CHAPTER 4

Methodologies for priority setting

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4.1 WHY DO WE NEED METHODOLOGIES FOR PRIORITY SETTING IN A PLANT BREEDING PROGRAMME?

Productivity improvements have been the key objective of most plant breeding programmes to date: international, national, private and public alike. Other major breeding objectives are indirectly related to this goal: resistance to pests and diseases, for instance, or adaptation to abiotic stresses (such as drought or low soil fertility), and aim at increasing or stabilizing yield or to allow higher production under certain environmental conditions.

Another group of 'classical' breeding objectives focus on adding 'value' to crops by improving their qualities for industrial processing, their storability, or by meeting certain consumer preferences. Some breeding programmes concentrate on increasing the nutritional value of staple food crops, an approach that is also known as biofortification (HarvestPlus, 2007).

Increasing the yield of important food crops was seen as the answer for overcoming food shortages and reducing hunger in the world. In fact, the production volume per hectare of some major food crops has increased about threefold in the last 70 years, partly as a result of plant breeding and partly due to intensification of farm management (Becker, 1993). In recent years, however, evidence has been mounting that the global availability of staple food alone is not sufficient for reducing hunger and malnutrition. Food insecurity is closely related to poverty in general: even if food is available, many poor people, including poor farmers, lack access to it. The alleviation of poverty has therefore become a key development goal. It is at the top of the agenda for many development organizations, both governmental and non-governmental, and also for international agricultural research centres. In view of this goal, international breeding programmes and their national partners have been compelled to redefine their programme objectives and specific targets. Crop breeding programmes, for instance, must be re-oriented towards the needs of poor farmers and other specific user groups. However, user differentiation and gender considerations are new concepts for many breeding programmes; developing new and 'better' varieties was assumed to be a largely user-neutral technology.

Furthermore, the benefits from newly developed varieties are not evenly distributed; in some regions, for example sub-Saharan Africa, where poor soil fertility and erratic rainfalls limit the potential for agricultural production, there has practically been no yield increase in major food crops in the last 20–30 years (FAOSTAT data, 2006). In such regions, farmers have often developed complex farming systems and strategies for reducing environmental risks. However, social, political and economic change can weaken such systems, leading to instability and overexploitation of the natural resources. Plant breeding for such situations requires different approaches: approaches that are based on a deep understanding of the functions of crops within the entire system, including farming, nutrition, local knowledge and technologies. Setting priorities for such programmes needs to be forward looking, as it may take at least ten generations before new products become available. They then need to be adapted to farmers' needs and production systems. Simple strategies, such as improving yield by increasing the ratio of the edible part at the expense of other plant organs (i.e. foliage, roots), do not generally work under such conditions. For example, certain 'minor' characteristics may

BOX 4.1
The value of pearl millet straw in drought years

In western Rajasthan, drought occurs so regularly that farmers have developed their strategies to cope with it. Many farmers, even though interested in new varieties for testing and experimentation, grow traditional pearl millet landraces. In good years, the yield of the landraces is moderate, but their real value is revealed in severe drought years: even if the grain yield may be strongly reduced, they produce some grain as food and biomass for feeding the animals. Many modern varieties fail totally under such conditions, producing neither straw nor grain.

There are several possibilities for people to find grain for human nutrition: some may have stored a surplus from previous years, or one can do labour work and buy grain from other regions in the market. In severe situations, food aid may be distributed by governmental or private aid agencies. But starvation of animals hits a farmer family hard for years; the animals are an important source of income, besides providing dung, draught power, milk or wool for the family and the farm.

be re-lated to environmental adaptation, or non-edible plant parts may have a high value in particular situations (see Box 4.1).

Another point receiving increasing attention is the conservation of agricultural biodiversity. Many countries have signed the Convention on Biological Diversity (CBD), or the legally binding International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). It is now widely recognized that industrialized farming has led to significant losses of biodiversity in agricultural systems. This is due to the use of only a few, widely adapted, varieties; the narrow genetic base of the breeding materials; and testing and release procedures allowing only the dissemination of a limited number of relatively uniform varieties. Economic considerations are one reason why previously selected breeding material is used as much as possible, but it is thus reducing the genetic diversity among the newly developed varieties. Landraces and wild plants are not incorporated as much as they could be, because it may take more time to derive stable and uniform varieties from such material, thus increasing the cost of such programmes (Haussmann *et al*., 2004). Furthermore, the business economics of breeding firms require a large geographical distribution of varieties within a few years, which conflicts with biodiversity considerations and other aspects of regional differentiation, such as respecting food culture and consumer preferences. Locally important crops often do not reach the scale of distribution that is needed by breeding institutions for them to invest in new varieties. However, as a result of international commitments, national and international breeding programmes are obliged to initiate efforts for broadening the genetic base of breeding materials, according to the Global Plan of Action (FAO, 1996), and the International Treaty for PGRFA (ITPGRFA, no date).

Decentralized breeding programmes, based on local crop germplasm and seed distribution systems, in contrast, could be an important step towards increasing the level of biodiversity in farmers' fields. Moreover, the goal of conserving agro-biodiversity could effectively be linked to efforts to increase food security and reduce poverty: Many 'minor' or traditional crops (or crop varieties) have outstanding nutritional qualities, are well adapted to marginal conditions and low input farming, or open up possibilities for income generation (IPGRI/GFU/MSSRF, 2005).

Thus, breeding programmes today often have to be designed in a manner different from the past. To meet the above-mentioned new goals, they tend to be less centralized, more targeted towards specific user groups and often use different germplasm. However, this is not all. To obtain impacts beyond a very local scale, approaches have to be developed that address large geographical areas while at the same time respecting agro-ecological and socio-cultural differences. This usually requires cooperation among different organizations that work at different scales, and often have diverse agendas and backgrounds. Consequently, methodologies for priority setting have to be adapted for such cooperation to make the process transparent and acceptable for all stakeholders.

The management of social cooperation, learning and decision-making processes is, as such, new for most plant breeders and their institutions. However, experiences exist from other disciplines, particularly social and economic sciences; here one can build on fundamental expertise in the fields of knowledge systems, communication, social learning and management (Leeuwis, 2004; Manktelow, 2003).

4.2 PARTICIPATORY PLANT BREEDING

The concept of participatory plant breeding (PPB) emerged in the late 1980s as part of a general development in participatory research methodologies during that period. Increased user orientation and more efficient allocation of research funds; higher adoption rates; a close relation to local cultures, knowledge and skills; empowerment of farmers; and overcoming typical limitations of ‘science’ in the development context—all these factors are the potential advantages of participatory plant breeding (Ashby and Sperling, 1995; Weltzien *et al*., 2003).

PPB includes all approaches to genetic plant improvement involving close farmer–researcher collaboration. The term particularly refers to active involvement of farmers in at least one of the stages of a plant breeding programme, including setting objectives, generating variability, selecting and testing, as well as seed production and distribution.

This active involvement of farmers can take different forms. Farmer participation can be consultative, if farmers are interviewed on agro-ecological issues, or on the performance of test varieties. More active forms of farmer participation include, for example, trial management, selection, priority setting and the development of action plans, or the overall management and implementation of the project (Farnworth and Jiggins, 2003; Lilja and Ashby, 1999). Which degree of farmer participation is appropriate and in which phase of a breeding programme depends largely on the goals of the programme, as well as the type of improvements needed, and it is thus also an issue for priority setting (see Section 4.5 below, under Roles and Responsibilities).

4.3 PRIORITY SETTING AS AN ITERATIVE PROCESS

Setting priorities is an important part of professional plant breeding work. Time and resources are usually limited, and they have to be allocated in a rational way in order to reach the goals of the breeding programme. Thus, considering issues and methodologies for priority setting is a necessary step for any plant breeding programme, irrespective of the degree of farmer participation or the institutional setting. However, little has been reported to date on methodologies for priority setting in plant breeding programmes. Resource allocation, primarily during the phase of testing experimental cultivars, has been researched intensely, usually based on models for maximizing genetic gain, thus focusing on one or two key traits (e.g. Cooper and Byth, 1996).

We regard priority setting as an iterative and progressive process that will be considered at many stages during a plant breeding programme, not only in the project planning phase. It is often not possible to anticipate all the options that may emerge in the course of the research process. Priority setting methodologies should therefore become part of the regular project work, in a way that allows adjustments and further development of goals and priorities as the project work evolves.

