators pooled their collection in one communal plot. This reduced or eliminated duplicates, though there were no replications when cultivars were later lost: the sweet potato collection decreased from 38 to 11 between first and second plantings. Most of their collections were from the nearby agricultural research station: FVs were not collected as the farms were found to be too distant. However, it was not explained why individual farmers did not bring in their own material(s) to the genebank. Both communities reported detailed passport data.

Overview of results

For both areas, the need to conserve a wide range of local landraces for future benefits was not immediately apparent to the community. Though conservation of crop diversity is a common household strategy, its extent varies among farmers. UPWARD found it hard to translate the household management of genetic diversity into a “public” project. The project assumed that making conservation into a communal activity would improve seed security. However, the basis of this assumption has not been analysed in relation to the actual seed security of the villages. As a result, the justification for a genebank was not clearly understood by all parties concerned.

This lack of clarity of purpose was compounded by the extra labour required. Voluntary labour availability became a serious problem in maintaining both genebanks, although the "Industrious Mothers" in Maambong coped better. UPWARD provided incentives, for household or community benefits (e.g., water tanks) to keep both projects going. In Dalwangan, significant planting losses resulted from community neglect, due to unclear objectives and expectations. The tribal group thought it was for income generation, typical of many development projects. The chosen organisational name, "Livelihood for the People", suggests such a misunderstanding.

Despite incentives, the Dalwangan project was in near collapse when women from the community took over the genebank. Hence for both areas, women were a significant factor in the project's success, and appeared more interested and capable than men. The vehicle of rescue for genetic diversity is their home gardens.

Some reflections

Seed security in food crops is essentially the concern of women, suggesting potential links to genetic conservation and use. The project concluded that the kind of management of home gardens (generally women's domains) is a major factor influencing the success of community genebanks. While women are interested in participating in the communal genebank to obtain access to planting materials, this is additional to labour for their home gardens. UPWARD concluded that community genebanks may function better as a small number of home gardens rather than large communal plots. Though seed exchange systems were not described, increasing the exposure and access of participants to each other's cultivars appears useful, given the interest mentioned above. A local network of gardens could increase 'visibility' of individual collections through workshops or other collective fora, as seen in other cases.

Though skills-development is unclear, women's empowerment may come through more formal recognition of their contribution. Organisational skills developed are significant, especially if scaling-up is considered.

No data were provided on farm-level biodiversity, hence impact remains unclear. Because conservation is linked to utilisation, some materials will inevitably disappear, and communal genebanks are limited in the number of accessions they can maintain. Similar to CONSERVE, complementary roles with formal conservation are possible. When new cultivars arrive, individual curators take cuttings for their own on-farm evaluation: the project hopes that this will lead to the spread of new and more materials. Information on the screening and testing approaches of individual farmers, or the transfer of materials to other farmers in the communities is lacking, however.

UPWARD emphasised that building trust and respect were very important to the project's acceptance and success. This was to be based on equal partnership of farmers and researchers. However, researchers' interests were not explicitly presented: unless discussion of goals among those involved is more transparent, establishing a more equal relationship with farmers could remain elusive.

This project highlights a number of organisational lessons:

- project activities should reflect limiting factors for farmers. There should be a tangible added value of having a community genebank in relation to individual home gardens.
- related to the first point, household-level dynamics of conservation and use should be complemented, not replaced by community-level activities.
- variations in household conservation strategies and seed security need more study.
- women's activity in seed conservation and utilisation is significant and must be understood in relation to the organisational demands of a community genebank and women's home gardens.

CIAL: Farmers' Committees for Testing and Seed Production in Colombia[21]

While this case is largely a formal initiative, it has developed into independent farmers' organisations, federated in a farmer-managed NGO active in experimentation and including seed production. In 1990 the International Center for Tropical Agriculture (CIAT) helped form Local Agricultural Research Committees (Comités de Investigación Agrícola Local—CIALs) in Cauca, southern Colombia. The CIALs' main goal was to organise farmer committees to take responsibility for comparing new or unknown technologies with local technologies by means of formal experiments. Although the primary objective of organizing CIALs was not to introduce new germplasm but to organize local farmer-led research teams to evaluate the relative advantages and disadvantages of local and introduced technologies, the priority set by most communities for their research was to experiment with new species or new varieties. Eventually, it is hoped, farmers' independence would mean less public sector involvement in this adaptive on-farm research, and CIALs could effectively articulate research needs to formal institutions. This case study focuses on six CIALs that chose to experiment with varieties and have developed into independent seed producers, enterprises that commercially disseminate farmer-improved seeds within and outside their community.

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21. Sources for this case study are Ashby et al. (1995; 1996), and IPRA (1995).

Overview of methods

Around 55 CIALs were formed in Colombia since 1990, covering 50,000 families. Each CIAL has a core of four community-elected farmers, locally recognised as experimenters with leadership qualities. These, together with the members, identified and planned their research agenda with the help of a "paraprofessional farmer" trained in participatory research methods and facilitation skills by CIAT staff. Each CIALs was also supported by a host institution in the community, which can be a state agency, NGO or farmer co-operative. To enable farmers to take risk in experimentation, CIAT provided each community with a one-time donation to an experiment fund of US$500, owned by the community and administered by the CIAL, which must report regularly to the community on all their activities using the fund.

Germplasm inputs and the development of cultural practices were frequent starting points. CIAL members received training on priority setting and basic tools of scientific experimentation. Skills-enhancement included problem diagnosis, trial design and implementation, data analysis, documentation, and financial analysis of trial cost. Once CIALs selected germplasm from their trials, they received training in seed production techniques. Experimentation may combine scientific with folk approaches, though this relationship was not described. Other technical training included agronomic practices, composition of feed mixes, and green manuring.

Overview of results

In 4 years, over 1000 trials on beans, maize, peas, and ground nuts were conducted by the 55 CIALs. Germplasm inputs included local FV collections, FVs from other areas, and exotic materials. On average, on-farm trials carried out by CIALs had 60% less of the labour costs of similar trials run by extension agents, a good example of cost-efficiency for participatory research. The CIALs' impact was wide, but this case study concentrates only on the spin-off effect of the six CIALs which established small seed production enterprises.

This began with a CIAL in El Diviso: the success of their maize variety trials impressed other non-CIAL farmers, who wanted to buy seed. The CIAL in El Diviso thought that producing and selling their maize seeds would strengthen their committee, and increase their funds. With the help of a CIAT technician, El Diviso CIAL members surveyed 20 farmers, to investigate the number of prospective buyers, planting date, seeding rates, and the importance of maize in their village. Furthermore, after testing varieties for profitability, they selected four of their five new maize varieties for seed production. They requested additional training from CIAT in simple seed production, processing, and quality control techniques. Eventually, additional demand for seeds came from other villages.

Five other CIALs established their own seed production enterprises. Local crop varieties available in the village and if the community desires, farmer varieties from other villages or regions are included in all CIAL germplasm experiments in addition to MVs. One CIAL decided to select and improve the seed quality of their local variety and included it in the seed production along with MVs. At their annual regional meeting to which all CIALs send two representatives, seed samples are displayed and exchanged, and community-to-community visits are arranged by farmers wanting to obtain larger amounts of seed.

Seed production of six CIALS and estimated impact over one planting season

The project objective, to diversify and increase rates of flow of technologies to improve adoption, farm incomes and welfare has been achieved by the six CIAL seed producers' committees. These CIALs have selected new locally adapted varieties, and have tested and introduced a new crop, peas, into the farming system. Furthermore, farmer groups have initiated enterprises and demanded additional training.

Enhancing farmers' access to novel germplasm and technical support, and giving them considerable input in testing design enabled them to advance quickly with successful combinations. The quality seed brings measurable production increases, and in the case of peas, provides a new cropping option. Whether this yield improvement is based on improved genetic potential or timeliness of seed availability and seed quality is not known.

CIALs responded quickly to new market niches. Seeds produced are distributed through local stores and markets with approval from the national seed certification agency, under the category "farmer-improved seed". However, other countries may not recognise such seed (see p. 79).

More than 10,000 farmers have purchased CIAL seeds, which by the fourth year after inception of the CIAL program, generated production with a gross value of US$2.5 million over one planting season. In terms of per capita benefits, the value of the yield increase obtained by the 10,000 users due to planting with CIAL seed was equivalent to a months' income for an agricultural wage laborer. The local seed production also generated employment for planting, harvesting, sorting, cleaning, and packing, and demand for packing sacks, which are locally made by women.

Distribution of revenues from sale of seed differs by each CIAL, based on their own formulated policy. For instance, two CIALs formed and financed an independent seed production enterprise which no longer drew on the CIAL fund: a small percentage of the gross value of each bag of seed sold is contributed to the CIAL fund. For CIALs using their committee fund for seed production, profits are distributed between the committee and individual members, in proportion to their contribution of seed to the joint seed production. However, CIAT is cautious about the opportunity for newer CIALs to easily follow in the footsteps of these six CIALs, who may have exploited the best opportunity and windfall profits from seed production in these crops. Nevertheless, the experience shows impact of farmer research and seed production for new high value crops, like garden peas, for which opportunity for innovation still exists.

Some reflections

An important parameter for CIAT's assessment of the impact of the CIALs is the distribution of CIAL technology rather than number of participants in the committees. Strategically, the project does not work with 'representative' farmers, but seeks local farmer experts. However, CIAT also noted concerns about possible barriers to diffusion of the technology. While half of the poor farmers may know about their local CIAL, the accessibility/usefulness of CIAL germplasm and information to different social groups was unclear. Social differentiation needs to be better understood in this context. Firstly, what is the economic status of those farmers who were able to become seed producers, or seed purchasers? Secondly, to what extent are certain user groups (women and landless) able to pursue their priorities through CIAL? Women's participation was poor, and CIAT concluded that they needed to be specially targeted.

