Underutilised plant species: Impacts of promotion on biodiversity

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The International Centre for Underutilised Crops

Championing underutilised plant species for food, nutrition and sustainable development

The International Centre for Underutilised Crops (ICUC) is an autonomous, non-profit, scientific research and training centre. ICUC promotes the use of underutilised crops for food, medicinal and industrial products, and also for environmental protection. The Centre provides expertise and works collaboratively for tropical, sub-tropical and temperate crop development.

Our Mission

Our mission is to promote the use of underutilised plant species for the benefit of humankind and the environment.

Our Goal

Our goal is to reduce poverty and suffering through the improvement and promotion of underutilised species for food, medicines, fodder and industrial needs, and for environmental protection.

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Summary

The International Centre for Underutilised Crops (ICUC) promotes the use of underutilised plant species (UPS). In so doing, it is concerned with developing agricultural landscapes and markets that work for smallholder farmers and local agricultural micro-entrepreneurs in the tropics and subtropics. An important element of bringing benefits to these clients is to stop – and indeed reverse – the biodiversity losses in farming systems that are part of a global trend toward less diverse agricultural landscapes. This document defines what is meant by biodiversity and explains why it is important to the poor. It describes the impacts that species promotion can have on biodiversity, and discusses the different interventions that can be made to support diverse agricultural landscapes, with particular reference to UPS.

In considering the importance of biodiversity, some of the complex linkages in agricultural and other ecosystems between diversity, productivity and stability are described. Whilst higher levels of biodiversity can improve the mean and decrease the variance of farmer incomes, and support health and nutrition through subsistence use, the level of the effect depends on how different production activities complement each other. ICUC's position with regard to the importance of biodiversity, therefore, is to see increases in diversity not as an 'end in itself', but rather in terms of the value diversity brings to maintaining and improving the livelihoods and landscapes of the poor, now and in the future.

In addressing the consequences of species promotion for biodiversity, the tradeoffs that may be necessary, including between short-term productivity and longer-term sustainability, are assessed. In part, understanding tradeoffs involves considering how the promotion of any given species or variety impacts on the diversity of other plants (and animals) found in the farm landscape. Although few quantitative data are available, any significant expansion in cultivation of a particular UPS may have important consequences for the genetic variation within the underutilised species itself, and for associated species diversity in agricultural systems. There are also particular risks to diversity associated with the modern biotechnologies used to promote crops, approaches that are beginning to be applied to some UPS. These risks relate to the centralised control of most biotechnology applications, inadequate integration of biotechnology with other promotion activities, and the passage of germplasm through very narrow genetic bottlenecks.

Different practical interventions to support biodiversity in agricultural systems and markets are considered within the context of ICUC's 'guiding principles' for UPS promotion, which include a pro-poor focus, fair sharing of benefits, and the need for participatory and adaptive responses. Since UPS are often found is species-rich landscapes, measures that are appropriate for managing variation for many species simultaneously are important. Intervention should where possible take a 'spear and shield' approach, in which, while certain UPS are the focus of concerted action, the use of a wider range of species is also promoted, for reserve and buffering functions. Promoting a diverse range of species means providing the poor with the whole range of strategic skills they need to respond to changing community- and market-preferences for different products.

Key interventions include improving access to planting material and associated knowledge for a wider range of species and varieties, and the development of 'intelligent markets' for varied products. Improving access to planting material involves the enhancement of community seed networks, the promotion of germplasm fairs and the application of 'village-level domestication' strategies for UPS. The challenge is to ensure sustainable access to germplasm, and this means that the development of decentralised, small-scale, commercial seed suppliers is also crucial. The development of 'intelligent markets' means understanding the roles that different types of product value chains and local, national and international markets can play in supporting biodiversity, and promoting best practice. Important measures include: enhancing the development of producer co-operatives, increasing the use of the media for educating consumers about a more diverse range of products; and greater training of key actors in value chain management. At the international level, niche markets such as those promoted by Denomination of Origin certification can be useful, as are efforts to remove barriers to market entry.

In order to place UPS promotion in the proper context of increasing useful biodiversity, ICUC will consider the following when determining the institute's involvement in any activity:

- Scenarios of promotion for agricultural and natural biodiversity should be described in advance, in order to assess potential livelihood and conservation risks. For new crops, formal environmental impact assessments that give proper consideration to biodiversity may be required.
- Specific incentives that support diversification should be included when promotion of a UPS carries significant risks for biodiversity.
- Particular methodologies that are known to support biodiversity, e.g., through improving germplasm access and supporting 'intelligent markets' for products, should be used during promotion.
- Studies that seek to quantify the consequences of promotion activities for biodiversity, and the linked impacts on livelihoods, will be encouraged.