In the following sections we will look at issues for priority setting first, and then suggest methods and communication tools that could help to achieve a transparent process and productive outcomes.

4.4 ISSUES FOR PRIORITY SETTING

Clear priorities need to be set for a number of issues. The **goals** are the guiding principles for priority setting in any project of a defined duration, scale and scope. At the same time, the goals themselves are also an issue for priority setting, as complex, conflicting or too general goals are not likely to be reached through technical plant breeding work alone.

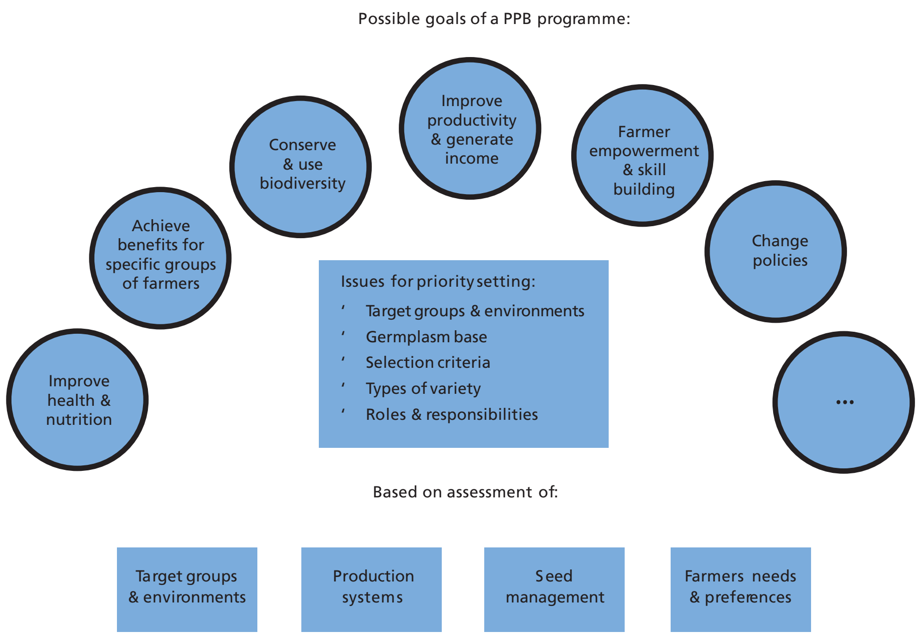
For plant breeding programmes, it is vital to define the **target group(s)** and **the target environment(s)**, i.e. production conditions under which the newly identified varieties should perform better than existing cultivars, and the specific needs of the target group of farmers. Closely linked to this are priority traits to be used as **selection criteria.** To achieve good progress from selection, the **germplasm base** must be chosen appropriately, based on profound knowledge of the available options. It is also important to discuss what **type of variety** might be the most appropriate for achieving the project or programme goals. Part of this issue is also to address the question of intravarietal diversity: how much of it would be beneficial or necessary, and for which traits. An issue that is often left until activities are planned is the identification of key **roles and responsibilities of partners**. However, since different options for sharing responsibilities between partners have a major impact on some of the goals, it is important to consider them from the outset of the breeding programme. The following sections explain in more detail how the different issues for priority setting for a breeding programme relate to the overarching goals in specific situations.

4.4.1 Goals as a basis for priority setting

All breeding programmes have at least one goal related to improving production, such as yield, yield stability or a higher product value. Many PPBs have additional goals, such as the conservation of local diversity, skill building and empowerment of farmers, policy and regulatory changes, increasing research efficiency, or benefits to specific users. Many of these goals tend to be implicit and depend on the institutional background and on the ‘history’ of the breeding project.

Each organization and institution has their own implicit goals that are not always easily communicated. Thus close interaction, exchange visits, and joint planning workshops that are held variously in the

FIGURE 4.1
Issues for priority setting in a plant breeding programme in relation to the overall goals and based on the assessment of target groups and environments, production systems, seed management, and farmers needs and preferences



Source: Weltzien, 2005.

different partners' workplace (e.g. research station, village, trading place) are important to achieve a mutual understanding of the different partners' perspectives. It is also understood that the relative importance of the different goals may change as the project and, foremost, the partnership advances and evolves.

If the project work involves close interaction between farmers or farmer organizations and researchers, it is particularly important to clarify the goals from the project planning phase. For many farmers, it is not easy to understand what scientists do and how research is organized. As a consequence, they may be tempted to overestimate the direct effects of the research on yield or income generation, or they may even expect other benefits from the cooperation, which cannot be fulfilled by a breeding programme. Such general aims of the people could perhaps better be addressed by activities other than plant breeding, or by establishing partnerships with marketing organizations or food processing companies (and including their specific goals into the breeding programme).

From goals to priority setting

The goals have been described as the guiding principles for priority setting. At the same time, the priority setting process builds on understanding the present situation, anticipated changes, and farmers' needs. A detailed analysis of the production environment is required, including existing varieties and how they are used by farmers, their preferences and relevant resources (i.e. local knowledge, skills, germplasm). In particular, it is necessary to identify the major constraints to production increases and income generation. Participatory methods for such situation analysis have been described in detail by Christinck, Weltzien and Hoffmann (2005). An open dialogue in the course of which all partners evaluate potential options and obstacles for future breeding activities could then follow (see Section 4.6 of this chapter). This approach is graphically summarized in Figure 4.1.

4.4.2 Target groups and target environments

Identifying the target environment and target group in view of the overall project goals is generally among the first strategic decisions to be taken in a plant breeding project. We therefore suggest a few subjects for consideration, which refer to agro-ecological as well as socio-economic factors.

Broad versus narrow adaptation, and the impact of PPB

The issue that certain plant types or varieties may perform differently in different environments is called 'genotype by environment interaction' by plant breeders. In general, most plant breeders tend to give preference to those populations that perform well under a wide range of conditions; this ability of plant populations is known as 'broad adaptation'.

Broadly adapted varieties are also the prime matter of interest for seed companies, as the potential profit from the entire release and multiplication 'business' is usually related to the scale of distribution. However, these varieties, if tested on research stations in multi-locational trials, may fail under the conditions of poor farmers working with limited resources and under marginal agro-climatic conditions. Ceccarelli, Grando and Booth (1996) and Ceccarelli *et al.* (2000) have shown theoretically and practically that interactions between genotype and environment can be positively exploited if the selection is done in the target environment, e.g. farmers' fields. Farmers as well as scientists successfully selected populations or experimental lines that produced better under the farmers' conditions than other varieties grown previously by those farmers. Experiences of other research groups, with various crops in differing natural and socio-cultural environments, support this understanding (Goyal, Joshi and Witcombe, 2001; Mekbib, 1997; Sperling, Loevinsohn and Ntabomvura, 1993; Weltzien *et al.*, 2003). Narrow adaptation to specific conditions, leading to the selection of many different cultivars for various conditions and purposes, is often regarded as an advantage of the PPB approach: it serves specific needs of farmers and enhances the level of agrobiodiversity in farmers' fields (Sperling, Loevinsohn and Ntabomvura, 1993; Joshi and Witcombe, 2001).

However, a possible criticism regarding decentralized plant breeding programmes could be that, due to the focus on specific, often marginal environments, and only the local importance of the varieties developed, their impact remains insignificant. Only a very few farmers who produce mainly for their own subsistence and modest requirements would profit from the activities, and this would never justify the breeding efforts, let alone the cost of official variety release and seed multiplication.

At the same time, there are also cases where varieties developed through PPB programmes are not necessarily so narrowly adapted. In Nepal, for example, a rice variety selected by farmers in a high-altitude environment was adopted by many farmers in the mid-altitude regions as well (Joshi, Sthapit and Witcombe, 2001). Also, rice varieties developed in a participatory breeding programme in Nepal were superior to check varieties in a region of Bangladesh, where rainfed agriculture prevails (Witcombe *et al*., 2005). Obviously, much depends on the characteristics of the varieties, the conditions under which they were selected and the limitations that were addressed and overcome through the plant breeding activities. Thus, information on target regions and how representative these are for other farmers of a larger area will be of vast importance for the later impact of the project.