In the case of the CIALs, it may be difficult to involve the poorest farmers unless research activities are incorporated into other development activities that offer immediate benefits. Moreover, when expanding, successful farmer co-operatives/enterprises tend to seek relatively wealthier farmers to maintain financial viability. This might also be the case for CIAL? Poorer farmers may indirectly benefit through better and cheaper seed supply, lower cost of food, and increased labour opportunities, but this needs monitoring and verification.

This case highlights farmers' ability to adapt appropriate material and innovate with production and crop husbandry, and points to possible modes of formal support and links. CIALs showed the merit of working with organised farmers groups to define objectives, conduct experiments, enhance skills, and exploit new market niches. Farmers' empowerment indicators include:

- skills (both in experimentation and organisational management)
- monetary gain, and
- capacity to make own demands from institutions for services.

However, social differentiation within communities needs further study. Finally, appropriate policies are important in supporting farmers' efforts in seed production and distribution.

Summary of Case Studies

These 11 case studies present a reasonably representative cross-section of programmes at the forefront of practice in farmer-led PPB. They describe activities taking place in Africa, Asia, North and South America. Crops across all breeding systems are featured: self-pollinators include rice, beans, wheat, barley, and peas; maize is the predominant cross-pollinating crop; and potatoes and sweet potatoes are propagated vegetatively. Crop types include cereals, vegetables, pulses, and root crops, of either Farmer or Modern Varieties.

Equally diverse is the type of initiating institution, including IARCs, NARS, NGOs, independent farmers' initiatives, and social movements. These rarely act alone, but often have ties to other organisations. Goals and approaches also show much variation. Enhancement of farmers' livelihoods and options through new or improved crop varieties is, not surprisingly, a central goal of most cases, but this is often tied to promoting self-reliance, or to conservation. Common strategies involved germplasm inputs, usually with testing by farmers, promotion, and some attention to storage and seed supply. Crop improvement also occurs, often related to enhancing farmers' skills. Finally, these projects often promote links between groups, and some offer indirect support to farmer-breeding through market development or advocacy. The following chapter compares goals and strategies more systematically.

A series of broad lessons can be drawn from these cases:

- exposure to new germplasm often meets an important need among farmers.
- such exposure usually needs to include variety testing by farmers and promotion.
- most importantly, attention and support to farmers' seed systems is needed. This may reflect either the challenges faced by formal seed supply, or the desire of farmers for control over seed supply, both rationales for PPB.
- local crop improvement may be necessary in some contexts, and farmers can display much enthusiasm and patience for such work.
- conservation should not be seen as an isolated activity, but tied to crop development.

- PPB projects and strategies are shaped by the institutions promoting them, and this may pose particular challenges for links between institutions.
- marketing and policy arenas are other important areas of support.
- skills-development, and self-reliance in areas such as seed supply may offer useful indicators for empowerment.

In the next chapter, we consider in detail what cross-analysis across these cases can offer.

5. Discussion

This chapter compares and contrasts farmer-led PPB approaches from the cases described above. The aim is to synthesise lessons learned, while gaps and key opportunities for future work are summarised in the concluding chapter. Though this discussion looks mainly at practical issues in PPB, we reflect upon broader issues, where appropriate.

The chapter is organised into five sections. First is an overview of the cases in terms of agroecology, goals, approaches, and key germplasm-related activities. Second is a discussion of breeding strategies and experimental methods. Following this, we explore how different kinds of farmers are involved. Fourth is a discussion of institutions and PPB, and the final section considers the transfer of benefits by farmers, both for information and seed.

This analysis considers the different priorities and concerns espoused by practitioners. No one case addresses all these issues: each case has its own priorities and raises valuable insights. Further inquiry is not meant as a critique of any case, but more to probe trade-offs (e.g., biodiversity conservation and crop development). Only by better understanding such trade-offs can we start to weigh methodologies, and hopefully harmonise different goals for PPB.

Overview

Agroecology

Table 4 outlines case studies' broad agroecological situation. Only REST, and some activities of PTA and Guanxi (in Northeast Brazil and Zhichen village, respectively) operate in the most unfavourable contexts, where crop failure can occur. Activities for Guanxi (Wenteng village) and some areas of USDA and CONSERVE are in favourable agroecologies, which generally also include good access to markets and infrastructure. Most cases are intermediate between these two poles.

Though PPB discussions sometimes suggest that 'marginal' or unfavourable areas may have particular relevance (as in hypothesis 2), Table 4 shows that there is farmer-led PPB activity across a wide

Table 4. Broad agroecology of case studies.

Unfavourable		Intermediate		Favourable
REST		CIAL		Guanxi[a]
	PTA[a]		USDA[a]	
			CONSERVE[a]	
		UPWARD		
		SOH		
		BBA		
		SAVE		

a. Cases with activities in different agroecological regions.

agroecological range. This suggests that the ability of (formal) seed systems to reach certain farmers, or to **meet their goals**, may be a more relevant indicator for interest in PPB than agroecology alone (though these factors can be related). For instance, farmers in CONSERVE and Guanxi (Wenteng) pursue their own selection and seed supply because the formal sector does not serve their needs.

Germplasm-related activities

Central to most farmer-led PPB activities is the introduction or manipulation of germplasm. Table 5 presents an overview of germplasm-related activities for analysed case studies, in bold, including other cases for comparison. Many cases supported seed systems for supply or storage; all cases (except Zamorano) seeking conservation/improvement (Table 6) included community seed banks, for example. In some cases (e.g., CONSERVE) *ex situ* storage served as a formal backup.

A number of cases involved farmer selection activities. Some cases for maintenance of pure types for home use (Guanxi), or commercial seed production (SAVE, CIAL). Other cases sought improvement through isolating interesting variations (USDA, BBA), or through more directed selection for specific traits (CONSERVE, REST, PTA, Zamorano). CONSERVE was the only project giving farmers early-generation crosses, for rice, thus cross-pollinating crops (primarily maize) were the main sources of widely segregating materials for farmer selection.

The crops subject to farmer-selection are mainly staple food crops; minor crops, thought to be good candidates for farmer-breeding, are more notable by their absence. This could be due to greater farmer interest in important crops (see hypothesis 4), or to their available diversity. It may also reflect better access to information and technical support for major crops, a factor that may influence the choice of support agencies (like NGOs) more than farmers.

Table 5. Main germplasm-related activities of (**bold**) in-depth case studies.

Cases	Germplasm[a]		Crop improvement[b]	
	Inputs	Storage	Selfing	Segregating[d]
BBA	x	x	Several crops	Several crops
BDI	x	x	Wheat	
BPP	x		Rice	
CIAL	x		Beans, peas[c]	Maize
CIP	x			
CONSERVE	x	x	Rice	Rice
MASIPAG	x	x	Rice	
Northern seedsavers		x		
PTA	x	x		Maize
REST		x	Barley, wheat	Maize, sorghum
SAVE	x		Rice, sweet potatoes[c]	
SOH	x			
Guanxi				Maize
UPWARD	x	x		
USDA	x		Several crops	Several crops
Zamorano				Maize

a. Germplasm - inputs: supply and testing of germplasm. Storage: support to seed storage, such as through community seed banks.
b. Improvement - deliberate selection to pursue of certain goals.
c. Produce seed for commercial production.
d. Segregating: includes open-pollinated species, and populations that are widely segregating, following hybridisation.

Overview of goals

Table 6 gives an overview of the principle goals and main approaches of the in-depth case studies, describing the type of initiating institution. Many of the cases work with FVs; thus interest in conservation is not surprising. What is interesting is that they mostly saw conservation and improvement as inter-linked, and classifying them as distinct goals was not always possible or useful. Conservation and use are reciprocal goals in farmer-breeding: continued use conserves FVs, while a conservation programme that ignores crop improvement may be or unethical or unsuccessful. Practitioners thus hope to avoid the either/or nature of the conservation vs. development debate. However, how well different PPB strategies achieve either goal, or the possible trade-offs involved are still relatively unknown. This will only come with detailed measurements over time.

Table 6. Cases showing their main goals and approaches taken.

Case[a]	Principle goals				Broad approaches				
	Conserve/ Improve germplasm[b]	Introduce new crop options	Promote self-reliance[c]	Adjust to change or disaster	Germplasm support		Skills development	Promoting links	Indirect support
					Local	Non-local			
BBA	FV		X			X			x
CIAL		MV/FV				X	x	x	x
CONSERVE	FV/MV		X		x	X	x	x	x
PTA	FV/MV		X		x		x	x	x
REST	FV		X		x		x		
SAVE		MV				X	x		
SOH	FV/MV			x	x	X		x	
Guanxi	FV/MV		x				x		
UPWARD	FV				x	X			
USDA		FV				X		x	
Zamorano	FV		x				x		

a. Main institutional type: **bold**: NGO; **underlined bold**: farmers' group; *Italic*: NARS; plain text: CGIAR.
b. FV: Farmer/local varieties; MV: Modern Varieties.
c. Seeking to regain farmers' control over seed supply or variety development that had previously been lost.

Though many projects introduced germplasm as a basic step in crop improvement, three cases made a central aim to expand farmers' options by supplying crops species that were new to an area. SAVE and CIAL introduced MVs, while USDA, operating at the dawn of professional plant breeding, still mainly distributed FVs.

