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# Participatory conservation: a means of encouraging community biodiversity

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## Summary

### Participatory conservation: a means of encouraging community biodiversity

The conservation of natural resources and biodiversity is threatened by increasing habitat loss, the degradation of the environment and the introduction of modern crop varieties. Although local landraces and crop varieties are potential sources of valuable genes that could benefit the farming community, their conservation depends to a large extent on the personal motivation of farmers and the continuation of traditional farming methods. There is growing apprehension that many landraces and site-specific genetic resources could be lost. Trait expression in these genetic resources is highly dependent upon the local environment, and has evolved over a long period of time through traditional and cultural cropping practices. Such varieties should be conserved *in situ* preferably on-farm. Techniques for their conservation, seed maintenance and regeneration can be fine-tuned and efficiently applied if farmer knowledge is reinforced with formal theory. Increasingly attention is being focused on participatory conservation to provide a synergy between formal-sector and farmer approaches. This paper describes how landraces and local crop varieties could be conserved by the use of field genebanks and area genebanks linked to community genebanks, and through these, to a national genebank. Improved breeding strategies, resulting from a farmer- formal sector synergy, offer more options for providing a secure and sustainable livelihood for the large numbers of poor farmers who at present receive little or no assistance from the formal sector.

**Key words:** Biodiversity, community genebank, conservation, field genebank, natural genetic resources

## Résumé

### Conservation participative: un moyen de sauvegarder et de revitaliser la biodiversité à l'échelle de la communauté

La disparition croissante des habitats, la dégradation de l'environnement et l'introduction de variétés modernes menacent la conservation des ressources naturelles et de la biodiversité. Bien que les races locales et les variétés cultivées locales soient des sources potentielles de gènes précieux dont la communauté agricole pourrait bénéficier, leur conservation dépend pour une bonne part des motivations personnelles des agriculteurs et de la persistance de l'emploi de méthodes agricoles traditionnelles. On redoute de plus en plus la disparition de nombreuses variétés locales et des ressources génétiques spécifiques d'un site. L'expression des caractères de ces ressources génétiques dépend dans une grande mesure de l'environnement local et s'est transformée au cours du temps sous l'effet des pratiques agricoles traditionnelles. Ces variétés doivent être conservées *in situ* et de préférence sur l'exploitation agricole. Des techniques pour leur conservation, la gestion et la régénération des semences peuvent être améliorées et appliquées avec succès si les connaissances des agriculteurs sont renforcées par des connaissances théoriques. On accorde de plus en plus d'attention à la conservation participative afin d'établir une synergie entre les approches du secteur formel et celles des agriculteurs. L'article décrit comment les races locales et les variétés cultivées locales pourraient être conservées dans des banques de gènes de terrain et des banque de gènes de zone rattachées à la banque de gènes communautaire et, par leur intermédiaire, à une banque de gènes nationale. Des stratégies de sélection améliorées, fruit d'une synergie entre le secteur formel et les agriculteurs offriraient plus de possibilités d'assurer une source de revenu sûre et durable aux nombreux agriculteurs à faible niveau de ressources, qui ne reçoivent actuellement qu'une aide minime, voire inexistante, de la part du secteur formel.

## Resumen

### La conservación participativa como medio para salvar y fortalecer la biodiversidad en las comunidades

La pérdida progresiva del hábitat, la degradación del medio ambiente y la introducción de variedades modernas de cultivos amenazan la conservación de los recursos naturales y la biodiversidad. Aunque los cultivos y variedades nativas poseen valiosos genes que podrían beneficiar la agricultura, su conservación depende en gran medida de la motivación personal de los agricultores y de la continuación de los métodos tradicionales de cultivo. Cada vez preocupa más la posibilidad de que se pierdan muchas variedades locales y recursos genéticos específicos de un lugar. Las características de esos recursos genéticos dependen mucho del medio ambiente local y han evolucionado durante mucho tiempo con las prácticas tradicionales y las modalidades de cultivo, por lo cual es preciso conservarlos *in situ* y preferiblemente en la explotación agrícola. Completar los conocimientos de los agricultores con estudios teóricos permitiría perfilar y aplicar con eficiencia técnicas para conservar variedades, y mantener y regenerar semillas. La conservación participativa está cobrando cada vez más importancia como medio para promover el entendimiento entre el sector formal y los planteamientos de los agricultores. En este trabajo se explica cómo pueden conservarse las variedades y los cultivos nativos y locales utilizando bancos de germoplasma en el campo o en determinadas zonas, vinculados a bancos comunitarios y, a través de éstos, a un banco nacional. Estrategias de mejoramiento genético resultantes del entendimiento entre el sector formal y los agricultores ofrecerían más opciones de sustento seguras y sostenibles a los numerosos agricultores pobres que actualmente reciben poca o ninguna asistencia del sector formal.