Identifying, specifying and delineating the target environments for a breeding programme more precisely is often done by analysing multi-location trials through which a broad range of potential varieties for a region can be evaluated. Calculating correlations between performance traits from the different testing sites usually gives an initial impression about the differences between the sites with respect to adaptation (Atlin, Paris and Courtois, 2002). If sufficient data is available, or can be generated during the course of the project, more complex statistical tools can be employed by breeders in order to delineate target environments and develop a selection and testing strategy for new varieties (e.g. Cooper *et al*., 1999; Cooper and Byth, 1996; Annicchiarico, Chapter 20). These statistical tools do not require farmer participation, but give a much more realistic assessment of the situation if the trials used for these analyses were conducted by farmers in farmers' fields, using farmers' selection and evaluation criteria. Similarly, farmers' description of requirements for adaptation to a specific zone can be a useful input, which could actually save efforts on long-term expensive experimentation and analysis (van Oosterom, Whitaker and Weltzien, 1996; van Oosterom *et al*., 2006).

New crop varieties: for people or for environments?

In general, plant breeders tend to focus their breeding strategies on regions and agro-ecological conditions: so-called 'target environments'. The idea that people belonging to different social groups (even when working under similar agro-ecological conditions) may have different requirements for seed and varieties, so that we have to target our work not only to natural, but also to social and economic conditions, may be less apparent. In this section, we therefore enter into more detail and describe why we need to explore and integrate both aspects: defining a target environment not only from natural but also from socio-economic perspectives.

General agro-ecological conditions can be described with relatively few parameters, which are usually available from secondary sources, such as general physical maps, soil maps and meteorological data. With this information, we can distinguish agro-ecological zones according to:

- different altitudes;
- different soil types;
- different rainfall patterns;
- availability of irrigation water;
- etc.

Depending on the scale for which this type of information is available, this analysis will result in relatively large zones that appear more or less homogenous. However, this is seldom true in the farmers' reality. Even farmers in relatively favourable agro-ecological regions or irrigated areas often have land that is of poor quality, due to local constraints such as stones, rocks, gravel or hard subsoil layers, hilly land, or poor quality or limited availability of irrigation water. Therefore, marginal agro-ecological conditions can be found surrounded by more favourable environments, and depending on a farm household's total land area and the location of the fields, these conditions can be of considerable importance (see Box 4.2). The farmers' requirements for seed and varieties depend directly on the conditions present on their land, and on the limitations and constraints they have to face in their daily work. Thus, it is indispensable to complement agro-ecological information from secondary sources with local information, including soil types, irrigation water and typical constraints to agricultural production. Care should be taken to include information from various social groups, as land quality and access to natural resources often vary for different people in a village.

Furthermore, the same natural and agroclimatic conditions can pose different problems and opportunities for people, depending on other resources they possess. For example, soil constraints may have different importance depending on the machinery used by a farmer, and the availability of groundwater for irrigation purposes helps only if a farmer family can afford the irrigation equipment and operation costs. Expensive seed and other costly inputs may not be accessible for poor farmers, so that they have a preference for varieties that can be multiplied on farm and successfully grown under low-input conditions, even in a favourable agro-climatic environment. These examples show how economic factors influence the farmers' needs and preferences regarding crop varieties.

Social factors may be of equal importance. People belonging to different social groups may have different needs, preferences and access to resources. In many cultures, for example, women and men have different responsibilities with regard to farming, nutrition and income generating activities, which may result in different preferences. Ethnic groups, clans or castes may be specialized in certain agricultural activities, such as pastoralism, general farming, horticulture or cultivation of trees, and

BOX 4.2

Soil quality and settlement patterns

In some parts of the world, we can observe some level of coincidence between agro-ecological conditions and settlement patterns, so that distinct social groups live and work under different agro-ecological conditions even in the same village. Examples are:

- Remains of feudal systems: The kings and members of the nobility usually possessed the best lands and the rights to access water and other natural resources. The 'ordinary people' worked on marginal lands.
- Remains of colonization: In the process of colonization, indigenous people were forced to leave their land and settle in less favourable conditions.
- Migration due to wars or disasters: Refugees and other 'newcomers' are often allocated marginal lands that are not used by the original population.

These settlement and land use patterns can persist for generations

Source: Christinck and Weltzien, 2005.

cooperate according to traditional rules and rights.

One practical option to clarify and limit the target environments for a plant breeding programme is to identify with farmers the variety that the new programme needs to replace in order to be successful. In cases where this is possible, the range of distribution of this variety may then be considered the target environment(s) for the new breeding programme. In areas of high varietal diversity, this may not be so evident, and may require more understanding about which varieties or group(s) of varieties play what role in the production system and livelihood of the target group of farmers. In other situations, it may actually be most useful to add a new variety to the spectrum of varieties already grown by farmers, with specific new uses or adaptation characteristics, such as sorghum with good malting qualities to meet the needs of an emerging industry.

In summary, farmers may have different needs and preferences regarding crop varieties and specific traits in relation to their economic situation and their social group(s). Therefore it will be important to develop an understanding of how natural as well as socio-economic factors relate to the farming practices of different farmer groups, particularly in view of their use of varieties and needs for specific traits. The decision about the target group of farmers determines largely which project goals can be achieved, which is decisive for the 'success' of a project. Since the decision on target groups guides many subsequent steps in the priority setting process, it should be a primary concern for plant breeders. Similarly, evidence from impact assessment studies has shown that adoption of new varieties is often limited because the target group and their specific needs and preferences were not adequately considered by breeding programmes (Weltzien *et al.*, 2003; Witcombe *et al.*, 2005).

4.4.3 Selection criteria

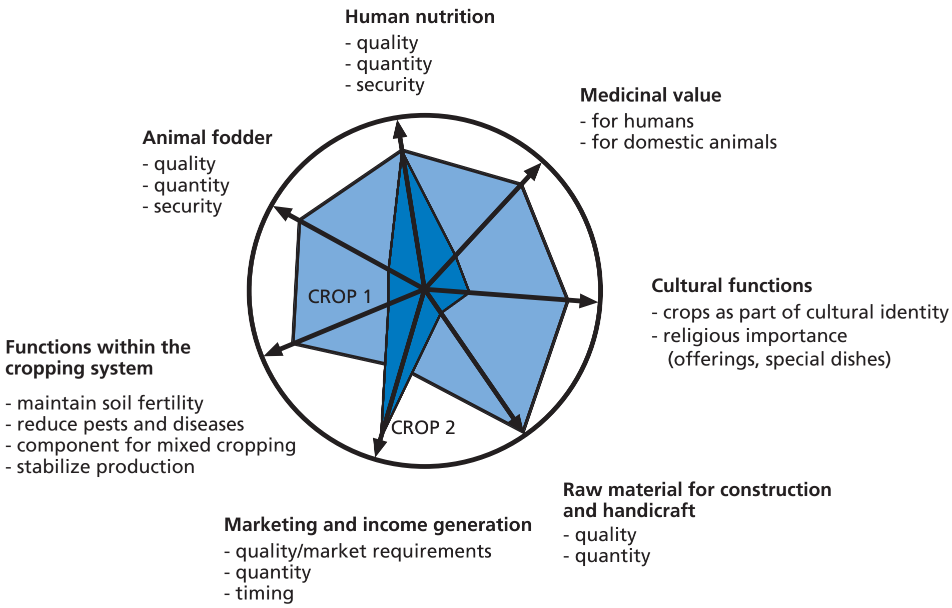
Once the project goals as well as target group and environments are identified, decisions about the type of improvements needed and the selection criteria will come into play. Looking towards future options requires a sound understanding of the situation and the conditions under which newly developed varieties will need to function. This will be the basis for developing new, creative options.

Functions of crop varieties in the farming system and related selection criteria

Crop varieties, particularly those with a long history of cultivation in a given region, are not only adapted to natural conditions, but also to the needs of the people and their cultural preferences. They can fulfil a wide range of functions within the entire system of farming, nutrition and cultural life of a farmer family, and provide important by-products (see Figure 4.2). However, as many rural areas are in a process of rapid socio-economic change, improvements in specific traits can be interesting for the farmers. In most cases, this will depend on the economic importance of this particular trait, and the overall acceptability of the variety with regard to other important traits. This figure can also help us to think about the type of improvements needed to achieve the project goals.

As a first step, we should gain some knowledge on the farmers' variety portfolio, their use of varieties and the strengths and weaknesses of these varieties in relation to functions and project goals. This characterization of varieties should be based on farmers' knowledge and perceptions.

FIGURE 4.2
Functions of crops within a farming system



Crop 1 is a typical multipurpose crop with high importance for most functions (except marketing), whereas crop 2 is a food crop important for nutrition and marketing, but not for other functions mentioned
Source: Christinck, Dhamotharan and Weltzien, 2005.