1. Introduction

Through promoting the sustainable production and consumption of underutilised plant species (UPS) in agricultural ecosystems and markets, the International Centre for Underutilised Crops (ICUC) intends to improve farmers' livelihoods and the environments in which they live (Jaenicke and Höschle-Zeledon, 2006). A very large range of UPS, including edible fruits, grains, leaves, nuts, oils, roots and tubers, and species that provide medicines, spices, stimulants and other products, currently contributes to the livelihoods of hundreds of millions of people worldwide, especially in the tropics and subtropics. The use of many of these species is important locally or regionally only, and limitations are evident in the field management, harvesting, storage and processing of different taxa. As a result, most UPS have received little investment to date through formal research and development activities. However, UPS have the potential to make a significantly stronger contribution to the nutrition, health, income and environmental sustainability of poor communities, and this potential has driven the current renewed interest in extending their use, e.g., to address Millennium Development Goals (IPGRI *et al.,* 2005). UPS can play a crucial 'safety net' function in poor communities and are well accepted because of their traditional use and cultural value. Long familiarity means that rural populations may hold extensive germplasm and knowledge on these species, which can facilitate community empowerment and encourage self-reliance. Many species have excellent nutritional profiles, with high protein, vitamin and/or mineral contents, and can contribute to alleviate 'hidden hunger' in wealthier as well as poor communities. Furthermore, they are generally not overly competitive and are able to fit well within particular 'micro-environments' in farming ecosystems.

Underutilised plant species are those with under-exploited potential for contributing to food security, health, income generation and environmental services.

The purpose of this document is to understand and explain the inter-relationships that exist between the promotion of UPS, livelihoods, and the biodiversity of varieties, species and landscapes in which cultivation takes place. These inter-relationships are considered by attempting to address the following fundamental questions:

- What is biodiversity and why is it important?
- What impacts does the promotion of particular species have on biodiversity?
- What interventions can be made to increase biodiversity?

After discussing these issues, indicators are presented that should allow ICUC to objectively evaluate the value and sustainability of various promotion activities, within a framework that explicitly considers – and indeed values – biodiversity.

2. What is biodiversity and why is it important?

The term 'biodiversity' encompasses all variation found in living organisms, both between and within ecosystems, and includes species diversity and intra-specific genetic variation. Biodiversity is at the foundation of human society, because we survive on the range of products and services that it provides. Biodiversity is vital for the food security, proper nutrition, income and self-reliance of human communities, and also sustains the environment. In addition, through sometimes complex linkages with food habits, languages, traditional medicine, and religious and other practices, biodiversity sustains cultural richness and community identity, encourages organisation and communication, maintains social cohesion, and fulfils the aesthetic needs that allow societies to flourish (Brush, 2004).

The term 'biodiversity' encompasses all variation found in living organisms, both between and within ecosystems, and includes species diversity and intra-specific genetic variation.

Biodiversity is also essential for providing an adaptive capability in a world that is continually undergoing change – change that may be positive, such as general improvements in human health and increases in purchasing power – or pose challenges, such as global warming. In agricultural systems, adaptive pressures include the changing requirements of farmers and the markets they serve, which require adjustments over time in the types of crops cultivated and products offered.

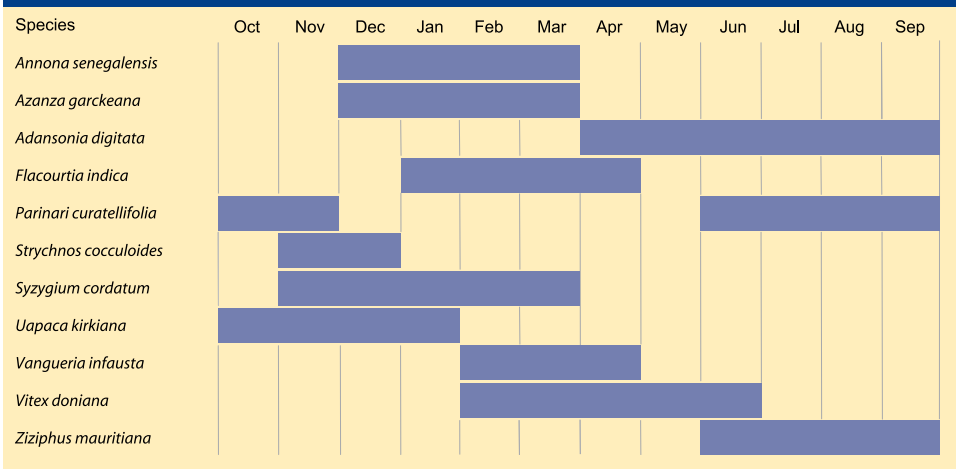
Diversity among and within species is linked to the productivity and stability of ecosystems, including agricultural systems, in several ways. In a smallholder farm or micro-enterprise context, more diverse cropping systems often appear to be both more productive (improved mean incomes) and more stable (decreased variance in incomes, across seasons and years). This is because efficiency increases are possible when different crop species or varieties occupy different production niches (physically and temporally) in the heterogeneous environment typical of small farms. Also, resistance and resilience are generally higher when more diversity is present, because the risks presented by possible environmental and market fluctuations can be spread among different crops and products. Plant species diversity in agricultural ecosystems is also often crucial for the maintenance of the birds, bats and insects that are the principal pollinators of many crops, any decline in which has significant implications for food production, measured in billions of USD annually (McNeely and Scherr, 2001).

Considering individual plant species, genetic variation may be important, e.g., in order to prevent inbreeding depression, the process by which self- or related-matings leads to reduced vigour and lower yields. Underutilised plants may be susceptible to inbreeding depression if they are subject to genetic bottlenecks, because many have not undergone the long processes of selection that have been experienced by major crops, and which have removed deleterious recessive alleles. Recent advances demonstrate the key role that genetic variation within species can play in determining both the productivity and stability of species and ecosystems, especially in the context of climate change. For example, Reusch *et al.* (2005) indicated that genetic variation in the seagrass (*Zostera marina*) could replace the role of species diversity in enhancing resilience in a species-poor coastal ecosystem subject to increasingly extreme climatic events.