## Introduction

Conservation of biodiversity is a complex area, even when confined to plant genetic resources (PGR). Collections can be conserved *ex situ* or *in situ* and in short-, medium- and long-term storage systems, as well as by cryopreservation in the form of tissue cultures. There is a need to look for extended avenues of conservation linked to the sustainable use of plants and equitable sharing of the benefits arising from their use. Participatory conservation, involving farmers and field genebanks, is an important element in this work.

**Table 1. Some valuable land types conserved by Indian tribal farmers for various purposes**

| State | Name of the variety | Predominant quality | Purpose of conservation |
|---|---|---|---|
| Orissa | Kalakrishna | Scented | All festivals |
| | Tulsi | Scented | Chaitra Parva festival |
| | Haladichudi | White slender long grains, good taste | Shakti Puja festival |
| | Machhakanta | White slender short grains, good taste | Manabasa and Laxmi Puja festival |
| | Deulabhoga | Bold and short grains, reddish tinge on cooking with mild scent preferred during worship at temples | Temple deities |
| | Mer | Black grains with medicinal properties | Annual ceremony of forefathers |
| Kerala | Njavara | Medicinal properties | Special consumption preference |
| Tamil Nadu | Landraces of small millet | Rich in micro-nutrients and vitamins | For good health and appetite |

Habitat loss is a potential danger to the natural environment, natural resources and biodiversity. Approximately 90% of known species are reported to have become extinct because of habitat loss (Avery 1997). Landraces and local varieties specific to sites (or niches) are potential sources of valuable and rare genes. However, in general, little is done to promote the specific conservation of such genes. Farmers living in such sites are usually under-privileged and resource-poor, and out of reach of institutional support.

Poor farmers often maintain a variety of valuable indigenous germplasm at their personal cost. In India, for instance, several rice varieties possessing special attributes are still grown because they are used in traditional religious functions or festivals. Other rice varieties such as "Mer" and "Njavara" have medicinal properties, such as a cure for stomach ailments. Many varieties of small millets found in the Kolli Hills, Tamil Nadu are rich in micronutrients and vitamins (MSSRF 1999; Table 1). Farmers in various Indian states prefer to use local landraces for cooking and grow these in small quantities, usually in the backyards of their homes. However, this tradition of farmer conservation is under constant threat because of the widening rift between the low incomes of these farmers and increasing demands on natural resources. Urgent action is needed if such valuable genetic resources are to be saved and utilized. This paper discusses the benefits of using participatory conservation to rescue and revitalize biodiversity in local communities.

## Conservation and utilization

Of the 250 000 plant species known to humankind, more than 30 000 are edible, approximately 7000 have been used for food and some 120 are still cultivated today. Of these, nine species provide more than 75% of the world's food needs and just three provide more than 50% of the world's food (ICSC 1996). An analysis of the success in increasing world food production reveals the narrow genetic base of the plant varieties on which it rests. For instance, all the modern US soyabean varieties can be traced to a dozen strains from one small area in northeastern China, and the majority of US hard red wheats come from two lines originating in Poland and Russia (Tanksley and McCouch 1997). In India, the green revolution, which produced breakthroughs in the production of wheat and rice, as well as sorghum, pearl millet and maize, was achieved by using a small number of genetic accessions.