Various tools for entering into dialogue with farmers on variety characterization and use have been proposed by Christinck, Weltzien and Dhamotharan (2005). Furthermore, understanding farmers' own seed selection and the underlying criteria will give us important keys for the types of improvements farmers are looking for.

Some selection criteria are largely determined by the requirements of adaptation to the target environment, e.g. flowering date, resistances to specific pests and diseases, or to abiotic stresses such as soil acidity. Other selection criteria are determined by the technologies farmers are using, such as ease of harvesting, transportability, manual threshing, or by the requirements of the farming system, e.g. mixed cropping and fodder use. Furthermore, selection criteria may also be related to culinary preferences, such as taste, usefulness for certain preferred dishes, to useful by-products (i.e. construction material) or to market requirements, e.g. grain colour and shape. In most cases these criteria must meet a certain threshold level of acceptability.

Experience from PPB projects has shown that farmers often select for many criteria simultaneously, and in this way can indirectly achieve considerable yield increase. This seems to be mainly related to the farmers' ability to anticipate the performance of certain plant types under specific conditions that are well known to them (Sperling, Loevinsohn and Ntabomvura, 1993; Christinck, vom Brocke and Weltzien, 2000).

However, for professional plant breeders, a detailed evaluation of each and every trait that might be important for farmers will lead to a dead end. Resources for testing and evaluating new germplasm or breeding material are always limited. The more criteria that are included in a selection programme, the less effort can be spent on each of them, and thus less progress tends to be obtained from selection. Thus, a guiding principle in the choice of selection criteria should be to keep them to the minimum necessary. The more focused and clear the targets for selection, the greater are the chances of achieving them. We find here an excellent option for cooperation between farmers and scientists in a breeding programme. Farmers can more efficiently select those materials that are overall compatible with their situation, farming system and marketing requirements and preferences, whereas scientists can be most effective in assembling appropriate germplasm with the traits desired by the farmer and in selection for a limited number of critical traits.

Heritability of traits and environmental adaptation

Formally trained plant breeders tend to classify traits by the complexity of their genetic control. They differentiate highly heritable traits with simple genetic control from genetically complex traits with low heritability, along a continuum of increasing complexity, and thus decreasing genetic control or heritability (see Chapter 2).

Highly heritable traits with simple genetic control tend to be mostly descriptive traits, such as colours of the grain or other plant parts, hairiness, key aspects of crop duration or flowering date, plant height and some types of disease resistance. While some of these traits are key factors for the adaptation of a variety, such as flowering date or disease resistance, many others are more related to what is intuitively often thought of as a preference: something visual, qualitative and not really associated with productivity or adaptation. Most of these traits could actually be incorporated into existing varieties by backcrossing, if a source for the desired trait, i.e. a gene, exists in the breeders' collection.

Complex traits have a low heritability because their expression is highly influenced by environmental factors, i.e. the conditions in which the variety is grown. Many of these traits also tend to show sizeable amounts of genotype × environment interactions, i.e. the expression of a trait in specific varieties depends on the conditions in which the trait is being evaluated (see Chapter 20). One example would be a variety which responds well to fertilizer; its yield under high fertility conditions could be higher than that of a local variety, whereas the local variety would outperform this variety under low soil fertility conditions. This example shows clearly that identifying yielding ability as a key preferred trait is of little relevance. However, what is important is the specification for which kind of growing conditions a higher yield performance is being sought by farmers. This type of specification is necessary for most of the complex, productivity-related, traits, as their assessment cannot be dissociated from the conditions under which they are evaluated.

Another example of a selection criterion, which is often high on farmers' lists of preferences, but usually very difficult to assess, is drought tolerance. The first problem is that a trait like drought tolerance may mean very different things to farmers, to crop physiologists or to breeders, and would thus entail very different ways of assessing it, from physiological measurements of drought response at the biochemical, plant tissue, plant organ or whole plant level, through to productivity under specific drought conditions. Practical breeding experience with drought tolerance has shown that it is of key importance to ensure that the crop's water requirements match the periods of water availability in the target production system. It is thus important that the nature of such complex traits of adaptation are well understood before deciding to use them as a focus for selection and variety improvement. Traits that cannot be assessed or evaluated with the necessary precision in the planned project should thus not be included as selection criteria. Before it can become a selection criterion, some research might be necessary to find appropriate ways of assessing or measuring such a trait.

New selection criteria can lead to new options

It could be a 'breakthrough' for farmers if some well known traits of already existing varieties could be improved. However, in some situations, radically new options can emerge if totally new selection criteria are taken into consideration. For example, in regions where crop production has so far been merely subsistence oriented, traits important for food processing industries could lead to new marketing options. Totally different plant types with different growing behaviour, such as extra-short growing cycle or extra-tall plants, could help farmers to diversify their farming systems.

Such extreme changes can often not be envisaged by farmers, if they have no practical experience with such varieties. Thus, it is an important task for plant breeders to find out (together with farmers or based on a thorough understanding of the farming systems) which new options could really be beneficial and interesting for the farmers.

On-farm or on-station evaluations of exotic varieties, excursions to food processing plants and visits to other regions could be a way to start developing radically new options with farmers.

Success from selection

A clear target is essential for the effectiveness of any plant breeding effort. The clearer and the simpler the target, the greater are the chances of achieving it. If the target, and thus the priorities for selection, can be simplified, then the full selection effort can be focused on those key traits. Such targeted selection efforts have a much higher rate of success and of progress from selection than programmes that have to consider multiple and very complex traits as selection criteria. Therefore, investing some time at the beginning into the development of clear priorities for selection can help enormously to increase the overall efficiency of a breeding programme. This is why most PPB programmes put great emphasis on understanding farmers' preferences and needs (Weltzien *et al*., 2003).

Selection priorities may be different for different groups of farmers. Transparency here can help to compare the identified selection priorities once again with the overall project goals, and then decide how (and with which group of farmers) to best achieve them. Tools for discussing different options and trade-offs with farmers will be presented in the last section of this chapter.

4.4.4 Choice of base germplasm

Selection can only be successful if there is sufficient diversity from which to choose. It is thus clear that the selection criteria and the choice of germplasm are intimately linked. Traits for which no genetic variability is available cannot be considered for genetic improvement. Similarly, the extent of diversity available for selection largely determines the success of the selection programme. This is particularly important in view of the first guiding principle for prioritizing selection criteria, namely to keep criteria to the minimum necessary.

Using local germplasm as breeding parent: a way to increase the acceptability and adaptation of new varieties

One basic approach for keeping the number of selection criteria to a minimum is to identify base germplasm that already has most of the traits expressed at the threshold level or above, but is variable for the major trait targeted for improvement. Many PPB programmes have been very successful in this respect, because they did use the local germplasm and farmers' knowledge of it for this purpose. By using local germplasm, most of the traits for adaptation and use are already expressed at this threshold level, and the novel germplasm can be chosen to introduce new variability specifically for improving one or two key traits, e.g. reducing the period from planting to flowering, or increasing yielding ability, or stover quality, or resistance to a major pest or disease.

Plant breeding and biodiversity conservation

The choice of germplasm is also a key issue for achieving goals related to biodiversity conservation. If used successfully in plant breeding programmes, there are much better chances of 'endangered' germplasm being preserved, compared with other approaches focusing on conservation *per se*. If diversity conservation is a primary goal of a plant breeding programme, a very good understanding of the nature and functions of this diversity for the target group needs to be achieved. Assessing local diversity in a participatory research process can, as such, contribute to raising awareness about the usefulness of this diversity among participating farmers and scientists, and thus increase the chances for future use of this germplasm. However, the goal of increasing biodiversity in farmers' fields does not necessarily require a focus on local and traditional germplasm. Particularly in those regions where a major part of the local diversity is already lost, a plant breeding programme could also be based on material from elsewhere, showing enough diversity in traits that have been identified as useful for the target group of farmers.

Any adoption of new varieties by farmers will change the portfolio of varieties available in a village community. This may provide interesting new options for some farmers, and possibly disadvantages for others. Such developments can often not be anticipated fully. Unintended (negative) outcomes for some farmers can be reduced by ensuring the multiplication and access to seed of the original varieties, for example through strengthening seed exchange networks, institutionalizing seed fairs or community seed banks.