Programmes with self-reliance as a goal sought to (re)gain farmers' control over key processes. This usually related to seed supply, but also to crop development; the latter goal closely related with skills-development as a PPB strategy. Notably, farmers' groups or NGOs generally initiated these cases.

SOH was the only case in this sample to respond directly to disaster or dramatic change, despite the potential need for farmer-led PPB to work in such situations. Agencies are only starting to appreciate the importance of rehabilitating seed systems (Richards, Ruivenkamp, et al., 1997), but interest is growing rapidly (e.g., FAO organised discussions on this topic in 1998), spurred in no small measure by the lessons learned from SOH.

Overview of approaches

Germplasm. The broad approaches in Table 6 parallel the PPB framework categories outlined in Chapter 3. Germplasm support was a common approach, working with both local and exotic material. Local germplasm support increased exposure to FVs from the area, through enhancing seed systems (CONSERVE, REST, SOH, UPWARD), or through increasing their visibility and accessibility (CONSERVE, PTA, UPWARD). These activities are tied to an interest in conservation/improvement of local germplasm. Supply of non-local varieties related to the introduction of new crop options as a central goal (CIAL, SAVE, USDA), or to the conservation/improvement of FVs from other regions (BBA, CONSERVE, UPWARD). SOH supplied local and non-local materials to help the previous system recover and adjust to change. Germplasm involved collection and storage, and often included evaluation and screening, discussed below.

Scale of germplasm collection and supply relates to the scale of the organisation: in BBA, REST, and Guanxi, farmers are solely responsible, and the latter two worked mainly with local materials (though with thorough collection). Occasionally, farmers do travel to obtain varieties, but systematic searches involving distant travel or material held in genebanks, pose considerable challenges for most farmers. Even BBA, a farmers' group with remarkable commitment and organisation, found such a task arduous. Supporting institutions could make a significant contribution in supplying distant or formally-held materials: development workers on their own (USDA, CIAL, SAVE), or working with farmers (CONSERVE, PTA, SOH, UPWARD) have supplied germplasm out of farmers' reach.

Several cases supported storage, the other major complementary activity, through community seed banks (BBA, UPWARD, CONSERVE, REST, PTA). On-farm storage, generally is effective for the short-term, though the latter three are considering ways to back this up. Such complementary methods are important to avoid accidental loss or to cope with growing collections. CONSERVE offers one model of an NGO forging an agreement with a formal institution for back-up storage *ex situ*. Though complementary strategies excite much enthusiasm (e.g., Cooper et al., 1992), barriers to institutional interaction may constrain such initiatives. Section four raises this matter in detail.

Skills. Farmers responded enthusiastically to skills-development, especially when this could improve their production potential. External agents generally helped transfer of new information and skills: CIAL, CONSERVE, PTA, SAVE, Zamorano. Well-documented training materials are valuable in developing and disseminating effective methods in skills-development. While CONSERVE, CIAL and Zamorano have training modules, only CIAL's is widely available, and has been adapted for use in other countries (Ashby et al., 1996). Though not possible here, a comparison of different methods would be valuable in assessing effective training approaches.

In all farmer-farmer transfers, especially of 'new' skills, there is a risk that misconceptions develop, which can subsequently be replicated. Monitoring and evaluation are important here, but how most cases followed up on training is unclear. Evaluation criteria reflect different aspects of impact. It is important that farmers understand the principles, of course, but being able to adapt these principles to different situations and levels of resources is even more so, as it relates to long-term impact. However, this is difficult to assess: indirect indicators of adaptive understanding may include the rate of spread of a practice, or the evolution of roles between farmers/ users and researchers, as seen in CIAL.

Difficult questions remain on whether skills-training offers a better approach to crop development. Exclusive attention to training may be ineffective if other aspects, such as access to diversity, are ignored.

Links. Both farmers and formal institutions initiate links to obtain ideas, skills, and germplasm, and to support their work. Since farmers and institutions enter into relationships as part of their normal course of affairs, we only consider where **new** links are being promoted. Table 7 shows a schema, listing example cases.

Farmers promote links among themselves through extending their own informal networks: this was particularly evident in cases initiated by farmers' groups (BBA, Guanxi). However, other projects cam also lead to farmers promoting links: farmer groups in both CIAL and REST (unconfirmed) organised their own sessions with other farmers to

Table 7. Possible forms of linkages that could be promoted in farmer-led PPB, with representative cases.

Linkages	Between farmers	Between farmers' and formal institutions	Between formal institutions
Promoted by farmers	BBA, Guanxi, CIAL, REST	BBA	
Promoted by supporting institutions	CIAL, PTA, CONSERVE, REST, SAVE, UPWARD	PTA, REST, SAVE, USDA	SOH

extend practices learned[22]. When support workers initiate links among farmers, it is largely through organising farmers' groups or associations (CIAL, SAVE, UPWARD, REST), or through facilitating networks and workshops (CIAL, PTA, SAVE). This promotion may play an important role, as noted in SAVE, where the farmers' clubs prevented a few individuals from hoarding new material.

Farmer-formal links are often over germplasm. BBA's efforts were an exception as the only farmer-initiated link (but this was for markets, not research). External support could help farmers place demands on breeders or genebanks, with NGOs, co-operatives, or farmers' organisations serving as a conduit for information and material. Again, the promotion of farmer-institution links could pass to farmers' hands as projects evolve. Only SAVE attempted to promote links that would out-last the project, though war prevented the realisation of this effort. Overall, there was little discussion on how to promote linkages that persist without project support; this represents a significant gap.

Finally, only SOH was active in promoting new formal-formal institutional links, perhaps reflecting SOH's status as an international coalition involving IARCs. Formal networks could greatly support farmer-breeding (e.g., through a seed security network), and the proactive fostering of them is worth more attention, especially for crisis situations.

Indirect support. The fourth approach presented in Table 6 is indirect support to farmer breeding. This has involved either market development to generate income for farmers (CIAL, BBA), or advocacy work around policy issues, particularly seed laws and Intellectual Property Rights (IPRs) (CONSERVE, PTA).

22. Currently, there is an impact study on how the CIAL's have evolved in Brazil.

Breeding Strategy

In this section we explore breeding strategy and related experimental methods across cases. The range of methodological options involves trade-offs around impact, both apparent and implicit. While we hope to stimulate reflection about methodological choices, such reflective discussion was sparse in the cases themselves. There may be several reasons for this:

- constraints limited the methodological choices many cases could consider, e.g., limited land restricting the number of testing sites.
- some projects may have felt they lacked the technical background to discuss different options.
- plant breeding methods themselves are not strictly standardised: they reflect the breeder's experience, and may be informed judgement calls as much as explicit choices among all possible options.

We discuss strategies in terms of establishing goals, followed by selection methods and testing approaches, closing by relating support strategies to project goals. Bearing the above points, particularly the last, in mind, we attempt to highlight where options may have clear implications.

Setting of goals

PPB requires flexible and sensitive approaches to setting goals. A general aim of farmer-led PPB is to support, rather than supplant, farmer practices. Diagnosing the constraints for different stakeholder to farmer-breeding (i.e. germplasm, access to information, or policy barriers), can help prioritise goals and support strategies. Farmer-initiated work, as in China and Brazil (Guanxi, PTA) implicitly reflects their own assessments of needs. Most cases, however, are external agencies offering support to farmers, with specific strategies arising through discussion with farmers (CONSERVE, REST), or through an assessment of farmers' needs from previous studies (e.g., SAVE, SOH, Zamorano). A discussion of how needs may differ among different types of farmers, or other stakeholders, was generally absent. A stakeholder analysis is one approach to understanding how users' goals may differ or converge.

Some cases, like UPWARD and PTA, describe their processes for setting priorities with farmers. In general, however, there was little discussion of the goals-setting process in PPB, or more importantly, a comparison of different methods (Weltzien R. et al., 1996, being an exception). This may constrain monitoring and evaluation, and limit the scope for participatory appraisal.

Selection methods

A number of projects pursue crop improvement (Table 5), usually through selection. For cross-pollinated species (mainly maize), cases sought to maintain desired types through spatial or temporal isolation. However, constraints to land or labour made it difficult for many farmers to isolate desired types individually on their farms. PTA and Guanxi found that community co-ordination could help farmers with closely spaced holdings control pollen-flow. Farmers' and community organisations play an important role in such co-ordination.

Farmers are interested and skilled in selection across breeding systems, and show enthusiasm for—and adaptation of—training in selection (PTA, Zamorano, REST). Teaching basic principles of fertility and pollination and encouraging flexible adaptation appeared effective in transferring skills in Zamorano. There was little mention of difficulties in farmers' understanding or use of concepts (though this may well occur, see p. 61).

Modifying traditional practices, to stratified mass selection, seemed to be a promising approach for dealing with environmental variation. Farmers are encouraged to select the best-performing plant, at regular intervals in the field (such as on a grid), to compensate for micro-environmental effects. Zamorano's initial evaluation suggests that this approach is more efficient than bulk selection in achieving yield gains (Gómez and Smith, 1996). However, there was little systematic comparison of selection methods for effectiveness in other cases. Effectiveness, of course, will depend to a large extent on the heritability of a trait under farmer conditions of genetic and environmental variation[23]. Farmers should have better results for traits controlled by few genes (oligogenetic), or with low environmental interactions, than for quantitative traits, or other traits not easily observed, like disease-resistance. Atlin (1997) suggests that replicated testing across environments is necessary to improve quantitative or cryptic traits beyond a few cycles. This is another area where formal breeders could assist. Though the division of tasks between farmers and breeders also has implications for the number of participants and the scale of work, there was little discussion among case studies about options for **how** or **when** (e.g., which generation) such a division may best occur. Methods for more difficult traits, and fruitful uses of formal breeders' skills merit more consideration.