Gollin and Smale (1999) describe the concerns affecting genetic diversity – high yielding varieties triggering genetic erosion, genetic uniformity resulting in the increased virulence of pests and pathogens, and the multifaceted depletion of the genetic diversity available to agriculture. At the same time, strong arguments are advanced that such concerns are often exaggerated. For example, the hypothesis that the spread of modern varieties erodes traditional diversity "goes beyond our knowledge of the facts of genetic erosion" (Wood and Lenne 1997). In fact, it is argued that without the high yielding crops and farming techniques of the green revolution, it would have been necessary to bring into agricultural production an amount of land equal to the combined area of the United States, Europe and Brazil (Avery 1997). In this context, there is a clear need to measure in some way the benefits of genetic diversity as a public good. The costs of the loss of diversity are exaggerated if opportunities available to people to find substitutes are ignored. In effect, conservation as a 'routine value' should give way to conservation as an 'option value', i.e. the value society places on genetic diversity, taking into account its potential use at some point in the near future. If this is done, it is difficult to sustain the supposition that all genetic diversity is of equal temporal value and that the average value is high (Gollin and Smale 1999).

The Leipzig Declaration, under which Governments committed themselves to implementing the Global Plan of Action, emphasized the need to enhance food security through conserving and sustainably using PGR (Cooper *et al.* 1998). Sustainable use includes incorporating PGR into varieties in addition to their direct use where feasible. An analysis carried out by Gollin and Evenson (quoted in Gollin and Smale 1999) showed that enhancement of rice productivity in India during 1956-84 was associated with the effective incorporation in breeding programmes of genetic resources carrying disease and pest resistance. Such 'incorporation' strategies (Simmonds 1993) can serve as potential paths to sustain farmers' interest in conserving genetic resources. Breeders find that even within a very narrow genetic base, constant improvements can be made in the short term (Cooper *et al.* 1998). More often, the first cycle of improved varieties is used as parents to initiate the next cycle. Though time-consuming, such approaches do provide varieties with enhanced productivity but the nature and magnitude of enhancement is circumscribed by the genetic divergence between the initiating parent varieties.

It is well known that a narrow genetic base leads to genetic homogeneity and hence to genetic vulnerability. The outbreak of severe epidemics such as corn leaf blight in the USA and pearl millet downy mildew in India are just two examples of the result of genetic homogeneity caused by the extensive use of a single source of male sterility that became disease-susceptible.

## Site-specific genetic resources

Site-specific natural genetic resources, such as those that exist in Indian tribal areas, are essential materials. Tribal areas in India are mostly situated in the interior of a state, and are usually underdeveloped in terms of social and economic infrastructure. A typical tribal area in Orissa may contain from 50 to 100 households and be occupied by people from one or a few tribes. Several tribal areas can be found in the same region, often only separated by distances of 10 to 15 km. In general, cultivable areas are rainfed and most of the land is undulating or on slopes. Crop success is, to a great extent, dependent upon climate and the frequency of natural risks such as heavy rains or drought. However, there are considerable differences between the tribal areas of various states. In the Wayanad district of Kerala state, for example, rainfall is highly regular and evenly distributed, soils are fertile and crops grow well. The social structure of local people, their language, food habits and farmer-desired traits, also differ from those in other states. In general, however, the use of chemical fertilizers in all tribal areas is uncommon. The natural environment is well maintained and there is vast scope for integrating formal crop improvement strategies with farmers' practices to increase productivity.

Usually farmers adopt the traditional methods of cultivation used by their ancestors. Generally only one main crop is grown and depending upon moisture availability, other crops are cultivated later. The tribal areas are usually situated far away from main townships and communication between tribal areas is generally lacking. Hence, institutional support, in terms of knowledge of modern cultivation techniques and modern seed varieties, is rarely available and tribal farmers usually have few resources. Some modern varieties do permeate tribal areas in time, although much later than they reach progressive farmers in well-endowed areas. Farmers refer to these as 'government' varieties. Rarely, if ever, do these varieties meet their cooking requirements. Hence, they depend for their consumption mostly on landraces. Tribal areas harbour a rich array of species, indigenous wild varieties and landraces, and are the source of valuable genes. As the possibility of transferring genes across species by using molecular tools increases, the exploitation of these natural plant resources is becoming more common. It is, therefore, not rare to come across commercial exploitation of such tribal resources with practically no compensation to the farmers.

## The need for traditional varieties

The fact that despite growing pressure of various kinds, resource-poor farmers in Indian tribal areas continue to cultivate traditional landraces and local varieties, clearly indicates that the high yields of the modern varieties that do eventually reach these farmers do not entirely meet their needs. Traits governing taste, cooking quality, nutritional value, yield stability rather than yield *per se*, and other attributes such as drought and disease resistance are of equal importance. Location-specific varieties answering such needs can be bred using local landraces as parents, as shown by case studies for barley in Syria; beans in Rwanda, Colombia and Brazil; potato in Peru; and pearl millet and rice in India (Hardon 1995).