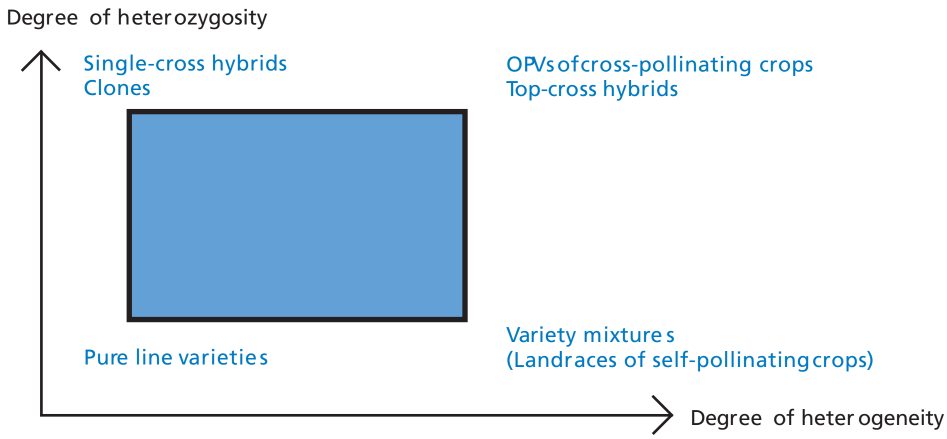
4.4.5 Types of variety

What type of variety will be developed in the course of a plant breeding programme has important implications with regard to the biodiversity in farmers' fields and to the options farmers have to use seed of this variety for re-sowing, selling, exchange and their own breeding activities. These aspects touch the overarching goals of the breeding programme, and are thus important for consideration in the process of priority setting.

Variety types and agrobiodiversity

Varieties can have very different genetic structures; they can differ in the degree

FIGURE 4.3
Degree of heterogeneity and heterozygosity in different types of varieties



Source: Weltzien and Christinck, 2005.

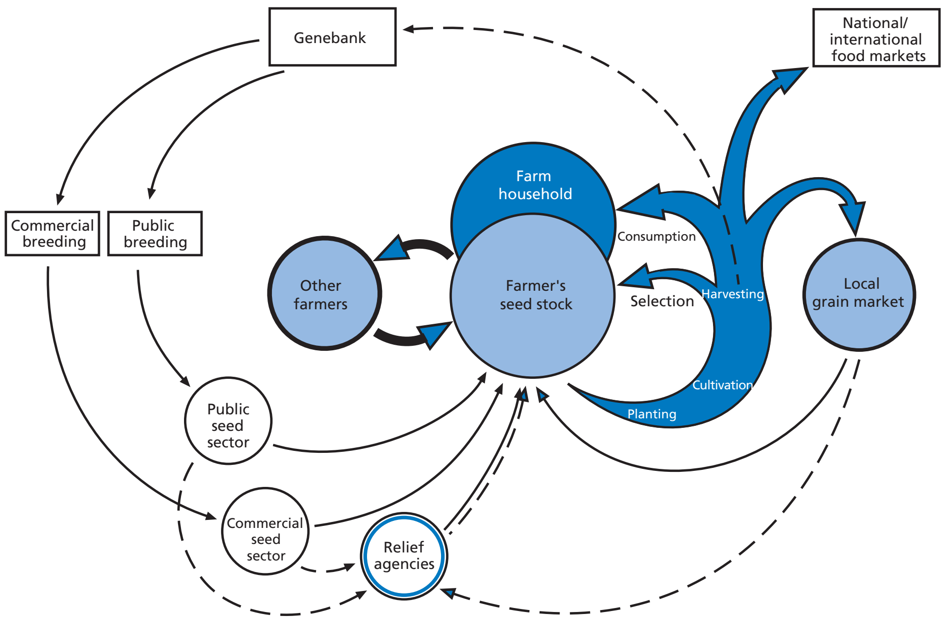
of variability maintained within the variety and in the degree of heterozygosity, with important implications for the ease of reproduction (Figure 4.3).

Pure line varieties of self-pollinated crops are homogenous and homozygous, and could theoretically just be made up of one single genotype that can easily be reproduced. Single-cross hybrids may also be made up of only one genotype (the offspring from a cross between two homozygous parental lines). However, they have very high degrees of heterozygosity and cannot easily be reproduced by farmers. Other types of hybrids will have different levels of diversity within them, such as top-cross hybrids, where one parent is an open-pollinated variety of a cross-pollinated crop. Open-pollinated varieties have a high degree of intravarietal diversity. Heterozygosity is also present in such varieties, depending on the out-crossing rate of the crop and the diversity of alleles for genes in the population. Open-pollinated varieties can be reproduced easily if contamination with pollen from other varieties can be prevented. Variety mixtures (multi-line varieties) or some landraces of self-pollinating crops may be both homozygous and heterogeneous. They are reproducible if natural selection pressures do not differ very much from the conditions under which they were developed, so that specific types or components will not disappear.

Furthermore, a breeding programme could also reach diversity-related goals through developing a number of varieties for specific conditions and uses, and for various user groups. This approach has important implications in the longer term, because it will require a continuous effort to maintain and disseminate all these varieties (see Section 4.5, on Roles and responsibilities of partners).

For the process of priority setting, we have to consider which form and degree of diversity—and of which material—will be required to reach the diversity-related goals of the programme, and how important it is that the seed can be easily reproduced and re-used by the farmers. The latter point is discussed in more detail below.

FIGURE 4.4
Formal and informal dimensions of seed systems and how they may interact; varieties from the formal system may enter the local systems and vice versa



Source: Sperling and Christinck, 2005.

Variety types and farmers' access to seed

The seed channels farmers use for sourcing their seed are normally grouped into two broad seed systems: the formal and the informal seed systems. The latter is also sometimes termed the local, traditional or farmer seed system (see Figure 4.4).

The formal seed system involves a chain of activities that lead to clear products: i.e. certified seed of verified varieties. Thus, the chain usually starts with plant breeding in research institutions or commercial companies, and results in varieties or hybrids intended for formal variety release. Formal regulations aim to maintain varietal identity and purity, as well as to guarantee physical, physiological and sanitary quality. Seed marketing takes place through officially recognized seed outlets, either commercially, or via national agricultural research systems (Louwaars, 1994).

The informal system embraces most of the ways in which farmers themselves produce, disseminate and obtain seed: directly from their own harvest; through barter among friends, neighbours and relatives; and through local grain markets or traders. The same general steps take place in the informal system as in the formal, but they take place as integral parts of farmers' routine grain production rather than as separate activities. Also, rather than be monitored or controlled by government regulations, informal seed sector production is guided by local technical knowledge and standards, and by local social structures and norms, including market forces (McGuire, 2001). Varieties may be landraces or mixed races, or improved varieties that have made their way into the local system.

Perhaps because of their ability to meet local needs and preferences, informal channels provide most of the seed that small farmers use: it is estimated that somewhere between 80 and 90 percent of total seed sown originates from the informal system, although this varies a lot between different countries and regions, as well as for different crops. A formal seed system does not exist in practice for many local crops or varieties of minor economic importance, whereas it is particularly important in regions where hybrid maize is grown. The relative importance of the formal and informal seed systems also much depends on the seed legislation of the respective country. Very restrictive seed laws have practically abolished the informal seed system in some countries, whereas in others the legislative framework allows for the co-existence of both systems.

Professional plant breeders are usually members of formal institutions (public or private), so that formal channels of seed production and dissemination are the 'normal' route through which newly developed varieties find their way to farmers' fields. However, the formal and the informal systems have both comparative advantages and disadvantages for variety diffusion, and often address different client groups. Considering these differences could form part of an active strategy for effective variety diffusion in relation to the goals of the breeding programme. For example, the informal seed system has various advantages for poor farmers, as the seed price is usually lower and the modes of payment flexible. If poor farmers' access to new varieties is a goal of the breeding programme, variety diffusion through the informal system could be a good option for reaching this goal. At the same time, the informal system often builds on traditional rules and forms of cooperation in village communities, including cooperation among different wealth and ethnic groups. Thus, detailed knowledge of the seed systems and how they are related to different groups of farmers is required for developing such strategies (Sperling and Christinck, 2005).

The type of variety that will be developed, and how it can be reproduced and maintained by farmers, is thus a very important consideration for a breeding programme, particularly in situations where the formal system alone cannot serve the target groups of farmers.

4.5 ROLES AND RESPONSIBILITIES OF PARTNERS

4.5.1 Cooperation between different organizations and stakeholders

Plant breeding is increasingly being done as a partnership among different stakeholders: individuals, groups, organizations who share an interest in using and improving crops. It is thus clear that the discussion about roles and responsibilities of the different partners is at the heart of such plant breeding projects, and is thus a critical issue in the priority-setting process.