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23. Presently, D. Soleri (pers. comm.) is measuring heritabilities in farmers' fields for important traits for maize in Mexico, adapting methods from S. Smith et al. (1998).

Testing

Testing methods for selecting and screening germplasm strongly reflect the types of institutions involved, whether formal or farmer. Germplasm introductions are characterised and evaluated to assess usefulness, either exclusively by farmers (BBA, Guanxi, USDA), or with significant formal input (CONSERVE, UPWARD). Testing and information could remain very local (BBA); other cases have tried to support information transfer across farmers and testing locations. PTA noted that farmers generally found information from single, large plots more meaningful than large, replicated ones. CIAL also sought experimental methods that farmers could appreciate, finding that, with some guidance, results were equally meaningful to researchers as to farmers. Though teaching farmers to rigidly apply formal testing methods may be misguided, trade-offs between formal and farmer methods may not be as sharp as feared. However, we need to know more about farmers' and breeders' ways of knowing to better understand how their perspectives converge or differ.

Testing methods matter in understanding GxE interactions: when E (social or agroecological) varies, the number and location of testing sites is an important consideration. Some cases worked from a single large community plot, while others decentralised to individual farmers or to groups. However, testing sites may be very different from ultimate destinations. One PTA community noted that their single selection plot biased their results because of fertility differences from the rest of the community, so they added another, more representative, site. Other projects did not mention systematic bias due to testing/ selection location; if this bias were against a particular group (e.g., poorer farmers) it may not even have been noticed. As with selection locations, choice and analysis of testing locations may be a fruitful area for formal technical support.

Farmers, however, may be able to extrapolate observations from a testing plot to their own fields (Sperling et al., 1993). SOH used baseline information from previous studies to target relief seed to particular ecologies, obtaining higher yield than if varieties had not been targeted. Large-scale testing and targeting may be beyond more informal institutions' capacity, especially since provenance and evaluation information is often incomplete, even from formal genebanks (van Hintum, 1994). To reach specific user groups, there may be trade-offs between testing a wide range of materials, and testing in a number of different sites.

Farmer management affects crop performance. Anil Gupta (pers. comm., 1997) terms conscious modification of phenotype “auxiliary selection”; for example, women can modify cassava tubers before harvest to influence growth forms (ibid.), or after harvest to limit toxicity (Chiwona-Karltun et al., n.d.). Differences in management may need more attention, especially when considering different user groups.

Impact in relation to project goals

Production. Goals that were clear to participants, and which could offer tangible local benefits, significantly contributed to projects' success. Generally, strategies appeared effective in improving crop performance of cropping options. Germplasm support to increase available supply of diversity (e.g., CIAL, PTA, SAVE, SOH), clearly contributed to production gains, as did work on crop improvement and seed quality (Guanxi, REST, Zamorano). Support to local storage and seed supply helped improve security of access to materials (e.g., REST, PTA), with probable production and equity impacts.

Conservation. The degree and nature of genetic improvement was not always clear, nor was the balance with conservation. Several cases hoped to link crop improvement, or seed system support, to conservation of (local) genetic diversity through use. This assumes a link between farmers' goals (e.g., yield stability) and diversity (BBA, CONSERVE, PTA). So far, evidence of PPB's potential to add value to local materials and support on-farm conservation is encouraging, but we stress that relationships between farmers' decisions and genetic diversity are only starting to be explored (Jarvis and Hodgkin, 1998).

Difficult questions persist over how to quantify diversity. Most cases consider varietal diversity, based on morphology which farmers can readily assess. Other measures may offer richer, even contradictory understandings of diversity changes, though only SOH is using molecular techniques to complement farmer assessments. This remains a rich area for future exploration (and for formal collaboration). Unfortunately, very few projects have even conducted baseline studies on diversity or production, or have made their results and methodologies available. This is a missed opportunity to learn more about methods for measuring diversity or crop development with local people.

Processes are as important as the material itself in biodiversity conservation (Bellón, 1996b). BBA, CONSERVE, PTA, and sought to maintain diversity through their selection and crossing approaches. Berg (1996b) points out that theory and a few long-term studies suggest that mass selection methods may be effective in this regard. However, initial genetic diversity remains a prerequisite: most cases gave attention to introducing and disseminating diversity, though inbreeding was a concern in at least one case.

Distinct patterns appear in Table 6: those with a priority on self-reliance do not focus on introducing new crop material. Cases emphasising conservation generally tied this to use of FVs and community seed banks. MVs, and ties to formal genebanks and breeders tended to be less explored. The consequences of new varieties for FV use are complex, but simple replacement by MVs is often less direct than feared (Brush, 1995). Linking conservation exclusively to FV promotion may sometimes limit farmer choice. The initiating institution may greatly influence the strategy pursued—or not pursued; we discuss this more under Institutions in Farmer-Led PPB (p. 73).

Links. Promoting links as a strategy also supports conservation and development goals through improving access to material and information. Working through established institutions and networks was useful, and forming new local institutions, such as community genebanks or farmers' clubs, was effective when tied to benefits for users.

Empowerment. Finally, despite empowerment being difficult to measure, some cases present useful indicators:

- users gain more control over processes of farmer-breeding through receiving material or skills
- users gain control over processes and decisions as relationships evolve.

In this sense, germplasm supply and local seed system support often contributed to user empowerment (e.g., PTA, BBA, CONSERVE). Skills training is also valuable, though perhaps more so is helping farmers develop a critical awareness, linking farmer-breeding to wider issues (PTA, CONSERVE).

There may be trade-offs between methods that farmers can understand and manipulate, and methods that are more challenging, but might better achieve breeding or conservation goals. A similar choice is between maximising farmers' choice for selection by giving them early-segregating material, and giving them a narrower range of fixed lines that they can easily manipulate. Formal input on difficult or time-consuming tasks does not necessarily dis-empower farmers: they may feel it saves them time. More central for empowerment is the degree of farmer control over goals and other decisions.

Costs and benefits. Better analyses of the cost of PPB would offer valuable comparisons with formal breeding programmes. Only USDA and CIAL measured financial benefits (the market value of new crops). Some PPB goals, such as empowerment, skills-development, or changes in policy or researchers' attitudes, are not easily quantified and may only appear in the long-term. Impact indicators warrant much more consideration and discussion.

On this topic, there is an emerging body of experience on participatory evaluation, where beneficiaries set indicators and are involved in the entire evaluation process (Selener et al., 1996). This allows communities to critically re-assess a programme underway, and adjust their goals. Some cases in this sample undoubtedly used participatory evaluation. Though we could learn much from the process and indicators used, and from the conclusions, no details were available: such 'process documentation' would be a valuable addition to the PPB literature.

Involvement of Different Users

The types of users directly involved also shape PPB's effectiveness, through their roles in farmer-breeding and their relationships with other users. This section first overviews who participated in cases, and how they were involved. A discussion of difference in gender, wealth, and knowledge follows, with a consideration of barriers to participation in PPB technology closing the section.

Overview

Table 8 presents different dimensions of farmer involvement in PPB work. Participants in most cases can be clustered in two broad profiles. "Experimenting farmers": those with a particular interest, and possibly aptitude, for trying new germplasm and selection approaches (CIAL, Wenteng village in Guanxi, SAVE, USDA, Zamorano). This correlated with more formal institutions seeking to introduce germplasm and skills. "Poorer farmers": seed insecure or more vulnerable farmers, and those seeking lower input use (BBA, CONSERVE, Zichen village in Guanxi, PTA, REST, SOH). These tended to be NGO or local initiatives to support the seed system for security and diversity of access. These two clusters overlap to some degree: experimenting farmers can be seed insecure, for example.

Selection processes describe both selection of participants and of lead collaborators. Many beneficiaries selected themselves in receiving germplasm (USDA, Guanxi, BBA) or purchasing seed (REST), though some had to organise in clubs (SAVE) or contribute labour (PTA). Lead collaborators sometimes advance themselves due to their organisational experience (BBA) or social status (UPWARD's tribal group). However, other cases elected community representatives (REST, CIAL, CONSERVE). User involvement is influenced by the transparency of social relations around these institutions (community associations, clubs, elected councils). Participation may be limited because of this, or other factors, discussed below.

Links with local institutions can facilitate reaching broader groups of users (e.g., via NGOs: SOH, Zamorano), or help integrate with other projects (REST). Membership-driven associations and co-operatives, such as those linked to CONSERVE and PTA, could show the greatest potential for reaching otherwise neglected farmers.

Table 8. General overview of farmers' involvement in PPB work.

Case	Profile of main participants[a]	Gender involvement[b]	Links to local institutions	Selection processes[c]	Specialist involvement[d]
BBA	Low input farmers	M	NGO	Self-selection	Yes
CIAL	'Experimenting farmers'	M (F)		Election by community	Yes
CONSERVE	Low input farmers	M (F)	Co-operative	Election among tenants	
PTA	Poorer farmers	M/F	Farmers' org. + labourers unions	Membership + labour	
REST	Poorer farmers (seed needy)	M/F	Local government	Election by community	Yes
SAVE	'Experimenting farmers'	M (F)		Self-selection	
SOH	Seed needy farmers (most farmers?)	F (M)	NGOs + local government	Large random sample	
Guanxi	Poor + market-oriented farmers	F		Self-selection	
UPWARD	Women + tribal farmers	M + F		Gender/ethnic identity	
USDA	'Experimenting farmers'	M (F)		Self-selection	Yes
Zamorano	'Experimenting farmers'	M	NGOs (+ extension?)	NGO sponsored?	Yes

a. General description of most participants, separate groups denoted by a "+".
b. Gender: Main activities involve M – only men, F – only women, M/F – both, M (F) – primarily men, M + F – separate men's and women's groups.
c. Process for selecting lead participants or respondents.
d. Technical activities carried out by farmers recognised as being particularly skilled in those particular tasks.