There is also considerable evidence of farmers participating in the selection process. For example, farmers in Colombia took part in selecting varieties of common bean developed by CIAT, ranking first a line derived from a cross between a local landrace and a modern variety of common bean (Kornegay *et al.* 1997). Farmers in eastern India adopted rice varieties such as "Mahsuri" suited for rainfed lowland, "Indrasan" suited for irrigated ecosystems and "Jalnidhi" and "Jalpriya" adapted to deep-water conditions, long before their formal institutional release (Dwivedi 1996). Another case study with common bean brought to light that when genes from high yielding varieties resistant to angular leaf spot were mixed with 25% genes from a local variety, a new variety resulted with enhanced yields and lower leaf spot incidence. This strategy not only prevented the rapid loss of local germplasm to angular leaf spot but also provided farmers with a new variety that conserved the characteristics of a local variety (Trutmann and Pyndji 1994).

In a participatory varietal selection programme in Togo, West Africa, farmers gave preference to varieties of rice having large grains, followed by high yield, medium and tall plants, long panicles, profuse tillering and short-growth duration (WARDA 1999). Farmers' preferences among landraces relate to agro-morphological diversity such as plant frame, colour, flavour and other adaptive traits such as adaptability to microenvironments, environmental stresses and biological hazards such as pests (Eyzaguirre and Iwanaga 1996). In India, similar farmer preferences exist. For example, farmers in the tribal areas of Orissa prefer adaptability to weather fluctuations, good tillering, mechanisms to resist or avoid biotic stresses, traits relating to cooking practices, and hulling quality that provides both unbroken kernels as well as good barn and straw yield. Therefore, adaptability, preferred traits and sustainable yield appear to be the key criteria in varietal choice, particularly of resource-poor farmers residing in genetically rich areas. Naturally, breeding for such preferred traits will involve the use of landraces carrying such traits.

That such resources have location-specific trait expression is generally accepted. This implies favourable genotype X environment (GE) interaction. This specific adaptation allows selection *in* the particular environment and not *for* it. In a way, such selection exploits GE interaction in contrast to formal selection avoiding it (in assured environments leading to modern high-yielding varieties) (Ceccarelli *et al.* 1994; Cooper *et al* 1998).

Basic studies exploring the underlying reasons suggest that such genetic resources would have evolved over time and be under the control of co-adapted gene complexes, and that a vast range of environmental factors can change a gene's activity. The belief that "individuals are the product of their genes, nothing more, nothing less" stems from "the constant emphasis on the power of genes" which has created "a 20th century form of fatalistic predestination" (Vines 1998). This has led to some geneticists calling for a new definition of the gene, based not only on DNA sequence, but also on its epigenetic instruction manual, such as the degree of methylation for example. Epigenetic inheritance has been well illustrated in laboratory fruit flies. When the activity, but not the sequence, of a key gene was changed in embryos through a brief heat shock, another gene became activated, causing the flies to have red eyes, a trait that was passed on to their offspring (Vines 1998). It has been stressed that the effect of the environment on one generation's epigenetic instruction manual can be passed on to the next. This is already known to be true for bacteria, yeast, plants and even fruit flies (Jablonka and Lamb 1995).

Thus, normal expression of genes is not, in general, a default phenomenon but the result of a finely balanced set of controls (Pardue 1991). Controls for germplasm found in tribal areas would be provided by the physical and agro-ecological environment, fine-tuned by the traditional cropping and cultural practices under which plants acquire their distinctive properties (Worede and Mekbib 1993). Efficient disruption of co-adapted gene arrangements by breeding or direct selection is, however, possible. This can result in an extended phenotypic range for traits of interest. Inter-allelic interaction coupled with elevated epistasis can explain such a possibility (Rasmusson and Phillips 1997). The above exposition would suggest that the genetic resources to be found in tribal areas should be conserved *in situ*. Tribal farmers, as custodians of the PGR, would have a prime role to play in this conservation.