The 'history' of a project (who took the initiative and for what interest?) appears to play an important role in this regard. It makes a difference whether one organization initiated the project and organized the major part of the resources, and then sought potential partners, or whether it was a joint initiative from the outset. The present structure of international agricultural research, particularly with regard to funding and accountability, potentially poses problems for cooperative research that involves very different types of institutions. This is due to the large differences between organizations regarding their access to external funding, and the fact that the institution that successfully acquires funds is usually alone accountable towards the donors, which often impedes a real sharing of project responsibilities among the partners (Kolanoski, 2003).

Notwithstanding, for the process of priority setting, it appears recommendable to look deeper into the key skills and resources (material and non-material) each partner or partner organization has to offer for reaching the identified project goals, for example, with regard to several issues:

- Overall project management, including decision-making processes, monitoring and evaluation, reporting, public relations work at different levels, fund acquisition and management.
- Planning and implementation of practical project activities, such as trial management and data analysis, or seed production and dissemination.
- Training and skill-building activities.

On this basis, contracts between the various institutions could be negotiated, which include tasks and duties with regard to the project, as well as the distribution of funds and resources among the partners. Furthermore, a pre-agreed procedure for mediation or a conciliation board should be foreseen in view of future cases of disagreement that might crop up between the partners.

4.5.2 Cooperation between farmers and scientists

In projects initiated by formal-sector breeding programmes, which are mostly concerned with the traditional goals of breeding programmes, such as productivity increases and possibly changes in policies for variety release or seed diffusion, most of the decision-making about the project tends to be initially in the hands of the scientists. The farmers often play a rather more consultative role, giving input into variety evaluation, prioritization of selection criteria, and the necessary insights required for focusing the project. However, as partners gain experience, and the scale at which the project operates increases, projects tend to develop towards a strengthened role for farmers or their organizations, especially in terms of selection decisions and variety evaluation.

If farmers, especially a farmer organization, initiate a plant breeding project, it tends to be clear that they seek specific support or input from scientists to find solutions to problems already well identified. In addition to specific technical support, scientists can make contributions to building farmers' skills with respect to obtaining new germplasm; crop biology or physiology; specific plant breeding activities, such as crossing; variety evaluation; and interpretation of results. In such situations, it is clear that the role of scientists is primarily a consultative one, while key decisions are taken by the farmers or their organizations.

In situations where farmers are not well organized, but project partners have identified farmer empowerment and skill building as a project goal, the project may invest major resources in the establishment of farmer organizations, committees or groups, which can then manage more of the key breeding activities, and over time become the primary decision-makers, as their skills and organizations grow. In such a scenario, the role of the researchers may change considerably over time, especially in terms of the management of trials, such as decisions about which materials to continue with or to abandon, or which priorities for selection to add to the project. Usually these changes are also accompanied by a change in the scale of the project. There is thus an increase in not only the skills of the farmers, but also in the number of farmers and of villages, and thus possibly the number of crops, target environments and priorities for selection.

In any case, a reflection on the different approaches and skills of farmers and researchers could be a valuable basis for priority setting with regard to roles and responsibilities of partners in a breeding project. Farmer experimentation is in various respects different from the experimental designs usually applied by scientists, and has been described by a number of authors (Johnson, 1972; ILEIA, 2000; Leeuwis, 2004; Reijntjes and Waters-Bayer, 2001; Saad, 2002). Respecting and learning from farmer's informal experimentation and evaluation approaches could lead to valuable insights and innovations, and could thus be assigned a role of its own in a participatory breeding project.

4.5.3 Decentralized breeding programmes

Breeding programmes that aim at exploiting local adaptation or increasing diversity in farmers' fields usually have to be organized in a strongly decentralized manner, as a number of varieties will have to be tested, multiplied and distributed among a limited number of users. In such cases, the responsibilities should also be shared from the outset to ensure the sustainability of such activities. Skill building, training and institutional development may be important elements in such projects, and could support farmers to manage locally preferred varieties by themselves.

4.6 PRACTICAL METHODS FOR PRIORITY SETTING

Priority setting for plant breeding programmes is, as such, not much different from other situations, and includes a number of steps (Figure 4.5).

FIGURE 4.5
Steps for priority setting in a plant breeding programme

1. Clarify the goals
↓
2. Identify the relevant issues for priority setting
↓
3. Analyse the situation in relation to the identified goals and issues
↓
4. Develop concrete new options
↓
5. Make decisions among options considering the goals

Before examining some practical tools, we will briefly refer to each of the aforementioned steps.

4.6.1 Clarifying goals

As indicated earlier in this chapter, plant breeding programmes can have a variety of goals, of very different natures. It is important that all the options are discussed with the partners, and that a common vision is achieved for each project and for the programme as a whole. It is important that discussions about the goals are held regularly to ensure that the goals remain relevant, and that they remain clear, evident and important to all partners involved in the programme.

4.6.2 Identify the relevant issues for priority setting

The critical issues for priority setting in a plant breeding programme have been outlined in the first part of this chapter (see Figure 4.1). All these issues need to be addressed by any plant breeding programme, but there may not always be viable alternatives to chose from. Besides, the goals of a breeding programme can change over time, reflecting the particular context or situation; thus, priorities need to be reviewed regularly.

For the purpose of identifying relevant options for the key issues, it may be helpful to examine the chances of success with regard to each of the goals. This could be done during a planning workshop, or also in the form of an e-mail discussion for those partners who are using this communication technology. Furthermore, it is likely that new options and insights emerge in the course of the practical project activities. Therefore, the process of priority setting should be implemented in such a way that insights and challenges can be addressed at regular intervals, and then be integrated into previous concepts.

4.6.3 Situation analysis

Realistic new options or technologies require a good knowledge of the situation under which they are intended to function, including the needs and preferences of the potential users. Client-orientation is a key concept in the general economy, and increasingly also in plant breeding (Witcombe *et al*., 2005). In the past, client-orientation was sometimes under-developed in plant breeding, particularly as far as resource-poor farmers in marginal areas were concerned. A basic understanding of the complexity of farming systems in such situations, as well as their dependency on environmental adaptation and biodiversity, has now been developing, mainly since the mid-1990s.

The situation analysis for a plant breeding programme should focus on those issues required to effectively reach the goals of the breeding programme. In general, it will have to include the following issues:

- agro-ecological conditions;
- socio-economic conditions, including marketing of crop-based products;
- the farming system, actual processes of change and main limitations;
- farmers' use of varieties and their seed management;
- seed system analysis; and
- specific varietal needs and preferences of the target group(s).

The situation analysis could include the following steps:

1. Review secondary sources.
2. Consult local experts, key people with good knowledge of the potential target area(s).
3. Visit potential target areas and consult farmers belonging to different social and wealth groups.
4. Structure and compile the information for further planning.

Experience gained in a number of PPB projects has shown that participatory communication tools, such as semi-structured or informal interviews, focus-group discussions, wealth ranking, transect walks, time lines, mapping, classification and ranking exercises, can be extremely useful for providing a good basis for further planning. The particular strength of such communication tools is that they facilitate direct dialogue between farmers and researchers, and can help to develop a common understanding of the situation, as well as of the main constraints and needs. Practical guidelines for conducting such a situation analysis, particularly for plant breeding projects, have been suggested by Christinck, Weltzien and Hoffmann (2005). Furthermore, much inspiration can be gained from general guides and

BOX 4.3
Web sites on participatory research methods

Sources of information and training materials are listed below. We concentrate here on those publications that are available via the Internet, often for free download.