Difference

Gender. Despite women's central role in farmer-breeding, their involvement was limited in these PPB cases. Though Guanxi and UPWARD had women-only groups, and many of the beneficiaries of SOH and REST were women farmers, other projects acknowledged low active participation of women (BBA, CIAL, CONSERVE, SAVE). Moreover, there was little mention of engaging women in project decision-making.

Several factors limit women's involvement in PPB:

- focus on major crops within the male sphere of control (Table 5), rather than for vegetable and minor crops generally controlled by women.
- though active in most farmer-breeding processes, women often exercise little decision-making control.
- productive and reproductive responsibilities may limit women's time to participate in PPB activities.
- even when present, social constraints may restrict active involvement (e.g., few women were elected to CIAL committees).

Some projects sought women's input and feedback separately, since ignoring their contributions would be detrimental to project effectiveness. Few cases discussed activities in terms of supporting women's specific roles in breeding, or considered their impact on gender roles. Choice of crop, activities within farmer-breeding, and mechanisms to seek participant involvement and control all has gendered implications: more evaluation of gender impact is needed to assess this, however.

Wealth/status. Like gender, the wealth/status of participants may influence farmer goals, e.g., poorer farmers may prefer material that performs well under low inputs. While some projects tended towards relatively poor and seed-insecure farmers (BBA, CONSERVE, PTA, REST, Zichen village in Guanxi), others took a less targeted approach, in the hopes of benefiting a cross-section (CIAL, SAVE, SOH, UPWARD). In different ways, these latter four cases considered how differences in wealth/status affect the degree and nature of involvement.

Only SOH conducted an impact evaluation differentiated by wealth, finding that poorer farmers had less access to seed. CIAL and SAVE noted that their clubs were biased to more well-off male farmers. SAVE chose to "co-opt" rather than exclude ruling families from their clubs, helping activities to spread to all types of farmers without arousing resistance. Members of UPWARD's group for tribal peoples included only their élites. SAVE and UPWARD's inclusion of higher-status farmers was perhaps strategic, but involved different trade-offs.

SAVE found that wealth influenced choice of crops in their clubs. UPWARD found a trade-off between roles and status that seems to have actually constrained success, as the tribal leaders (unlike UPWARD's women's group) had little skill or interest in seed and food security.

Poverty may in other ways constrain participation. For instance, tenant-farmers in both SAVE and CONSERVE have less freedom in crop and management decisions: some of CONSERVE's participants needed to ask landlords' permission to switch to low-input technologies. Zamorano farmers accepted incurring costs for materials (string, pollination bags, etc.) as an investment, as they were taught that crop improvement may not be obvious for several seasons. Still, poorer farmers may be unable to face such costs or risks. Some projects linked participation to labour inputs (e.g., PTA, Guanxi), though the poorest farmers may be unable to spare even this. CIAL lowered individual risk with a fund to cover trial costs, while other projects spread risks through community-level involvement. The costs and risks of participation, as well as the time required to realise benefits, remain issues across all PPB work.

Knowledge and expertise. Nearly half the projects involved recognised local experts at some point. This facilitated practical breeding work, experimental design (e.g., numerate members of CIAL clubs), or links with formal institutions (Zamorano, USDA). Provided benefits spread more widely, it can be efficient to work with only a few farmers at some stages. Giving attention and external support to experts and their skills may also raise their public esteem, especially for individuals or activities that were previously neglected (such as seed selection in REST).

While not questioning the potential place of specialised participants, we argue for a critical assessment of how people and processes are socially-embedded in farmer-breeding. For instance, farmers with breeding expertise are not always central to networks for seed or information exchange. Also, while such networks often do centre on prominent individuals (e.g., because they are able to produce better **quality** seed), they sometimes exclude certain farmers (Green, 1987; Sthapit et al., 1996). When expertise does not coincide with social power, as with women and seed selection in BBA, sources of knowledge may be excluded.

As important as **who** is involved in specialised tasks is the type of institution involved, and how it transfers benefits to different users. We discuss these issues under Institutions in Farmer-Led PPB (p. 73) and Transfer of Benefits (p. 78).

Biases to beneficiaries within the technologies themselves

Technologies themselves can shape participation. Despite a general concern for making approaches and materials accessible to the poor, there was little assessment or discussion of how adoption may vary by users, or of the factors that influence this. Possible technical factors include choice of crop, testing site, selection criteria, and skills-development approach, all of which have been mentioned above. SAVE distributed seed packets to many farmers in a small packet size to avoid the seed becoming a resource for local interests to hoard or control (small packets may also help keep prices affordable for poor farmers). Wealthier farmers in SAVE clubs sought oil-palm seedlings; tenant-farmers lacking control of land could gain little benefit from this, so project workers ensured other, more poor-friendly crops were included as well.

In summary, restrictive social structures may constrain involvement of some groups. Relationships are not static: some cases show the changing nature of farmers' involvement over time. Finally, not all users need direct participation in PPB to benefit, an important consideration given the amount of other tasks farmers—especially women farmers—have to do. These points underscore the importance that goal-setting be participatory manner and take account of different stakeholders.

Institutions in Farmer-Led PPB

Farmer-led PPB embraces a wide range of institutions. We start with an overview of the current forms, followed by a discussion of participation, funding arrangements, and scale. The discussion closes reflecting on the advantages and challenges of co-operation and building links across different institutional types.

Current institutional arrangements

At first blush, the case studies in our sample can be divided into four different groups (Table 6). Projects may be:

- initiated and entirely run by farmers' groups: BBA, Guanxi.
- started by NGOs: PTA, CONSERVE, SAVE, UPWARD, and REST.
- CGIAR-based projects: CIAL and SOH (though these are also linked to other institutions).
- associated with a NARS: Zamorano, USDA.

Such broad institutional categories mask considerable diversity, and Okali et al. (1994) conclude they have little value on their own for discussing the division of labour in agricultural research. For instance, perspective, approaches, and skills vary widely among NGOs involved in agricultural research (Farrington and Bebbington, 1993).

Given their local roots, farmers' organisations should be even more diverse. We consider other distinctions below.

Institutions and participation

As outlined in Table 8, groups are common in PPB, established both by members and by external agents (though lead collaborators may be internally-selected: REST, CIAL, CONSERVE). Social differentiation and internal group dynamics greatly affect the nature of member involvement and accountability, even in member-driven groups. Politics may be implicit within institutions, and rapid or group approaches to seek 'consensus' may only stifle divergent views. For example, an Ethiopian study found that while government agents and policy makers preferred Participatory Rural Appraisal (PRA) to diagnose socio-economic issues, farmers felt undermined by local political leaders in group meetings, and preferred giving their views in private (Bekele-Tessema, 1997).

Local political or economic institutions like labour-unions or co-operatives (for example, with PTA and CONSERVE) often have more established structures for transparency, and active member involvement, as resources are directly at stake. Experience elsewhere (e.g., Sperling and Scheidegger, 1996), and with CONSERVE and PTA, suggests that groups grounded in mutually-beneficial activities can contribute to project sustainability, as members maintain a keen interest in their representatives' actions.

Most cases hope to reach beyond those initially involved, thus the dynamics between PPB groups and surrounding society are relevant. CIAL and CONSERVE endeavoured to maintain community involvement by rotating committee leadership from community members. Working with women's groups may tie in well with their role in household and community food security, as seen with the relative success of UPWARD's women's group. Still, institutions, including women's development committees, can sometimes be vehicles for special interests. Approaches to strengthen a community's sense of 'ownership' of a project need further exploration.

Finally, non-farmer user groups, such as landless farm labourers, urban consumers, or seed merchants, may be significant stakeholders yet have different interests than farmers (Lipton, 1989). Their voices may not be heard in community-level fora. However, structured involvement of non-farmer users in planning or in setting goals remains a gap in PPB practice.

Funding and scale

Though the cost of farmer-led PPB can be modest, as farmers support much of the work themselves, most cases incurred costs for training and technical support. Also, cases paid local people for wage labour (BBA), honoraria (for farmer-selectors in REST), or to lower the risks of participation (CIAL's trial funds).

The geographical scale of activities was related to funding: the most local projects, Guanxi and BBA, received no formal donor support, while USDA and SOH required considerable resources for their large geographical and crop range. Most cases received external funding, from sources including international donor-funded programmes such as the CBDC (PTA, CONSERVE) or CGIAR (SOH, CIAL), but also from non-agricultural sources such as a mining company (SAVE) or Northern trade-unions (PTA). Only CIAL mentioned marketing their products, though SAVE had also planned seed multiplication and marketing, and BBA reportedly hopes to raise funds by selling wild products.

Some projects expanded their coverage over time, though this is more apparent geographically than socially. For instance, CIAL, SAVE, and PTA added new farmer groups over time. Transferring skills and roles to participants (e.g., the "paraprofessional" farmers in Zamorano and CIAL) as programmes evolve appears to help this scaling up. Over time, SAVE and CIAL groups needed less contact from support staff, freeing staff to work with new groups. However, some activities require more continuous investment of time or support, and may not be so easily devolved or replicated: joint breeding activities in CONSERVE or community genebanking in UPWARD or REST are some examples.