## Participatory conservation in practice

Participatory conservation is essentially an approach bridging farmer (indigenous) knowledge and formal (scientific) theory for conservation, sustainable use and benefit sharing. Over time, farmers have learnt the techniques of conserving their genetic resources based on practical knowledge of pollinating systems, flowering time, tillering capacity, biomass accumulation, disease and pest incidence, seed size and maturity.

Farmers have the know-how of seed selection and seed production. Strong support for this statement is clear from literature reviews and case studies highlighting the capabilities of small farmers in seed selection, and the production of local varieties and landraces (Almekinders *et al.* 1994). These include the success of farmers' research committees in generating a large quantity of good quality seeds of field peas in southern Colombia (Ashby *et al.* 1997), the excellent progress in seed production of the pearl millet variety, 'Okashana 1' through a network of seed growers' cooperatives, with a lead role for small-scale farmers in Namibia (Rohrbach *et al.* 1999), the farmer community-based seed production programme in Côte d'Ivoire (WARDA 1999), and the example of farmer screening and multiplication of new varieties in Sierra Leone (McGuire *et al.* 1999).

But farmer practices of cultivation, though effective on site and cost-effective, are often not geared to optimal trait expression. For instance, rice cultivation by tribal farmers in Orissa suffers from incorrect use of fertilizer. The resulting very high seed rate leads to stunted and uneven crop growth. Such deficiencies can be corrected by introducing formal practices into farmer cultivation and the use of more, but affordable, inputs. This will enable farmers to derive macro-benefits from micro-investments. For example, farmer-formal sector collaboration has enabled tribal farmers in the Jeypore area of Orissa taking part in participatory breeding experiments, to triple yields.

Similarly, farmers' flair for seed selection can be honed by scientific tenets of seed production, storage and maintenance. Farmers do learn the science behind seed quality, production and protection quite efficiently. One example in support of this is the farmers' participatory seed production of rice and wheat in Punjab, India (Kolar *et al.* 1996). At the same time, farmers' selection practices with Mexican maize in Sierra de Santa Marta, Mexico, bring to light the need to consider interaction among households and their collective behaviour, and cost-benefit analysis across crops, cultures and growing environments if improved practices are to be introduced (Rice *et al.* 1998). This does not put into question, however, the benefit of the farmer-formal sector participatory approach in seed production, distribution and maintenance. A similar logic would also hold for the participation of the farmer-formal sector in identifying and efficiently conserving germplasm.

In the context of site-specific optimality in trait expression, participatory conservation implies that indigenous plant genetic resources need to be conserved on site. Therefore, farmers will have a high stake in participatory conservation. However, in the absence of incentives or perceivable benefits, this activity cannot gain momentum and will remain dormant. One avenue is to involve farmers in the plant breeding process, for example by generating $F_1$ seeds by making crosses between formally identified parents. Farmers can learn the techniques of emasculation – pollination and can understand the protocol of pedigree breeding, hybrid breeding, etc. If participatory plant breeding initiates from crosses between local landraces or between a local type and a modern variety, farmers can not only take an active part but will also be able to realize the benefits of gene introgression in terms of high yields and desired quality. It would then be possible to emphasize the benefit of conserving their site-specific genetic resources and to interface genetic enhancement with gene diversity conservation. Such an activity plan would help to preserve co-adapted gene combinations upgraded by desirable recombination.

Within this basic frame, a possible action plan for participatory conservation is proposed here. In specific sites, farmer plots can be identified for regenerating PGR that merit conservation. Village bodies such as "gram panchayats" in India and farmers' research committees "CIALs" in Colombia (mentioned in Ashby *et al.* 1997) can assist in identifying farmer plots for PGR conservation. Crop failure caused by severe drought can be overcome by selecting plots that have a nearby source of irrigation. Seeds of the harvested PGR can be stored in a farmhouse near the site, denominated as a field genebank. On-site farmer training to select and harvest seeds, together with careful assessment of the degree of farmer knowledge, would give farmers the self-confidence to take care of field genebank activities.

That it is possible to set up such field genebanks is shown by an example reported in Nissila *et al.* (1999). In the Asia, Pacific and Oceania region most of the sweet-potato germplasm existing *ex situ* is maintained in field genebanks with a very small percentage of cultivars maintained *in vitro* or as seed populations. Of the 16 950 accessions maintained in field genebanks from 11 Asian countries, apart from modern varieties, approximately 36% are local cultivars, 17% introductions and 13% breeding lines. Field genebanks in tribal areas located at high altitudes would not even need temperature control, as the climate would be cool enough to preserve seeds for a few seasons.