A simple example of the importance of species diversity for human welfare is the potential nutritional value to communities of a range of indigenous and naturalised fruit trees in southern Africa (Fig. 1; trees currently underutilised, but harvested from the wild and

Figure 1. Ripening times of selected indigenous and naturalised fruits in southern Africa: the case of Zambia

A diversity of species with different fruiting periods is able to provide important nutrients to rural communities throughout the year. (Based on a World Agroforestry Centre case study, figure used with permission.)



entering cultivation). The fact that different species fruit at different times means that important nutrients may be more easily obtained by village communities throughout the year, in a way that would not be possible if villagers were forced to rely on only one or two fruit trees with restricted phenologies. At present, fruit consumption in many parts of Africa is well below Food and Agriculture Organisation recommendations, and further promotion of a diversity of local fruit tree species could thereby bring significant enhancements in nutritional security. This is especially so for children, who are allowed to pick and eat fruit from trees as they play. In another example related to fruit trees, in this case in Sri Lanka, the variation in maturation period of a range of available fruit species is seen as an opportunity for dried jackfruit (*Artocarpus heterophyllus*) micro-enterprises to diversify. By processing other species with the equipment that would otherwise be standing idle during the jackfruit off-season, the profitability of local micro-processors can be increased. Furthermore, because processing increases shelf life, a range of processed fruit can be made more widely available than fresh produce can, benefiting consumer health (Abeyrathne and Jaenicke, 2006).

Whilst the interconnections between biodiversity and nutritive, economic and other values can sometimes be visualised in relatively straightforward ways, linkages with ecosystem productivity and stability are often rather complex. In farming systems, the utility of diversity depends on the different production environments of different crops complementing each other. Existing synergies may have evolved over centuries, and new interventions require careful choice of species if complementarities are to be maintained. Furthermore, dealing with many crops can mean that farmers don't have all the knowledge they need on how to best use and manage all of them, and can lead to other inefficiencies that limit effective production (Box 1).

Box 1. Complexities in linkages between diversity, productivity and stability in ecosystems

Whilst the interconnections between biodiversity and value can sometimes be visualised in relatively straightforward ways, linkages with productivity and stability are often more complex:

- Available evidence suggests that, while there is often a positive relationship between species diversity and ecosystem function, this is conditional on the traits (e.g., growth characteristics) of the species in question and the level of environmental heterogeneity present.
- In order to maximise the efficiency of ecosystem processes, interventions are better to focus on the different functions of taxa, rather than the absolute number of species; that is, it may be best to give more detailed attention to fewer species that have optimally complementary traits. In addition, interventions must operate at a geographic scale that matches environmental heterogeneity.
- Although on-farm diversity can generally be seen as positive, its utility depends on how different production activities complement each other: there are instances when higher diversity can result in lower productivity and lower value, even in smallholder farming systems that are typically characterised by high variation. Thus, attention needs to be given to crop complementary when choosing species for cultivation.
- Dealing with many species simultaneously can sometimes lead to a 'lack of focus' for farmers, as accessing current knowledge for the proper management of a large number of crops can be difficult. Dealing with many crops can also lead to larger transaction costs in accessing markets, with volume and processing issues arising for small amounts of a wide range of products. Co-operative action can help overcome these limitations.

ICUC's position on biodiversity

ICUC's position on biodiversity is that its promotion should not be viewed as an 'end in itself'. Rather, diversity needs to be 'conserved through use', for the livelihood opportunities it presents and the other services that it provides to the poor, both primary producers and local product processors, now and for the future. The significant nutritional and other health benefits received by consumers further a-field in, e.g., urban areas and in other countries, through being able to access a more diverse range of foods, medicines and other products, should, however, also not be neglected.

ICUC considers that UPS present particular opportunities – and challenges – in the context of biodiversity management. Currently underutilised plant species are very many in number and frequently display very high morphological variation at an intra-specific level. Furthermore, UPS generally fit well within particular 'micro-environments' in farming ecosystems that are often otherwise not fully exploited by crops. Better filling these environments may allow significant contributions to overall farm diversity, productivity and stability. In addition, some UPS grow well with low inputs in marginal conditions in land that is often difficult to place under alternative production systems, an important consideration in maintaining and enhancing diversity in such areas.

3. What impacts does the promotion of particular species have on biodiversity?

Intensive promotion of a few widely available high-yielding cultivars of major crops has led to the displacement of traditional varieties of these crops, and of other cultivated species.

Increased contacts and exchanges of germplasm and knowledge between human populations over the last centuries have resulted in a few dozen crops dominating world agricultural trade (see the classic text of Harlan, 1975). During the Green Revolution of the 1960s and 1970s, a focus on the productivity of major crops led to large increases in yield through plant breeding and associated agronomic practices, and improved food availability for rapidly increasing human populations in the tropics and subtropics. At the same time, however, intensive promotion of a few widely available high-yielding cultivars of these crops has, in general, led to further biodiversity losses in farm ecosystems, with displacement of traditional varieties and other species, and the simplification of human diets. This has been exacerbated by other worldwide trends, such as habitat destruction and extinctions caused by deforestation, increased international commodity trading, substitution of natural with manufactured products, and the consolidation of plant breeding enterprises. Global food security and agricultural incomes currently rely heavily on a very few crops – especially maize, wheat and rice – making humankind vulnerable to social and environmental changes.