The involvement of farmers' groups with links to networks or social movements was striking, and can also help expand scope. Social movements relating conservation and organic production are a growing presence in genetic resource management (Berg, 1996a; Jongerden and Ruivenkamp, 1996; Shiva et al., 1995; Vellvé, 1992). Networks or coalitions may be able to extend their activities, even on modest budgets. PTA developed a broad framework for seed system analysis and action, helping it to organise and support local groups in different ecological or socio-economic situations to pursue seed-related goals. Social movements and farmers' organisations will remain important to PPB, and demand much more attention, especially for the technical approaches and particular perspectives they bring to PPB (cf. Bebbington et al., 1994). We discuss contrasting institutional perspectives below.

Institutional roles and links

Different types of institutions bring particular strengths to supporting farmer-breeding, and there is much hope that complementary interactions between different types of institution can combine these strengths to improve efficiency of work, or the scope of impact. Institutional co-operation could be valuable for activities such as stakeholder diagnoses of seed systems, skills-training, developing local marketing, or the collection, testing, selection and storage of germplasm. Such activities benefit from close links to users on one hand, and to networks for information, germplasm, and technical skills on the other. For example, NGOs in Austria, Canada, and Switzerland, with rare variety collections obtained through their member networks, gave formal genebanks access to these collections in exchange for cleaning them of viruses (M. Brossard, S. Rempel, and K. Schüler, pers. comms., 1997).

Work initiated by or involving NARS is conspicuous more by its relative absence. Breeding stations, genebanks, or educational institutions certainly have considerable potential to support work initiated by other institutions. Given the potential importance a supportive national research system could have for scaling up and for sustaining long-term work, as well as the need for capacity-building, greater involvement of NARS should be a priority concern. Moreover, this could help formal research systems to develop much-needed shifts in their attitudes towards farmer-breeding, leading to greater respect for farmers' systems (REST), more appropriate approaches to technology development (SAVE), or support in policy struggles.

Barriers to institutional co-operation

Associations among institutions tend to certain patterns that relate, in part, to the type of institutions involved. For example, NGOs and social movements form networks for organising and lobbying, but generally maintain few formal institutional ties (BBA, CONSERVE), though some have made attempts to do so (e.g., PTA). The more formally-initiated projects tend to link farmers with formal research programmes, especially around germplasm supply and breeding skills (e.g., CIAL, SAVE, SOH).

Despite the potential for collaborations between different types of institutions, in many instances these appear to be uncommon, or strained. A combination of 'structural' (policy and economics) and 'cultural' barriers (poor communication and distrust) contribute to this. An important task facing farmer-led PPB is to acknowledge such barriers, and to probe and analyse their causes. Understanding the causes of institutional gaps could help suggest approaches to building bridges through new joint activity, or at least indicate areas where formal-sector institutions need to show tact (or maintain a respectful distance). Vigorous, though well-meaning attempts to overcome institutional barriers may in fact entrench them, for reasons that we propose below.

Structural barriers: challenges to building ties. Most discussion of barriers to institutional collaboration has focused on policy, especially seed policy (Tripp, 1997), or on economics. Farmer and formal-breeding are embedded within different seed systems, and these differences are heightened when countries pursue more market-oriented seed policies through IPRs on planting material. This itself may limit interaction with farmers' seed systems by restricting germplasm flow (van Wijk, 1997; Jaffé and van Wijk, 1995). Also, partly due to declining public support, many formal breeders seek collaboration and funding from the seed industry or other parts of the industrial food-chain. These new relationships direct scientists' efforts towards client groups that can pay or offer new market links (McGuire, 1997), distancing farmers and other users, especially those lacking political or economic clout. For instance, the Dutch genebank encountered constraints on collaborating directly with farmers' groups, as policy-makers viewed this as a less important use of time than (paid) work for commercial clients. Though these barriers are more obvious in the North, similar barriers are appearing in the South as NARS formalise seed laws and respond to the demand pull of particular, well-connected, groups of farmers (Eicher, 1995; Smale, 1995).

Cultural barriers: challenges to building trust. Even when different institutions are able to work together, differences in institutional culture often pose other barriers. For example, NGOs and farmers' organisations tend to be wary of closer association with research institutions, fearing this would compromise their independence. Considerable suspicion exists, often strongly expressed around issues such as biodiversity, intellectual property, germplasm access, or underlying motivations (conservation, empowerment, research). We have encountered it ourselves in requests for information. Debates are frequently ones of opposition, such as Plant Breeders' versus Farmers' Rights. These are important, substantive issues, and the debates deserve the utmost attention (cf. IPRs on p. 80), but we argue that some of these tensions derive from differences in the way different institutions structure social relations. Divergent institutional cultures are not innate, but the outcomes of social action, formed through interactions with others. Useful insights come from the Cultural Theory of Mary Douglas and her collaborators, which analyses how institutions differ in their perceptions of risk (Douglas, 1996; Douglas and Wildavsky, 1982, Thompson et al., 1990).

Institutions, we argue, do much of our thinking for us; the differences between farmer and formal breeding reflect more than contrasting selection approaches or scales of activity, but also different core values. Formal breeding is broadly hierarchical: germplasm and training often flows from international to national centres, with extension and adaptive research at regional and local levels. Similarly, most formal institutions operate hierarchically, with clear procedures and lines of authority. These structures shape how those within formal breeding institutions regard farmer-breeding: for instance, the types of research questions raised, and the terms in which they recognise it, if at all. Moreover, even if an individual recognises farmer-breeding, she/he may lack the incentives or ability to for further investigation.

Farmers' seed systems are considerably less hierarchical, and evidence suggests that they often carry strongly egalitarian values, though outcomes are not always equitable. For instance, an ethic of seed exchange across social groupings, rather than hoarding, is common, as seen in Zhichen village in Guanxi. Furthermore, though farmers recognise knowledgeable individuals, they do not appear to view them as the source of all gene flow or authority in crop development. Farmers' innovation can also reflect their own institutions and values. Grassroots organisations promoting farmer-breeding, such as co-operatives, local NGOs, and social movements, also tend to have strongly egalitarian organisations and values.

Interaction between formal and more grassroots institutions, encouraged by PPB, frequently induces conflict, which we argue is rooted in these diverging institutional values. Hierarchical groups assign members different roles and capabilities, and deal with internal conflicts by shifting members' positions within the organisation. Egalitarian groups make fewer distinctions among members, but define membership sharply (e.g., in 'us and them' terms), and often respond to internal conflicts by splitting or excluding members. In other words, in conflict, hierarchs look to procedure, egalitarians to purity. At the very least, these divergent values heighten confusion in debating the policy barriers noted above. Cultural Theory has been justly criticised for creating essentialist categories of social organisation (Boholm, 1996), but our point here is that such categories are **relative**, and may actually form and strengthen in response to each other, heightening discord. Political exclusion or denial of access to resources can contribute to the rise of social movements, which oppose the formal system. At the same time, parts of the formal system unable to relate to groups that they view as sectarian may react by withdrawing even more.

Those directly involved in these arenas are fully aware of their highly politicised nature, and the difficulty in bringing different groups together. Doing so is important, but we need to be frank about the challenges. In the end, institutional re-design may be necessary to create spaces for farmer and formal institutions to recognise each other and work together.

Transfer of Benefits

Farmers not receiving material or information directly may still benefit from PPB. We discuss how cases have promoted transfers, particularly horizontal exchange among users, considering IPRs in closing.

Transfer of knowledge and skills

Both the focus on skills-development and the role of farmers in its transfer are important, innovative features of farmer-led PPB. From workshops (SAVE and CIAL), or from a follow-up survey of course graduates (Zamorano), some cases monitored the nature of information exchange among farmers. Unfortunately, most cases did not assess farmer-farmer transfers of information, or discuss approaches to stimulate it. Workshops, or links to networks (as with PTA, BBA, and CONSERVE) are one way to stimulate exchange, by bringing disparate members together. Other approaches to increase the 'visibility' of local best practice, including seed fairs, community-walks, or external citation (e.g., in vernacular journals like *Honeybee*) have encouraged information-exchange elsewhere, but were not mentioned here.

SAVE noted that farmers receiving new material were often quite secretive, and informal exchanges with neighbours was rather slight. Thus, workshops played an important role in making knowledge and experience with varieties a public asset, where farmers had to discuss his or her findings, and others could probe for details. However, farmers known for particular skills could, like many traditional herbalists, be hesitant to share this with others, for fear of losing their role (T. Berg, pers. comm., 1997).

Formal extension could help to evaluate or backstop farmers' horizontal information-exchange, as well as feed information back to formal research. However, despite the rich discussion of multiple sources of information and innovation (e.g., Lyon, 1996; Biggs and Clay, 1981), there has been little attention in PPB to fruitfully linking formal extension and training with farmer-breeding.

Transfer of seed

As with information, farmers obtain planting material through multiple sources, and farmer-farmer transfer may be supported in many of the same ways: workshops, interaction with networks, or other means to increase the visibility' of novel material. Several cases used community-level conservation plots (UPWARD, Guanxi, BBA, CONSERVE, REST) as a source of planting material. Again, networks that regularly share performance information among different locations, like SAVE, CIAL, and PTA, could facilitate movement across environments.

We repeat SAVE's observation that the type of planting material affects rate of transfer: cuttings of vegetative crops, like sweet-potato, spread quickly. Rice, however, disseminates more slowly as it requires multiplication to reach quantities sufficient for seeding. In some situations, poor or low-status farmers may have little access. More information is needed on how crop type and diversity interact with accessibility of seed channels. The absence of baselines and follow-up monitoring of the rate and social patterns of seed transfer leave a major gap in assessing impact.