Scientists collaborating with farmers can also train them to keep and update records on ownership, passport data and

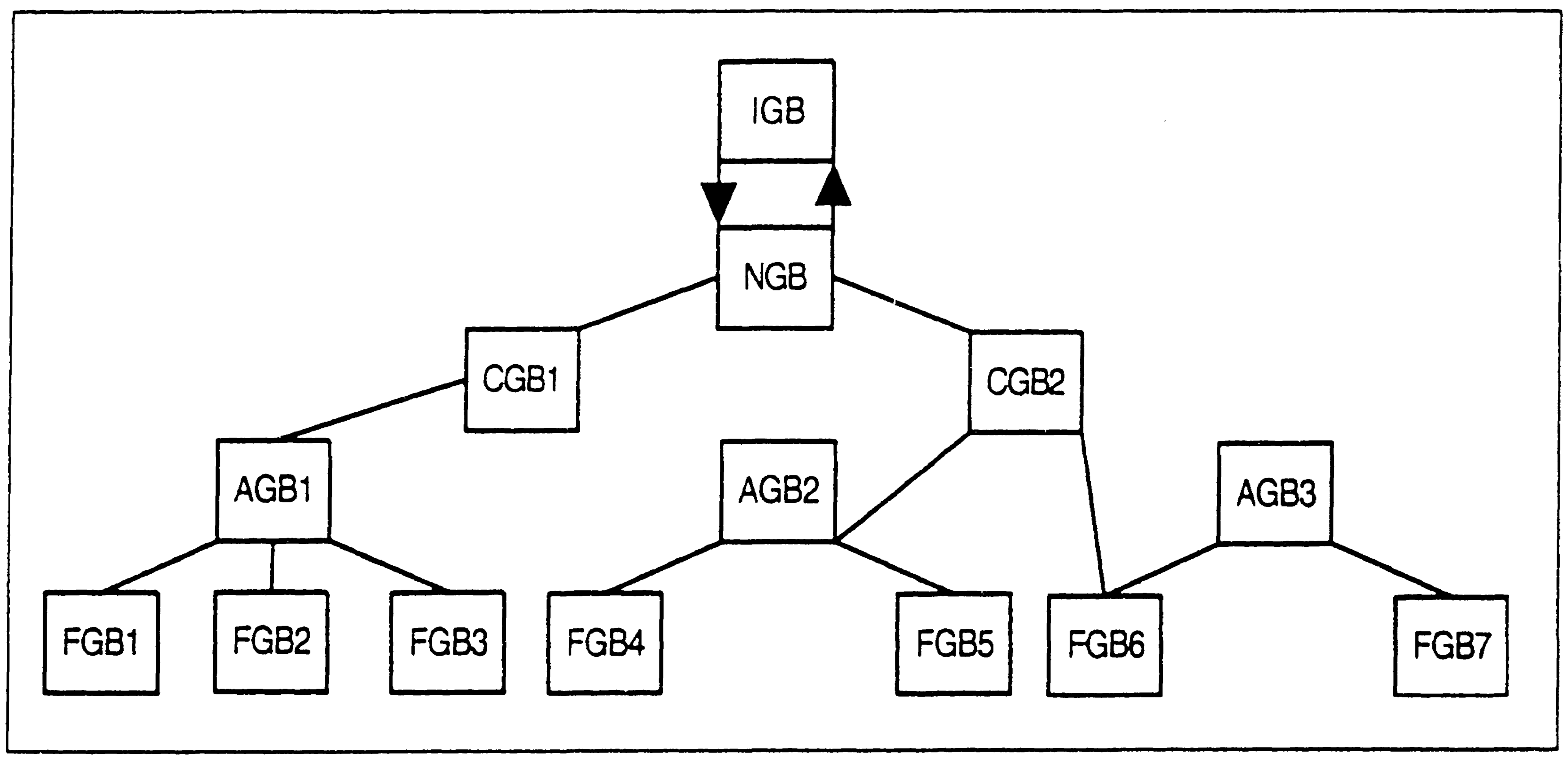

**Fig. 1.** Organizational setup of participatory conservation. FGB = Field Genebank; AGB = Area Genebank; CGB = Community Genebank; NGB = National Genebank; IGB = International Genebank.