Tradeoffs in management

The example of important commodity crops is illustrative of the tradeoffs often faced in agriculture. Greater use of a species often leads to a process of selection for a generally narrow set of characters, coupled with an intensification of production systems that is associated with a tendency toward monoculture and the displacement of other varieties and species.

Effects of selection

Selection by definition results in a narrowing of the genetic base and functional use of a crop, with production therefore becoming increasingly vulnerable to adaptive pressures, such as changes in market requirements or possible disease attack. For those species

subjected to intensive selection, sustaining production in the medium- to long-term requires the periodic infusion of new variation from the wider gene pool, including wild relatives, through continual breeding and promotion of new cultivars. Sustaining high performance, therefore, carries the cost of maintaining diversity that is not 'immediately useful' in the production process. Such diversity can be classed as a 'public' or 'social' good, rather than a 'private' or 'personal' one, because the consequences of loss for farmers and wider society may not be experienced immediately. As a result, new ways, often outside 'mainstream' cultivation, may need to be found to maintain this variation; in the case of major crops, this is done partly through significant ex *situ* 'genebank' collections, which store and regenerate seed and vegetative materials at central locations.

Box 2. Biodiversity impacts of five agricultural commodity production systems

Donald (2004) describes the impacts of cocoa, coffee, oil palm, rice and soybean production systems on biodiversity, indicating how impacts can vary greatly between commodities, with lower intensity production of some crops providing biodiversity-friendly and improved livelihood options.

Cocoa

Full-sun production of cocoa on large intensive farms in, e.g., Malaysia is generally unsympathetic to landscape biodiversity and has resulted in increased pressures from various pests and diseases, contributing to business collapse. In, e.g., Indonesia, however, traditional small-scale shade-production practices that protect diversity persist, in which part of the forest canopy is maintained during land clearance, or shade trees are planted over cocoa. These practices help prevent disease problems, and the cocoa business has faired better.

Coffee

Like cocoa, coffee is grown in shade as well as non-shade systems, from almost wild conditions to monoculture. Shade systems that better support landscape biodiversity can help control pest problems and can (because of slower ripening) produce better tasting coffee that can be sold at a premium. In addition, although coffee is partly self-pollinating, yield depends to a degree on the presence of pollinating insects. These are more likely to be found in more biologically diverse landscapes.

Oil palm

Due to the biological characteristics of the crop and the way in which it is generally managed for efficient production and harvest, oil palm cultivation appears to have particularly negative consequences for biodiversity, with limited options available for improvement.

Rice

Many traditional varieties of rice were replaced by a few modern selected cultivars in India and elsewhere during the Green Revolution. How rice cultivation is managed has important consequences for biodiversity: flooding paddy fields during the fallow season can provide a habitat for birds, and can help control weeds and diseases. Planting of a more diverse range of rice varieties can be used as a strategy to control rice blast disease, thereby increasing yields, reducing chemical use and providing a friendlier environment for biodiversity. Using a more diverse range of varieties can also contribute to human nutrition, since traditional varieties often have better nutritive profiles than higher-yielding modern types (see also Frei and Becker, 2004).

Soybean

Large-scale soybean production in locations such as Brazil has displaced smallholder farmers, who have cleared new, previously forested, land. Soybean cultivation has slowed down the development of other more sustainable crop production systems.

The promotion of high-yielding varieties is often also accompanied by more variable production. This is because of the heightened sensitivity of modern cultivars to the availability of appropriate external inputs such as irrigation, fertilisers and pesticides, and the lack of 'micro-adaptation' to particular local conditions. Modern cultivars may therefore on average perform better than older varieties, but in particular situations, such as extreme events of drought or flood, they may do worse, showing higher variance in yield between 'good' and 'bad' seasons. Additional tradeoffs are therefore sometimes required between average returns and risks of production. For poor farmers who are unable to afford the inputs required to sustain the yields of modern crop varieties, reducing risks by growing older types may be more important than increasing returns, since the results of crop failure are often catastrophic.

Effects of intensification

Intensification of production systems with selected cultivars often leads to the displacement of other varieties of the promoted species, and loss of alternative crops and associated (plant and animal) biodiversity. Donald (2004) describes the process of intensification for a number of tropical and subtropical commodities (cocoa, coffee, oil palm, rice and soybean; Box 2). He indicates that low intensity cropping systems under alternative management regimes can, however, offer some advantages for both biodiversity and livelihoods. Such systems are more feasible for some species (e.g., coffee) than others, for which economically viable diversity-friendly management options may be rather limited (e.g., oil palm).

Donald (2004) makes the obvious, though often un-stated, point that the extent to which intensification has an impact on biodiversity depends on how degraded the current environment already is. If existing agricultural ecosystems are already low in variation, e.g., if they only contain modern cultivars, further intensification may make little difference to the biodiversity found in the immediate farm environment. In this situation, intensification appears a more appropriate option for farm management than in circumstances when biodiversity in farmland is still high.

Different displacement scenarios

A number of different displacement scenarios can be envisaged during crop promotion, each with different effects on biodiversity, and each with different tradeoffs between conservation and livelihoods. Consequences relate to both the change in type of germplasm planted and to alterations in the management practices that are employed in production (see above and Box 3). It may be that it is the introduction of new management practices, especially associated with a switch from subsistence to commercial production, rather than the introduction of new genetic material *per se*, that will have the biggest impact on landscape diversity. It should be noted that the displacement of food crops by non-food varieties of the same species could carry particular risks for rural populations, through both losses in food security and by de-linking experiences on traditional use from new functions, which may result in 'knowledge displacement' (Box 3).