Farmers in CIAL could sell their multiplied varieties commercially, taking advantage of a special category of “farmer-improved seed” in Colombia’s seed legislation. Though links to formal seed systems were possible in other cases (e.g., PTA), national seed legislation was less flexible (Cromwell, 1997): unlike CIAL, most cases worked with FVs, which potentially clash with DUS requirements. Furthermore, the challenges formal seed distribution faces in reaching all farmers on time with affordable, quality seed (often a major impetus to PPB), would presumably still apply.

There are many possible intermediate channels, between completely formal and farmer sources, including local markets, NGOs, and local institutions. Using small seed quantities, considerable diversity may be disseminated this way. SOH considered a range of such channels in the expectation that it would need to re-supply a wide range of varieties to Rwandan farmers, giving out many small packets from which projects or farmers could select and further multiply interesting material. Informal local institutions, especially mutual-aid associations such as Ethiopia’s *edir* burial societies (Rahmato, 1991), may also serve as robust channels for seed, which may also strive to reach the poorest farmers. Though fashionable in natural resource management, associating with informal local institutions has received little attention for seed dissemination in PPB.

Intellectual Property Rights

Farmer-led PPB aims to involve farmers’ knowledge and germplasm more directly in crop development, raising a host of questions around ownership, access, rights to benefits from this. It might seem that prior informed consent would be sufficient in most situations, where collaborators agree to a code of conduct involving openness and reciprocity, identifying ‘owners’ of germplasm and associated knowledge, and giving them the final word on its fate. Germplasm and associated knowledge is increasingly seen as a contested resource, raising questions about access and benefit over longer terms and broader, even global, scales. This is due to the dramatic expansion in the scope of commercial seed industries and biological technologies (RAFI, 1996), and the (related) World Trade Organization’s (WTO) push to establish industrial models of intellectual property on life (including crop variety protection) under Trade-Related Intellectual Property Rights (TRIPs) (Jaffé and van Wijk, 1995).

Thus farmer-led PPB is pulled into the complex global debate on IPRs. The most relevant forum for PPB, the FAO’s International Undertaking on Plant Genetic Resources, shows no sign of quickly resolving years of debate over germplasm access, benefits, and Farmers' Rights (cf. de Fontaubert et al., 1997, and other issues of Earth Negotiations Bulletin). Current legal frameworks are not transparent, and exclude important stakeholders, such as farmers (IPGRI, 1996b). Advocacy groups struggle to use existing legal instruments and conventions to defend farmers' and communities' ownership rights: some propose combining these to develop a "bundle of rights" (GRAIN, 1995). However, examination of the range of **processes** of farmer-breeding, and of local cultures' different **concepts** of ownership and responsibility leaves much room for debate among different systems of ownership (e.g., individual, collective) (Cleveland and Murray, 1997). More critically, current framework agreements such as the Convention on Biodiversity are silent on the issue of material or knowledge developed **jointly** between farmers and scientists. Some PPB practitioners may be tempted to avoid these complex and volatile debates, and concentrate on practical implementation. However, a very significant group of actors in PPB, NGOs and social movements, hold strong positions, including opposition to **all** forms of IPRs on life by some (e.g., Montecinos, 1996). Therefore, these issues cannot be ignored, as doing so risks undermining trust and co-operation between institutions still further. More to the point, farmers' interests and Rights (to benefits, germplasm, support) could be jeopardised.

Best practice models are needed for new PPB projects to develop codes of conduct, which critically consider both work in related fields like ethnobotany (e.g., ten Kate, 1995) and existing frameworks (e.g., CBDC, 1996). Projects will need guidance on scope of coverage (information, type of germplasm), level and structure of involvement (communities, individuals, institutions), and on mechanisms and legal instruments. Workers in formal institutions need to 'declare their (institutional) interest', since regardless of their personal views, they may be bound by IPR policy of their host institution. Finally, supporting farmers means helping them understand and engage with these frameworks, as CONSERVE and PTA have pursued in their advocacy work. However, this may not be enough. IPR issues reveal the divergent institutional values discussed above, perhaps better than any other issue. Thus, we argue that, even in the case of pure transparency and accountability, there may remain areas of fundamental disagreement. For the future of PPB, this is better acknowledged and respected, otherwise such tensions are exacerbated and positions further entrenched.[24]

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24. The PRGA has recently commissioned work to look at the property right implications of scientists, development specialists and farming communities working together to develop 'joint products'. It aims to provide models for promoting best practice, ethical codes, and legal alternatives for a range of PPB situations.'

6. Gaps and Further Work

Diagnosis and Priority-Setting

Knowledge and practice in farmer-breeding

While farmer-led PPB should proceed **inductively** from farmer knowledge and practices, many gaps in understanding remain. Related to farmers' knowledge and goals, we still know little about:

- how farmers view varietal improvement in relation to conservation.
- the scale of adaptation farmers seek, or their goals for stability of performance.
- farmers' folk taxonomies, especially how they use these to define varieties in selection and exchange.
- their understanding of genetic change, especially in relation to environmental variation, pollination biology, and human selection.

Understanding farmers' theories can help us understand their practices and their chances of meeting their breeding goals, as well as identify gaps for skills-development to address. Such an understanding may illuminate possible spaces for farmer-innovation that are important for supporting farmer-breeding and areas where farmers' perspectives may differ from formal breeders' (cf., Cleveland, n.d.). Also, it may help assess some of the Chapter 3 hypotheses about where there is farmer interest in breeding, thus helping target future work.

However, the most important gaps exist in the study of farmers' breeding practice:

- important sources of germplasm introductions, and how farmers recognise and test novelty.
- methods and timing for selection, and the degree to which farmers seek—or avoid—recombination.
- the effectiveness of different local storage methods.
- factors in gene flow: the quantity and social conditions of seed movement, and any biological or social bottlenecks that limit gene flow.
- roles, especially gender roles, in farmer-breeding.

The full range of such an analysis would be impossible for any single project, though previous studies may help shed light, as they did for two cases. Focusing diagnosis around priority goals may be the best course of action, especially for organisations with limited resources. For example, a project with a goal to support food security for the poorest might concentrate diagnosis on germplasm access and skills of key food crops, differing by stakeholder. We discuss goals-setting next.

Establishing goals

For several reasons, we recommend that goals-setting be a participatory, transparent process, involving a broad consideration of stakeholders and of possible limits to farmer-breeding. This process may identify different limiting factors (germplasm, skills, policy) to better target goals and linking institutions. For example, cases taking a framework approach to problem diagnosis (CONSERVE, PTA) were able to tailor strategies to the needs of different communities. Future projects could greatly benefit from knowing more about:

- frameworks for seed system diagnosis and support used by these cases and other projects. Networking and 'mentoring', especially among more grassroots organisations, could help.
- methods for participatory diagnosis, goal-setting, and evaluation. Especially valuable would be comparisons of different approaches.
- internal institutional structure (e.g., of farmers' clubs), and frank discussions of challenges faced would greatly help our understanding of how institutions confront issues of transparency.
- different stakeholders' limitations and goals, and the ecological and socio-economic factors that shape access to technologies.
- the needs of non-farmer users, especially important where there is market-involvement.

Certainly, participatory goal-setting is still influenced by farmers' knowledge of what options for support are possible, and the support agencies offer. The frameworks discussed above, or the involvement of different institutions, could present new options and broaden this discussion. Finally, goals can extend beyond breeding *per se*. Still lacking is clarity on agrarian versus empowerment goals, and a discussion of the skills that different supporting institutions can reasonably be expected to bring.

PPB Methods

Breeding

Most strategies involved germplasm supply, sometimes connected with crop improvement. Several projects tended towards FVs and local material, possibly reflecting conservation concerns, or simple availability of material. Other options, including non-local FVs or diverse MV populations, received less attention. There should be more open discussion of how decisions were made, to assist other groups in weighing their options.

Similarly, there was little discussion around choices for breeding work, e.g., segregating versus fixed lines, number and diversity of testing sites, number of lines passed to farmers, etc. Selection approaches other than modified mass selection received less mention, and we know little of selection intensity or efficiency. Giving farmers diverse or early-segregating material received less consideration, possibly reflecting realistic limits to the resources and abilities of farmers or support organisations. Technical or material support from other organisations could expand breeding options.

Projects gave relatively little attention to minor crops. Again, support from for formal organisations may help others obtain germplasm or explore breeding options for neglected species. Even by screening varieties, NGOs and farmers' organisations could make valuable contributions in areas where formal systems are not working.

We noted that work in highly unfavourable areas was less than some commentators predicted. This may reflect the challenges of working in areas where crop failure often occurs. Formal research does admit low impact in marginal areas, but it may equally fail to meet users' needs in higher potential areas, as farmers across the agroecological spectrum are interested in PPB. There should be more recognition of different contexts for PPB, and of differences among users in productive areas.

Finally, future work should systematically consider ways to support seed systems beyond assisting local storage and seed banks, or publicising information and material through gatherings and workshops. Approaches such as using local informal institutions, networks of local groups, or semi-formal (intermediate) channels, should be considered for spreading germplasm and information more rapidly, or to a broader group of users. Generally lacking is the involvement of formal seed and extension systems in such processes.

Skills

Skills-support is an important and innovative area of PPB. Training manuals from cases pioneering skills-training, outlining topics covered and teaching methods used, would be a valuable resource for others; dissemination of such materials may merit special funding support. Extension of local best practice to other farmers should receive more attention, especially since these practices may be within the reach of most farmers. Finally, as with transferring seeds, bringing disparate farmers together (e.g., in regional workshops) may greatly facilitate skills-transfer, and might also provide insights into the different ways farmers acquire and transfer information about breeding.