diagnostic traits. This would then facilitate decisions on intellectual property rights should a gene source become commercial. Field genebanks may be of variable size, depending on the site and the number of germplasm accessions to be conserved, and could be linked to an area genebank managed by a committee made up of representatives from the village genebanks. This committee could be vested with the responsibility of settling any intellectual property rights issues or disputes that arise. The area genebank would be a rescue seed source for the field genebanks should germplasm accessions become lost due to natural or other causes. In turn, the area genebanks could be linked to a community genebank located in a Non-governmental Organization or other institution situated within easy reach of the area genebank. This would serve the interests of the farmers involved in the field genebanks in the area. Community genebanks would be equipped with long- and medium-term storage facilities, documentation and networking channels. They would also help to provide an indirect link between field genebanks and the national genebank and international genebanks (Arunachalam 1999; Fig. 1).

This organizational structure of participatory conservation would (a) provide a network to rescue and regenerate site-specific genetic resources and (b) make valuable genes available for participatory crop improvement directed at aiding poor farmers to obtain a secure and sustainable livelihood.

## Implementing a programme

Participatory conservation that makes farmers the conservers through their field genebanks has various advantages. Worede and Mekbib (1993) provide case histories in support of this concept. *In situ* on-farm conservation provides a mechanism to sustain the evolutionary avenues through which genetic variability is generated. Field genebanks can be a source of seeds for post-drought planting when traditional crops fail. The same logic extends to adverse conditions caused by natural calamities such as floods and cyclones, and human-induced disasters such as war and famine.

- Material in field genebanks can be used to restore cultivation in areas abandoned due to consistent crop failures. Genes in genotypes are expressed in phenotypes; phenotypes only are conserved. On-site maintenance would then sustain the distinctive traits in phenotypes acquired over a long time under traditional cropping practices. Field genebanks, which maintain and update their genetic resources, can provide valuable genetic material for formal interventions to improve community and breeding research. This would open new avenues of benefit accrual for farmers, such as participatory breeding, royalty income for providing source material to formal and commercial channels, and community-based post-harvest produce management.
- Field genebanks, with their farmer members, provide an ideal framework for genetic enhancement centres. Scientists and farmers can work there together to expand the utility of landraces and local varieties by generating high-yielding populations (pure lines, mixtures or open-pollinated varieties) carrying farmer-desired traits. They can even take up plant improvement based on specific molecular techniques if adequate funding is made available. Successful case histories on the use of "portable (molecular) laboratories" in the improvement of *Hevea* and sugarcane provide encouraging evidence of this (Lenaud and Lebot 1997).
- In India the establishment of a community gene fund, as a recognition and reward system and means of sustaining community conservation, has been proposed in draft legislation relating to plant breeders' and farmers' rights (Swaminathan 1995). This seeks to recognize "the contributions of farm women and men, and rural and tribal families to the creation, conservation, exchange and knowledge of genetic and species diversity of value in plant breeding". For instance, "three per cent of the net proceeds from the sale of seeds of the new variety will constitute a royalty and the total amount accruing in a year through royalty will be distributed to breeders and farmers in the ratio of 2:1".

A specific example of farmers deriving benefit is the distribution of a substantial monetary benefit of Rupees 500 000 to Kani tribes of India who participated in identifying the plant *Trichopus zeylanicus* (locally known as "arogya pacha"). From this plant, a poly-herbal ayurvedic drug "Jeevani", which helps to remove fatigue and is given to the aged and ill as a tonic, is commercially manufactured.

Similarly, harvested seeds of little millet (*Panicum sumatrense*) can be dehusked and polished by mechanical or power-based equipment at a high benefit-cost ratio, by the farming community itself, as is currently being done by tribal farmers at Kolli Hills, India. Such seeds would find commercial markets as they are in demand. This would be an indirect incentive for conserving valuable PGR of little millet in India and would enable farmers to earn a profitable livelihood.