1. The Web sites of FAO (www.fao.org) and the World Bank (www.worldbank.org) contain sections on publications for download and/or purchase (search for "participation" or "PRA").
2. Further publications may be found via the online bookshop of UNEP (United Nations Environment Programme) www.earthprint.com in the section on Participation and training.
3. An introductory guide to participatory learning approaches can be downloaded free of cost from the GTZ homepage: Schönhuth, M. & Kievelitz, U. 1994. Participatory Learning Approaches. Rapid rural appraisal, Participatory Appraisal – an introductory guide. http://www2.gtz.de/dokumente/bib/95-0930.pdf Other language versions (Spanish, French) are available upon request. More specific publications on participatory research and learning are accessible for download from: http://www.gtz.de/de/themen/uebergreifende-themen/partizipation/15201.htm (Accessed 12 September 2008).
4. Participatory Learning and Action (formerly PLA Notes) is a series on Participatory Learning and Action (Methods and Approaches), accessible through the IIED homepage (International Institute for Environment and Development, London, UK): http://www.iied.org/NR/agbioliv/pla_notes/about.html#a (Accessed 12 September 2008).
5. The Programme for Participatory Research and Gender Analysis (PRGA) has a Web site with a series of publications and resources, including a listing of cases for participatory plant breeding. (www.prgaprogramme.org)
6. Reading University, UK, maintains a Web site with training materials and resources focusing on the statistical analysis of data from participatory research activities: http://www.reading.ac.uk/ssc/workareas/participation.html (Accessed 12 September 2008).

publications on participatory research (see Box 4.3).

The use of qualitative social science methods for conducting studies in plant breeding projects has long been debated. Plant breeders are used to working with large numbers of accessions and observations on various trial sites, so that statistical data analysis is a standard method in this field of research. However, results from informal qualitative research are not necessarily less precise (only there are no numerical estimates of how precise). For many purposes in a plant breeding programme, and particularly in the initial phase, the main focus would be to initiate dialogue and identify potential partners. Often, it is possible to start with rather informal and qualitative research methods, in order to identify the main issues of relevance, and to use this knowledge later for more formal studies, if required. There are also increasing efforts to combine qualitative with quantitative, and informal with more formal methods (Bellon and Reeves, 2002; Abbeyasekera, 2002).

4.6.4 Develop concrete new options

Developing new options for varieties requires creativity and good knowledge of the conditions under which a new variety will have to 'function'. It also requires good knowledge of the available diversity of the crop. Similarly, it may require detailed understanding of options for new crop uses, and for marketing of crop products, possibly new ones. Traditionally, plant breeders have done this based on their own understanding of the farmers' reality, especially as many of the early private plant breeders were farmers themselves. Nowadays, when plant breeders work on a national, regional or international scale, the development of new options for variety development, and seed distribution requires working creatively with farmers and other project partners from various institutions and disciplines. This is usually a continuing process, and thus the project or programme should be organized in such a way that regular reviews of alternative new options can take place.

4.6.5 Making decisions among various options considering the goals

Making choices between the different options needs to be forward looking, based on the identified project goals, and on chances for success. Different stakeholders and partners will have different perspectives, and thus their choices and preferences for specific options will vary. Hence it is important that the process of making decisions among an array of options is transparent, and that the roles and responsibilities of the different partners in the decision-making process are agreed. Ranking exercises are ideal tools for taking decisions based on transparent criteria. Participants may make their decision first, and then explain the reasons for their choice. Implicit reasons can thus be made explicit and transparent. More refined tools, which can consider several criteria simultaneously, may be used once the key criteria are agreed.

4.6.6 Tools for farmer participation in the priority-setting process

In this last section, we present a series of tools that have been used successfully in one or more of the steps of the priority-setting process outlined above. Some may be used only for one specific step in the decision-making process; others may apply to several of the steps. Many of the tools have been successfully used with farmers for the identification of critical selection criteria. The tools we choose to describe are primarily those that can be used with a wide variety of partners, specifically with farmers, but also with those who may have very little time, may not be literate, but may have a profound knowledge of their culture and crop related issues. Many of the tools are described in more detail and with more examples in other sources, sometimes in other contexts. Some good source materials are cited and listed. In most instances, one would apply not only a single tool, but several; it is advisable to vary the tools for different steps of the priority-setting process, and also for the purpose of verifying and increasing the reliability of previous results and hypotheses.

Facilitated discussions on goals, issues and criteria

Invite all relevant project partners to a meeting on discussing goals for a new plant breeding programme. As the outcomes will possibly depend on the circle of persons invited, the invitation list should be carefully thought out. Furthermore, particularly if farmers are involved, the language, the general 'setting' and the working style (are all participants literate?) should be considered with awareness.

Depending on the number of participants, there are various options for facilitating such a meeting. One option would be that the participants from each organization are asked to prepare a short presentation, which would include a sort of problem analysis based on their own experience and viewpoints, and should propose goals and priorities. After the presentation, the main goals mentioned in the presentation would be documented on a board. In this manner, there would be a preliminary list of goals at the end, which could then be further discussed.

Another way would be to start with a 'brain-storming session' or open discussion on goals, and to document the proposed goals on a board for further discussion.

There should then be time to discuss these goals in more detail and clarify what they imply. Very often, it helps if the participants are asked what kind of indicators they would suggest as a 'measurement' of whether the future project activities would be successful or not in reaching these goals. Such indicators could thus also be useful for future monitoring and evaluation meetings.

It is of particular importance to identify potentially conflicting goals, or utopian goals. In such cases, the group could try to weigh up different goals, or to make utopian goals more realistic and situation-specific. In general, it is of course much easier to reach a few clear goals with high priority on the agenda of all participants, than a long list of potentially conflicting goals. At the same time, the discussion of goals can anticipate many problems that might occur in the course of a plant breeding programme, particularly if many partners are involved.

The meeting could then finish by prioritizing the suggested goals, such as through a simple ranking or scoring exercise (see below).

In any case, such discussions on goals should be regarded as preliminary results. Many goals are not easily expressed and are closely related to individual or culture-specific values. Moreover, goals may evolve in the course of the project activities. It is thus recommended that this discussion be repeated later, for example after completing the situation analysis (see Section 4.6.3, above), and particularly in view of the question of whether the goals are really relevant for the target group. Regular discussions on goals and indicators, for example at the beginning of each new working phase, or in a general planning meeting, can be rewarding if a good facilitator helps to ensure productive outcomes.

SWOT analysis

A discussion about the overall goals and more specific priorities involving key actors or stakeholders can be structured in the format of an analysis of the present situation of the crop under discussion and the development of future varietal options. A strategic planning tool for this type of analysis is SWOT analysis, a structured discussion on **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats. This discussion could be held as part of a project planning workshop, for example on the topic: 'Farmers' groundnut varieties for the dry areas of Senegal', or any other crop and region.

The participants, either individually or in small groups, are first asked to think about the strengths of the situation under discussion. The results should be documented on a board or piece of paper (for later presentation to the whole group). In the following steps, the participants also discuss weaknesses, opportunities and threats. The results should be documented visually on a board, and could then serve as a starting point for discussion on goals and priorities of a breeding programme (see also Weltzien, 2005).

Recurrent feedback discussions

Successful project work depends on good interaction between partners, e.g. researchers from various institutions, farmers, and extension or NGO personnel. Feedback discussions during which the different partners openly exchange their views and experiences with specific project activities should be held at regular intervals. These discussions about what worked well, or which problems or opportunities arose, are the basis for reviewing the project priorities in an evolving partnership between very different types of organization. While there may not necessarily be a fixed framework for such discussions, they are instrumental in refining project priorities and in the evolution of the overall goals of a project and a partnership. Participatory Monitoring and Evaluation (PM&E) would be a more 'institutionalized' way of conducting such feedback discussions (Germann, Gohl and Schwarz, 1996).

Simple scoring exercises

If you wish to set priorities among a number of possible goals, criteria, problems or issues in a formal way, simple scoring exercises can be applied. This requires that a tentative list of goals and criteria is already established.

These goals should be written on a board or be represented visually in some form (graphically or as text). All participants get a predefined number of counters, such as pebbles, paper pieces, adhesive dots, etc., and are asked to put their counter next to those goals with the highest priority for them. The goals should be well understood for this exercise, and the rules explained carefully. Generally, each participant should have fewer counters than goals, so that a real decision has to be taken. It should be clarified whether it is allowed to assemble all counters at one goal, the one perceived to be more important than any other, or if only one counter can be placed for each goal. In this manner, you will obtain a clear result within a relatively short time—a result on which further discussions can be based.

Ideal variety

Invite a small group of participants, preferably 2 to 4, with whom you have already discussed variety trials or the importance of specific traits in particular. Larger groups could split up into separate working groups and later present their results to the whole group. Invite each participant to think about what a really good variety of the crop on which you are working could look like, referring to the previous discussions you have had. Focus group discussion, where different groups represent farmers with differing backgrounds, farming situations, gender, ethnic groups, etc., can reveal underlying differing needs.