Links and indirect support

Farmer-initiated links with other institutions were less common than formal-initiated links. Farmer-formal links warrant more support and encouragement. Formal system links beyond germplasm supply should be explored, especially for technical backstopping. Projects could give more consideration to promoting **sustainable** links that extend beyond the project's life: this can be helped if plant breeders and genebanks consider NGOs and farmers' groups as full clients. Institutional links could be strengthened by activities that bring material benefits (e.g., seed multiplication), drawing participants' interest, or that otherwise empower farmers' organisations, helping them demand researchers' attention.

Indirect support to farmer-breeding needs more consideration, especially around issues like seed policy: international organisations could assist by outlining key issues and supporting national-level initiatives for change. Local, specialised (e.g., organic), or South-North Fair Trade markets offer potential incentives to sustain farmer-breeding work: such networks are close-knit in countries like Germany, and similar ties could be pursued in many Southern countries. Other approaches, such as modifying school curriculum, warrant further attention.

Comparative discussions

We do not propose a simple methodological tool-kit, but suggest that practitioners who are able to make choices, should base them on some awareness of their possible implications. Trade-offs exist between different goals (e.g., crop conservation and improvement) and between methodological approaches (e.g., germplasm introduction or skills-development). As noted for breeding methods and skills, comparative discussion across PPB cases is needed to discuss these trade-offs, but this is generally hampered by lack of detail in most accounts. Equally valuable would be process documentation, explaining why certain approaches were chosen, and describing both problems and successes.

While comparing different methods for the same goal (like yield) is, in theory, relatively straightforward, comparing different goals such as biodiversity or empowerment presents considerable challenges. Studies (e.g., IPGRI, 1996a; Smithson and Lenné, 1996) can help shed light on how different goals interrelate, especially for production and crop diversity. Appropriate impact assessments are equally important for comparing among different methods or goals. We expand on this below.

Evaluating Impact

Testing and documentation

Formal research characterises the environments of testing sites to be able to describe the effect of environment on performance, and assign recommendation domains to technologies. Similarly, better description of testing sites in PPB, and of how socio-economic and ecological constraints vary among intended beneficiaries, could help target materials and assess scope of impact. Documentation of characterisation and evaluation information also needs more attention, especially where there are varied conditions or multiple locations. Common lists of characters and environmental factors to specify (as with IPGRI descriptor lists) would help information and germplasm exchange among locales in a network, or even between projects. This is another area where formal support or backstopping could be fruitful.

Baselines and indicators of impact

Baselines appear to be lacking in most cases, making measurement of impact over time difficult. As with screening, common terms of reference and analysis may be useful for comparing changes in performance between locations or cases (e.g., changes to yield, yield stability, fodder quality, market price). However, assessing changes in other goals—skills, biodiversity, strength of links, empowerment—is more challenging, though the frameworks mentioned above might help weigh trade-offs. Participatory evaluation, where users determine goals and monitor indicators of their own choosing is desirable in all cases, and may be the only option available for organisations lacking resources for large-scale or complex evaluations. However, farmers may be unable to see cryptic changes, e.g., in genetic diversity, so there is certainly a role for formal monitoring to play, though only SOH was doing this, to compare with farmers' evaluations.

Impact on different users

A very common gap is determining how impact differs across different users. Some users may have restricted access to germplasm or information, or may find it inappropriate to their situation. Differentiating impact by user can help determine if more attention to certain stakeholders is needed in diagnosis and planning stages. Women and particularly vulnerable users merit special attention: this latter group often includes the non-farming poor, stakeholders rarely mentioned in PPB projects. One issue for further consideration is how PPB could be targeted to specific groups. Finally, some approaches, such as considering changes in the bargaining position of different users (e.g., women in intra-household decisions) may offer ways to assess empowerment by user.

Institutional Issues

Certain supporting institutions tend to associate themselves with certain PPB approaches, partly due to differences in resources, but also to different perspectives and values. Though grassroots organisation activity is notable, the lower involvement of NARS represents a significant gap in PPB practice. Potential for complementary partnerships between different types of institutions is considerable, combining technical expertise with local knowledge and contact, for example. However, the strained nature of institutional interaction limits such collaborations. To encourage further NARS involvement and institutional co-operation:

- political and economic barriers need to be identified and challenged.
- the nature and culture of institutions must also be considered.

Donor-led programmes may not be enough to foster interest or collaboration. Research questions and activities need to be strategically framed to engage NARS staff. However, promoting new lines of work, co-operative or otherwise, may require shifts in institutional culture.

As mentioned, we know little of the internal dynamics of farmers' groups and supporting organisations (e.g., the nature of membership and decision-making processes). More discussion is needed on approaches that help local groups to evolve to more independent, decision-making bodies, and more generally, on approaches to foster participants' sense of ownership of a project. Grassroots organisations and social movements could offer valuable insights on this.

Finally, particularly controversial issues like intellectual property rights need special consideration. The development of best practice models is an area where politically-engaged NGOs can be significant sources of expertise and information. Positions on these issues are intimately intertwined with institutional perspectives, and need to be understood in that light, with full awareness that disagreement on fundamentals is possible. Institutional partnerships or national or regional networks may function best as coalitions, collaborating on areas of agreement, but acknowledging differences. Given the range of perspectives on PPB, from crop development to empowerment, this may be the only workable arrangement between different institutions.

Conclusions

Farmer-led PPB excites great interest for its promise in crop improvement, biodiversity conservation, and farmer empowerment; though its potential is most anticipated for unfavourable areas beyond formal breeding's reach, PPB could have significant impact across a wide range of contexts. While all work seeks to support farmer-breeding, the processes supported and goals pursued vary considerably. PPB had notable successes in providing new options and promoting self-reliance, though questions remain about its effect on biodiversity and crop improvement, and differing impact by user groups, especially non-farmer users, remains a significant gap.

While stakeholder diagnoses or participatory evaluations may help projects better choose support strategies, and assess trade-offs between different goals, all programmes occur within a particular institutional context. Particular strengths, resource constraints, and values, shape the work institutions do and interpretations they draw, perhaps especially so for the farmers' initiatives and grassroots organisations that are prominent in farmer-led PPB. Institutional collaboration offers much promise for enhancing the understanding and practice of PPB, but this may only flourish when the internal culture and motivations of the organisations involved is understood and accounted for. Without this, sustainability of the collaboration, even of the project itself, could be challenged. As PPB develops from the pioneering examples cited here, work will need to balance—and perhaps make difficult choices among—different goals and methodological options; we sincerely hope that it can draw upon the broadest possible base of knowledge and experience to do this.

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List of Acronyms and Abbreviations Used in the Text

BBA	Beej Bachao Andolan: Save the Seeds Movement, an NGO in India
BoA	Board of Agriculture, Tigray Region, Ethiopia
BPP	Bo-Pujehun Project, an NGO-run PPB project in Sierra Leone
CARE	An international NGO
CBCD	Community Biodiversity Conservation and Development Programme
CDR	Complex, Risk-prone, and Diverse
CGIAR	Consultative Group on International Agricultural Research
CIALs	Comités de Investigación Agrícola Local (Local Agricultural Research Committees)
CIAT	Centro Internacional de Agricultura Tropical
CIIFAD	Cornell International Institute for Food, Agriculture and Development of Cornell University, NY
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CIP	Centro Internacional de la Papa (International Potato Center); also, for PPB project at Center
CONSERVE	Community-Based Native Seeds Research Centre, a Filipino NGO
DUS	Distinct, Uniform, and Stable crop variety
BDI	Biodiversity Institute of Ethiopia; also, for PPB project at Institute
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Enterprise for Agricultural Research)
ENMC	National Criollo Maize Trial, in Brazil
FAO	Food and Agriculture Organization
FVs	Farmer Varieties
GxE	Genotype-by-Environment interactions
Guanxi	Refers to case study of women's maize regeneration, in Guanxi province, China
HYVs	High-Yielding Varieties
IARCs	International Agricultural Research Centres
ICRAF	International Center for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IPGRI	International Plant Genetic Resources Institute

IPRs	Intellectual Property Rights
IRRI	International Rice Research Institute
ISAR	Institut des Sciences Agronomiques du Rwanda
MASIPAG	Mga Magsasaka at Siyentipiko para Pagpapaunlad ng Agham Pang-agrikultura or 'Farmer-Scientist Participation for Development': a Filipino NGO
MVs	Modern Varieties
NARS	National Agricultural Research Systems
NGO	Non-Governmental Organisation
OPV	Open-Pollinated Variety
PPB	Participatory Plant Breeding
PTA	Projects in Alternative Agriculture, a Brazilian NGO
PVS	Participatory Varietal
REST	Relief Society of Tigray, an Ethiopian NGO
RRA	Rapid Rural Appraisal
SAVE	Sustainable Agriculture and Village Extension, a CARE project in Sierra Leone
SCMPC	Santa Catalina Multi-Purpose Co-operative, in the Philippines
SEARICE	South-East Asia Regional Institute for Community Education, a Filipino NGO
SOH	Seeds of Hope, a rehabilitation project in Rwanda
SWP/PRGA	Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation
TRIPs	Trade-Related Intellectual Property Rights
TVs	Traditional Varieties
UPWARD	User's Perspective in Genetic Resources Research, a Filipino NGO
USDA	United States Department of Agriculture
WTO	World Trade Organization