In general, formal breeding employs advanced techniques with *ex situ* collections as a major source of genes, whereas farmer breeding employs simple tools of plant and seed selection with *in situ* on-farm genetic resources. There are no rigid

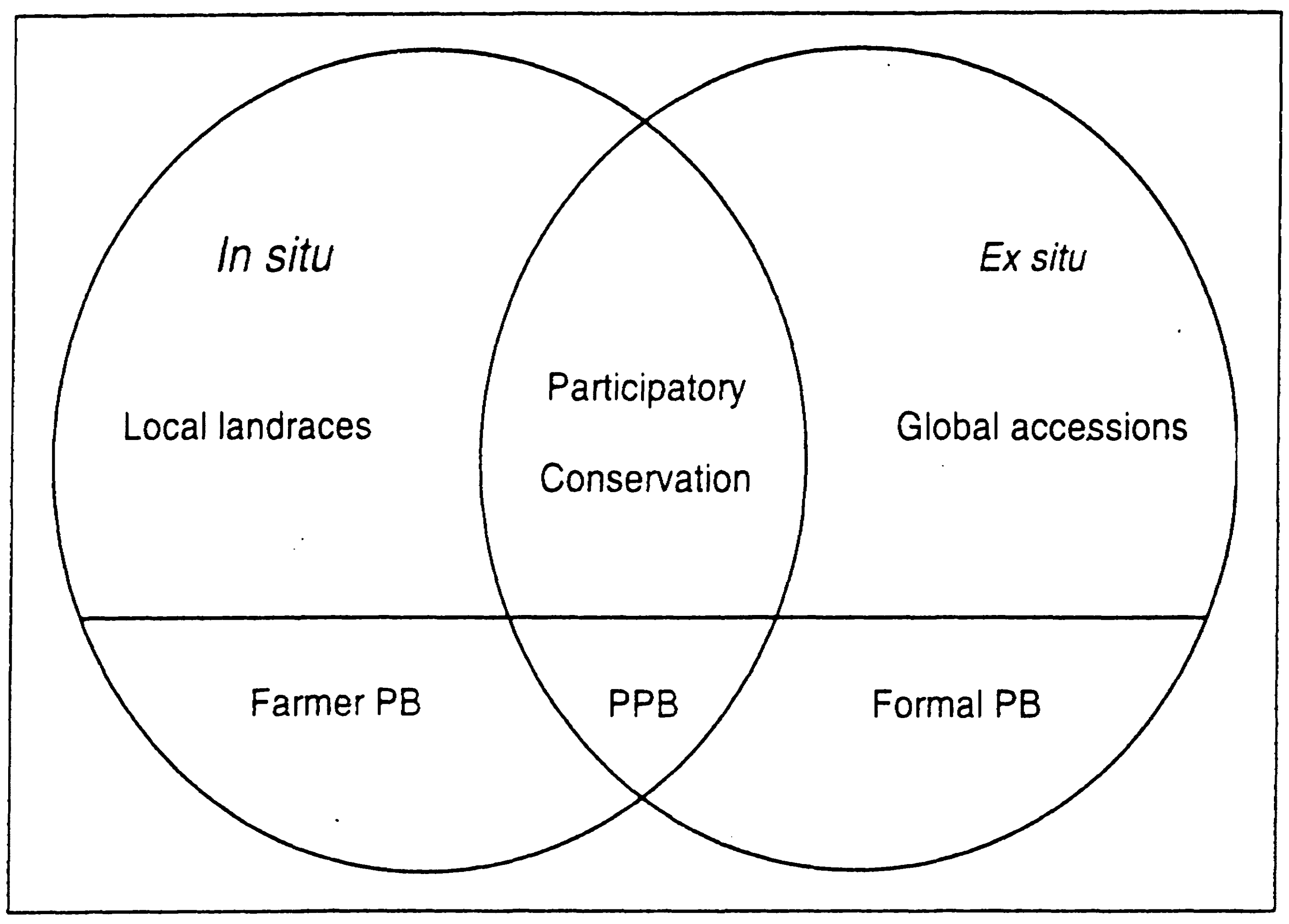

**Fig. 2.** Participatory conservation and genetic enhancement. PB: plant breeding; PPB: participatory plant breeding.

borders, however, and it is not uncommon to find overlapping activity regimes. This situation is well depicted by representing them as two interesting sets (Fig. 2). Participatory conservation and genetic enhancement could manifest themselves in the intersection zone as a synergistic interaction between formal and farmer breeding. It is time that the conservation and utilization of PGR fosters that synergy to provide a secure livelihood for the large number of poor farmers at present beyond the reach of the formal sector.

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