Ask the participants to think about all the characters that a good variety of millet, cowpea, etc., should have, to be useful for them. The traits mentioned by the participants should be written on cards, or the participants should find symbols for visual representation; the cards should then be placed vertically in a column. Make sure that everybody contributes and that all the important traits are mentioned. In the course of the exercise, you may also suggest some trait(s) if you are particularly interested in sparking off a discussion on the relative importance of some new traits. Once all the traits have been identified, you can then ask the farmers to discuss the importance of the trait for a new variety that would be better than the existing ones. To indicate the level of importance of each trait the farmers could distribute a fixed total number of tokens between the traits they (and you) have mentioned. The more important a trait, the more tokens it receives. Traits that are not required should get no tokens, and can be eliminated.

It is best to facilitate this discussion in such a way that the participants primarily discuss among themselves about each trait; for example, how early the ideal variety should be, or how much grain yield in relation to stover yield they think would be useful. The difficulty is to try to keep the discussion within the realm of biological reality, i.e. **not** only grain yield, increased 10-fold with half the growth duration of existing varieties.

Create scenarios

Scenarios can be used to find out whether certain concrete new options are attractive for the target group(s) of farmers. This approach is particularly useful in the case of complex or interrelated trait combinations. For this purpose, we need seed and plant material in which these new trait combinations are already expressed (i.e. exotic or experimental varieties).

By simulating a situation in which farmers have to take a decision between various complex options, immediately followed by an interview about the reasons, then important criteria and trade-offs may be revealed. Furthermore, this is also a way to study whether and why people belonging to different groups take different decisions regarding the proposed options.

Scenarios are only useful if the farmers' reality is reasonably well understood. If the options or choices presented to farmers are not realistic, the responses cannot be expected to be realistic either.

Example 1: Seed shop exercise

The scenario is that the farmer who has no seed of this crop at the time of sowing enters into a seed shop and has to choose among a set of varieties with different properties.

For this purpose, seed of different varieties, local and introduced, is displayed in the 'shop', so that the farmers can see and touch the seed. Variety names, plant samples or drawings of the plant type can provide additional information. If you really plan to give the seed to the farmers after the exercise, small packages in sufficient number should be prepared.

The farmers are asked to enter the 'shop' one by one, take their decision and leave the 'shop'; an interview on the reasons for their choice will be conducted immediately after leaving the 'shop'.

The rules of the exercise should be made very clear at the beginning, particularly concerning questions such as whether the farmers will really get seed of the preferred variety, how much, at what time (in the 'shop' or afterwards) and from whom. Such rules potentially influence the result. They should be carefully considered beforehand and then announced very clearly to the participating farmers.

Example 2: Simulating plant selection in a 'field'

The scenario here is that a farmer selects plants from a 'field'. This is very close to the farmers' reality in most cases. A further advantage of this scenario is that many different traits, which may be relevant for the adaptation to specific conditions, different uses or situations, will be included into the farmer's decision-making.

A small plot or grow-out of a variety mixture or broad-based population will be required, which shows variability with regard to all traits in which the farmers or the plant breeders are interested (known from previous exercises).

The participating farmers are invited individually or in groups to the 'field'. They are then asked to mark with a coloured ribbon or tag a certain number of plants that they would select for growing in their field. Alternatively, the farmers could be asked to cut the plants from the plot for further evaluation. Interviews on the choices taken by the participants could follow.

Simple ranking

If decisions have to be taken among few options (2 to 5), write the options on paper cards or represent them visually with photographs, drawings or real objects. The options and what they imply should be very clear to the participants. Ask a person or small group to put the cards or objects in an order of preference, starting with the best, the second best, third best, etc. Then ask for reasons and criteria used. A detailed description and training exercises can be found in Guerrero, Ashby and Gracia (1993).

Pair-wise ranking

This exercise works well with up to six items or options. The participants are asked to make pair comparisons, indicating which alternative is better, and why. This exercise often results in an exact description of the conditions under which the alternatives work well or otherwise. This exercise has proven very useful for discussions about selection criteria and farmers' preferences, and is explained in more detail by Weltzien and Christinck (2005).

Matrix ranking

Matrix ranking can provide more detailed insights into the advantages or disadvantages of various options. The ranking criteria have to be defined beforehand. Pair-wise ranking or the Ideal Variety exercises could be used to identify criteria for further discussion and variety evaluation. In a planning workshop, the different options or scenarios to be ranked can be related directly to the project goals, or to criteria that are related to the project goals; for example, if income generation through processing is one of the project goals, some of the ranking criteria could be concrete advantages for processing and marketing.

The matrix could be prepared on a large sheet of paper or on the ground. The visual or text representations of the different options to be ranked are usually placed vertically in a row, with the criteria or aspects in a horizontal row. The participants are then asked to rank all options for the first criterion by placing counters (adhesive markers if done on paper, otherwise pebbles, large seeds, etc.). There should be clear rules for placing counters (i.e. only one counter for the option that fulfils best this criterion; or a certain number of counters for the best, second best, etc.).

If you assign a number to each participant, and write the number on the counters used by this person, the result could be useful for further analysis (who preferred which option, and why). Thus matrix ranking needs some efforts for preparation, but can then deliver very detailed results, especially for identifying selection criteria, user groups and target growing conditions.

Scoring exercises

Scores are frequently used by breeders to assess newly-created varieties and breeding lines. A similar approach can also be pursued with farmers.

Scores indicate a certain level of performance or expression of a trait. For example, the early vigour of varieties could be assessed using a score, where 5 indicates that a variety is extremely vigorous, 4 = very vigorous, 3 = vigorous, 2 = less vigorous and 1 = not vigorous, or weak. Thus scoring applies a fixed scale, as a tool for assessing potentially a large number of new varieties or other options.

There is a fundamental difference between scores and ranks, which can have far-reaching implications. For example, ranking puts varieties in the order of performance or expression of a specific trait. The best variety could actually have a fairly poor performance, if all the other varieties are still worse. The differences between varieties could be very small, but they may lead to different ranks. Ranks do not have an underlying scale, and thus quantitative analysis is more difficult. Ranking can only be done meaningfully with a small set of varieties (not more than seven) (Coe, 2002; Weltzien and Christinck, 2005).

Discussions on the reasons for giving a particular score to a variety will reveal the underlying criteria. It is furthermore possible to compare the scores given by different groups of farmers (gender groups, people from different villages, etc.).

Practically, scoring exercises can be realized in the field in various ways. Literate participants can enter scores (= numbers) in a previously prepared evaluation form. Alternatively, one can use counters (stones, pebbles, paper pieces), which have to be put into a basket, box or bag near the scored plot. More detailed descriptions and examples can be found in Weltzien and Christinck (2005).

Discussions with farmers about their scoring will lead to a better understanding of selection criteria, preferences of specific user groups or for target growing conditions, market demands, etc.

Other tools used for priority setting

The tools described above are explained in more detail in various training manuals and handbooks (Box 4.4) for farmer participatory rural appraisals. Economists tend to use

BOX 4.4

Training materials and books on participatory research methodologies in plant breeding projects

1. Bellon, M.R. & Reeves, J. 2002. *Quantitative analysis of data from participatory methods in plant breeding.* Mexico, CIMMYT.
2 Christinck, A., Weltzien E. & Hoffmann, V. 2005. *Setting breeding objectives and developing seed systems with farmers. A handbook for practical use in participatory plant breeding projects.* Margraf Publishers, Weikersheim, Germany, and CTA, Wageningen, Netherlands.
3. IPRA & CIAT. 1991. *Farmer evaluations of technology: Methodology for open-ended evaluation.* Instructional Unit No. 1. IPRA, CIAT, Cali, Colombia.
4. Guerrero, M.P., Ashby, J.A. & Gracia, T. 1993. *Farmer evaluations of technology: Preference ranking.* Instructional Unit No. 2. IPRA, CIAT, Cali, Colombia.
5. Cleveland, D.A. & Soleri, D. 2002. *Farmers, scientists and plant breeding: Integrating knowledge and practice.* Wallingford, UK, CABI.

other tools, such as Decision Trees, Grid Analysis or Hedonic Pricing Models, for priority setting and the identification of specific selection criteria. These tools have rarely been applied specifically to plant breeding programmes, with the important exception of the hedonic pricing model, which has been used in a number of instances (e.g. Dalton, 2004; Faye *et al*., 2004). These quantitative analytical tools can also be used to analyse data from specifically set up scenarios, or from ranking or scoring exercises. More examples for combining qualitative and quantitative tools can be found in Bellon and Reeves (2002) or Barahona and Levy (2002).

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