Underutilised plant species, crop promotion and biodiversity

Despite the trend toward biodiversity losses in farming systems, several thousand plant species, many underutilised, are still cultivated today around the world for food and other products. Several factors determine how promotion of a particular underutilised species, or of other crops within the landscapes in which UPS are found, is likely to affect diversity within and among these taxa. These include:

Box 3. Displacement scenarios in agricultural ecosystems

Various displacement scenarios associated with promotion of particular crops can be defined for agricultural systems, with different implications for biodiversity and the tradeoffs between conservation and livelihoods:

- ***Substitution of one crop variety by a 'better' variety of the same species, production function remains the same,*** e.g., replacement of traditional varieties of rice in Asia by modern high-yielding selected cultivars; displacement of other traditional banana types in the Pacific by the more nutritious 'karat' banana, which is higher in beta-carotene. Retention of the same production function means that local knowledge on appropriate management during farm cultivation, processing and use remains relevant, although local varietal diversity may be lost.

- ***Substitution of one crop variety by another of the same species, production function changes,*** e.g., replacement of maize varieties cultivated for food with alternative types selected for ethanol fuel production; displacement of cassava varieties traditionally raised for food in, e.g., Nigeria with cultivars selected for industrial starch and ethanol production, coupled with a switch from subsistence to commercial cultivation. A switch to non-food production may result in losses in food security. A switch from traditional use to a new function may mean that local knowledge on appropriate management during cultivation, processing and use is no longer relevant, with risks of 'knowledge displacement' (loss of local knowledge connected to management).

- ***Displacement of one species by another that already exists in the farm landscape, but for which land area under cultivation increases,*** e.g., a rapid expansion in production area of a traditionally cultivated commodity such as cocoa or coffee, caused by an increase in world demand/market value, displacing local food crops. 'Cycles' in cultivation may result in diversity bottlenecks and an overall tendency to monoculture, with consequences for sustainability.

- ***Displacement of one species by another that is new to the farm landscape,*** e.g., introduction of a completely novel crop into a region, such as artemisia in Africa, for the production of an extract for the prevention of malaria, displacing local food crops. Particular risks for new crops in farm systems are evident through limited adaptation, e.g., to pests/diseases, and product substitution, e.g., by synthetic product or by the same product grown elsewhere. There may be particular risks for the new species becoming established in monoculture.

- Biological characteristics of the UPS (see Box 4 for details).
- Functional use, i.e. which part of the plant is harvested, e.g., whether the reproductive part of the plant is included, and how selection operates during collection.
- Type of market for product, i.e. local, national or international, and the level of uniformity required for that market.
- Type of farming system, e.g., the current level of adoption of modern varieties, the particular farm management practices employed, and the intensity of cultivation.
- Particular promotional methods, e.g., whether the emphasis is on genetic improvement, on more efficient germplasm supply, on better processing, or on improved marketing.
- Level of previous domestication, i.e. whether a UPS is wild, incipiently-, semi- or highly-domesticated.

Box 4. The relationship between promotion, crop biological variables and diversity

How promotion activities impact on the diversity of a given UPS depends on a number of biological variables, including:

Longevity

Longer-lived species may be less susceptible to diversity losses because of the long interval in regeneration, and the possibilities for multiple overlapping generations between different introductions of germplasm. Mixing and inter-breeding between various sources introduced at different times may sustain diversity.

Breeding system

Outbreeding species have higher effective population sizes than selfed taxa, and may thus sustain population diversity better, all other factors being equal. However, outbreeding species may also be susceptible to inbreeding depression, leading to loss in function and possible farmer substitution, as a crop becomes no longer productive to cultivate.

Propagation techniques

Whether a species is propagated vegetatively or sexually has implications for effective population sizes. Vegetatively propagated species (e.g., by grafts, cuttings, tubers, suckers) are more susceptible to losses in diversity because germplasm distribution may rely on only a few clones, which furthermore can be vulnerable to substitution by each other.

Methods of pollination

Pollination by flying insects, bats or birds may promote connectivity within farm landscapes, helping to sustain effective population sizes and diversity. Plants relying on animal pollination are, however, vulnerable to pollinator losses, which may occur when farms intensify or natural forest bordering farmland is cut down (loss and/or fragmentation of pollinator habitat).

Methods of seed exchange

Active seed exchange mediated by humans will facilitate population connectivity and may help maintain diversity within farm landscapes. On the other hand, if seed movement occurs over large distances, it may lead to 'over-homogenisation' and the loss or dilution of 'unique' variation. Human seed exchange may also, theoretically, lead to outbreeding depression, which can occur when mating individuals come from two sources that are very different from each other, and result in the dilution of locally adapted alleles and/or the breakdown of co-adapted gene complexes. Like inbreeding depression, the resulting loss in function could lead to substitution by other crops.

Plant size

The size of an individual productive plant determines the number of individuals that can be supported on individual farms and in the wider agricultural landscape. In general, the larger the growth-form of an individual, the smaller the population size on a given farm is expected to be. This may make larger plants more vulnerable to diversity loss. On the other hand, larger plants may live longer, and through their size support greater pollination and seed dispersal distances, facilitating the maintenance of diversity (see above).

Level of previous domestication is an important issue for UPS, as many species used for medicines, food and other products are harvested from the wild and to date have been subjected to little domestication, if any. In this situation, experience shows that promotion generally results in initial over-exploitation from natural stands, resulting in population extinction, genetic diversity losses and wider habitat disturbances, even when cultivation develops to help fulfil product demand (Marshall *et al.,* 2006). In this instance, the tradeoff between biodiversity loss and economic gain can be particularly high, and whether or not it is possible to quickly accelerate cultivation through simple interventions is an important factor for consideration. Furthermore, a move from wild harvesting to cultivation will switch benefits from wild collectors to farmers, with possibly complex and unpredictable impacts on communities and

the ways in which they manage both cultivated and wild landscapes. Finally, domestication of a currently wild species may initially result in highly significant bottlenecks and very rapid reductions in genetic base when material is first sampled for cultivation.

Little quantitative data are available on how current promotion activities impact on levels of diversity across a range of UPS. This reflects a general neglect of these taxa in formal research, and a lack of suitable 'pre'- and 'post'-promotion comparisons. In addition, it reflects the problems that are involved in measuring diversity, especially within species. One difficulty in quantification is the 'cryptic' diversity that is important for function but is not obvious to the naked eye at first inspection, e.g., adaptive variation that is only evident after testing in a range of environments. In addition, the large number of species involved results in dilution and diffusion of effort. Furthermore, a multidisciplinary approach is needed to synthesise scientific and local knowledge on variation into a coherent overall picture, but the necessary expertise is often difficult to bring together. However, recent developments in methodology, such as in participatory farm survey techniques that can capture local knowledge, and in molecular marker characterisation, may prove useful, when these are finally widely applied to a range of UPS.

Despite the current absence of detailed information and the large number of variables that may impact on diversity, it is possible to make some generalisations from a theoretical standpoint about how UPS promotion activities are likely to impact on genetic variation in species, and on the diversity of associated species, in farming systems:

- ***Impacts on genetic variation in UPS***. Since individual UPS are often characterised by particularly high levels of within-species variation, the promotion of a particular cultivar may have significant implications for intra-specific diversity. An expansion in cultivation of any one type may well be at the expense of many other traditional cultivars or natural variants of the same species, variants that may only be found in specific, narrow locations. Displacement may thus lead to high losses in genetic variation. This effect may be exacerbated because UPS populations are generally small in farmland, and are therefore vulnerable to reductions in genetic variation through the natural process of random drift, in which particular genes are lost from populations due to limited effective population sizes. Countering this loss of genetic variation is the observation that farmers can have strong cultural preferences for certain crop varieties, and these may be maintained in home-gardens or other niche sites for personal use, even when the rest of their farms are placed under single variety production for the purpose of sale (Brush, 2004). In addition, the absence of formal germplasm distribution systems for most UPS means that individual locations are more likely to maintain their own particular patterns of variation, different from other sites, with less of the homogenising effect of intensive germplasm exchange.
- ***Impacts on the diversity of associated crop species***. Since underutilised species are generally found at relatively low densities in species-rich landscapes, any significant expansion in cultivation of a particular UPS may have important consequences for associated crop species diversity. This is because, starting from a small cultivated base, large expansions in planting volume for a given UPS are theoretically possible in farmland, thereby encouraging displacement of other cultivated species. The larger the numbers of species that are present (at low densities) in farmland, the greater the chance of some being displaced following the expansion of any one crop. This is unless expansion involves bringing new land under cultivation, but this will then have its own impacts on wild biodiversity. Countering displacement is the observation that some UPS are limited in their potential for expansion because they can only occupy particular farm niches. In addition, the farm landscapes often occupied by resource-poor farmers are species-rich at least partly by design, as a risk-minimisation strategy built around crop diversity. Therefore, unless the incentives to grow a particular UPS are very high, farmers may prefer to maintain at least a medium level of biodiversity in their farms.

Modern methods of promotion: the risks of biotechnology

Threats to diversity within the framework of recent agricultural practice include the application of biotechnology. Biotechnology applications include: (i) tissue culture and micro-propagation, (ii) molecular marker characterisation of genetic diversity, (iii) genetic maps, marker-assisted selection and genomics; and (iv) genetic modification. With different levels of success, these techniques have now been adopted quite widely for major crop promotion, and are also beginning to be applied to UPS (Dawson and Jaenicke, 2006). Although practical deployment to date for UPS is still generally limited, tissue culture and micro-propagation are currently being applied at field level, and such methods are likely to continue to be highly relevant in the future for promoting a range of species. Furthermore, genetic mapping, marker-assisted selection, genomic and genetic modification approaches have high potential for a small number of more strongly researched and widely important UPS, such as quinoa (*Chenopodium quinoa*), sesame (*Sesamum indicum*) and tef (*Eragrostis tef*).

Biotechnology can assist in the characterisation of genetic variation in UPS and this may in the future contribute to better conservation and management practices (Dawson and Jaenicke, 2006). On the other hand, biotechnology also carries risks for diversity, because the laboratory requirements of many of the techniques involved mean that it is generally applied in a 'centralised' way during crop breeding and product development (Dawson and Jaenicke, 2006). Centralisation of technology can lead to the disenfranchisement of farmers, as they loose the rights and controls they previously had over germplasm. This can lead to a stifling of the local innovation that can promote diverse use and local crop development. In addition, frequent lack of direct smallholder farmer involvement in biotechnology programmes means that the wider concerns of producers that must be tackled during crop promotion are not always well considered, which may result in limited adoption. Furthermore, for convenience of application and to minimise costs (and, in the case of industrial agriculture, in order to provide a uniform product), biotechnological breeding approaches often involve the passage of germplasm through very narrow genetic bottlenecks. This is especially so when activities such as widespread cloning (micro-propagation) of individual genotypes are involved in germplasm multiplication and distribution. This can lead to significant losses in deployed variation, and results in sustainability concerns, especially for species that rely on cultivation for conservation. Presently, the effects of biotechnology promotion methods on genetic variation in UPS appear limited, but impacts should in future be monitored (Dawson and Jaenicke, 2006).

4. What interventions can be made to increase biodiversity?

Practical interventions to support biodiversity require tradeoffs, and success depends on the initial baseline of the current agricultural environment.

Interventions to increase biodiversity need to be placed within the framework of the livelihood opportunities that they present and the other services that they provide to the poor. Obtaining the right balance between livelihoods and biodiversity conservation is a significant challenge for development experts and environmentalists (McNeely and Scherr, 2001). This is because an understanding of the tradeoffs between development and conservation is only just emerging. In addition, there are significant difficulties in linking knowledge with action, partly because of the limited channels for information flow between scientists, markets, farmers and other stakeholders. In any case, the ideal scenario of a 'win-win' situation, in which both production and conservation are enhanced in 'conservation through use' approaches, can often be difficult to reach. Furthermore, judging success depends on knowing how degraded or diverse the current farm landscape is (Donald, 2004), information that is rarely collected before interventions are made.

The danger of over-emphasising the value of any one variety or species, resulting in one of the displacement scenarios described above, means that there is a need for balance in

interventions. For example, more strategic approaches are needed than are often currently applied in (single-species) UPS promotion, with wide-ranging skills development for general farm management required. On the other hand, interventions should not be so diffuse, by being spread across such a wide range of taxa, that any potential for immediate impact on the livelihoods of farmers is limited. The need for a 'spear and shield' approach to promotion is therefore evident. In this approach, certain UPS are championed for intensive domestication, large increases in production and immediate impact ('spears'), while use of a much wider range of taxa (the 'shield') is enhanced through a range of different and more diffuse actions related to general improvements in knowledge sharing, germplasm access and market development. These provide reserve and buffering functions.

ICUC's guiding principles for UPS promotion

ICUC takes the position that interventions promoting UPS should, where possible, follow a number of other guiding 'philosophical' principles. Interventions should be participatory, multidisciplinary and gender-sensitive, and promote open access to germplasm and information. Moreover, approaches should involve the evolution of existing farmer practice and be responsive to future change. Given these principles, five 'maximum impact' intervention areas for realising UPS potential have been recognised, with the specific activities required in any particular area depending on the context in which species are found (Box 5; Jaenicke and Höschle-Zeledon, 2006).

Box 5. Possible interventions for UPS promotion

Jaenicke and Höschle-Zeledon (2006) indicated five 'maximum impact' areas for possible intervention during UPS promotion:

Generating new knowledge

For example, by studying specific cultural practices for UPS, and through improved determination of important species that producers, processors and consumers are interested in. Also included is further scientific research on: characterising available genetic resources and their value, the genetic enhancement of priority species, how to better maintain genetic and species diversity, how to supply farmers with germplasm, more appropriate crop management procedures; and improved methods for post-harvest handling and processing.

Better communication of knowledge

For example, through more farm demonstration sites, by collecting and disseminating successful UPS promotion stories, by reducing information asymmetries during promotion, through lobbying of policy makers and other influential interest groups, by more targeted media campaigns, and through the continued development of school curricula that promote UPS.

Better policies to remove barriers to production and marketing

For example, by initiating national dialogues on UPS, by promoting policies that enhance access to existing and new markets (e.g., through less costly certification schemes and by the reduction of other non-tariff barriers), and through better protecting farmers' intellectual property rights to local knowledge on taxa.

Improved market development

For example, through increased entrepreneurial training to support value chain development, by fostering more public-private partnerships, through organising buyer-supplier fora, through demonstrations and trade fairs, by promoting credit and grant schemes for marginalized stakeholders, and by carrying out more market surveys on preferences, risks, compatibilities, etc.

Better partnerships amongst all stakeholders

For example, through further encouraging strategic alliances on UPS, by promoting multidisciplinary research teams and regional networks, and by strengthening relationships among all participants in value chains.

The practices, innovations and experimentation of the poor depend upon the particular range of limitations and opportunities that they face, but activities centre on improving the livelihoods of their families and communities. Practical experience shows that germplasm availability and market access are crucial factors in determining what is planted on farms. Within the context of possible promotion activities (Box 5), therefore, ensuring better access to a wider range of germplasm and related knowledge on management and use, and devising 'intelligent markets' for a wider range of plant products, should help support more diverse agricultural landscapes. Much recent work on biodiversity management in farmland has focused on interventions in these areas (e.g., Leakey *et al.,* 2005), which are described below.

Improving the availability of germplasm and associated knowledge

A key reason why farmers do not cultivate certain species or varieties is because of limited access to appropriate germplasm and to the information they need on how to plant, manage and use such material. This can reflect the limited distribution of particular species and varieties in the current farm landscape, possibly due to farm intensification, and/or natural habitat loss (when planting material is collected directly from wild stands), which restrict access to material to all but a few individuals. In addition, it may reflect cultural changes that have resulted in the loss of knowledge on how to manage and use certain taxa. In these situations, a number of measures to improve access and promote diversity have been practiced, including those described below.

Enhancing community germplasm-exchange networks

Strengthening of existing community networks that exchange plant germplasm and knowledge, through providing training in various areas, and by raising awareness of species and variety use and management, can facilitate the redistribution of diversity in farm landscapes. Training may be provided in appropriate methods for germplasm collection, in different participatory breeding approaches, in the different ways in which germplasm can be effectively distributed through communities, and in the establishment of community seed banks (Friis-Hansen and Sthapit, 2000). Emphasis may also be placed on offering communities incentives that encourage distribution of germplasm of rare species and varieties, in order that these may substitute for more common types in new planting rounds. Measures should, however, be taken to ensure that this approach does not dangerously reduce effective populations sizes of the once more common species and varieties. One way to ensure a proper balance in planting is to link the distribution of rare and more common species/varieties together, through providing incentives for 'bundling'. This strategy has been used to ensure diversification and minimise environmental impacts during the domestication of, until recently, completely wild species (e.g., *Allanblackia* cultivation for edible oil extraction as a new tree crop in Africa: www.worldagroforestry.org/treesandmarkets/allanblackia/).

During network development, proper consideration must be given to geographic scale. Since much variation in the availability of species can occur between villages, emphasis may be placed on developing appropriate linkages between communities. However, if possible, exchange should not be at such a scale that significant genetic variation within a particular species is lost through homogenisation and dilution of 'unique' variation, or that significant outbreeding depression (see Box 4) is likely to result. The prospects for outbreeding depression will clearly depend on the historical use and past exchange of individual species. Research also shows that certain 'nodal' farmers and nurseries are especially responsible for maintaining and distributing a wide range of species and varieties; recognising and enhancing the involvement of these key players within networks is therefore crucial (see Subedi *et al.,* 2003 for the example of rice landraces).

Promoting 'germplasm fairs'

The 'germplasm fair' is an extension of the 'network' approach for improving access to planting material. In the farming literature, two types of fair are frequently referred to: 'seed fairs' and 'diversity fairs', both of which are used to manage genetic variation in traditional agricultural crops (Friis-Hansen and Sthapit, 2000). 'Seed fairs' have been used to promote links between farmers and seed suppliers in order to help rehabilitate farmlands after emergency situations, and to obtain information on the type of within-species variation that farmers are interested in. This last function assists government breeders and commercial seed suppliers in producing crop varieties that farmers want to plant. 'Diversity fairs' are more explicitly designed to promote diversification at both between- and within-species levels in crops. They do not focus on particular crops, but rather cover the whole range of species that farmers are interested in.

Diversity fairs are often organised to coincide with large social gatherings of a local community. These events may be part of more formal agricultural shows or research institution open days that are organised by government services. Farmers are encouraged to bring local varieties, and exchange germplasm and associated knowledge, with prizes sometimes awarded for the most unusual or interesting material exhibited (Friis-Hansen and Sthapit, 2000). These fairs have great potential for enhancing species diversity and genetic variation for UPS in farm landscapes, especially if ways can be found to include the very poor that can otherwise be excluded (through, e.g., the use of 'voucher' systems). Fairs work best for crops where the propagule relates clearly to the product for which it is grown – when, e.g., the most important qualities of a variety can be seen from the seed or fruit. Clearly, this direct relationship is not observable when it is other products that are important (leaves, roots, bark, etc.) and where the development of other 'means of verification' is required.

Encouraging application of 'village-level domestication' strategies

The 'village-level domestication' approach is about empowering communities to carry out crop domestication activities based on locally available genetic resources. Communities are trained in a range of germplasm collection, selection, propagation, farm management, harvesting and processing techniques, and are encouraged to apply these techniques to a wide range of taxa in the landscapes that they inhabit. The species on which to act are identified through participatory priority-setting methods that involve farmers, processors and traders of products. In addition, where appropriate, access to 'starter' germplasm and the necessary tools and materials for collection, propagation and management of species is facilitated by project intervention.

This approach has been widely used in situations where a very large range of species may be subject to 'parallel' promotion, e.g., indigenous tree species in the tropics (Weber *et al.,* 2001). The purpose is to provide the strategic skills that farmers require in order to allow them to respond to changing community and market preferences for products. By providing farmers with the skills required to manage a range of species, and therefore potentially many species simultaneously, rural communities have an increased capacity to 'buffer' against changing conditions (the 'shield' mentioned above). The approach works well in supporting local knowledge systems because it helps communities to formalise the decision-making processes by which they already undertake plant domestications into more general, well-defined promotion strategies. It also allows for a range of different responses by different communities, and facilitates adoption and rapid impact.

Village-level approaches work best when high diversity is available at a local level, without the necessity of bringing in germplasm from outside. These conditions can be best met in the early stages of crop domestication, e.g., when dealing with previously wild species or incipient domesticates, and when farmers can still access wild and/or relatively

unmanaged habitats to obtain germplasm. When domesticating previously wild species, interventions that specifically integrate cross-boundary (wild-agricultural) management of resources, e.g., by training farmers in participatory natural habitat management strategies as well as germplasm collection, can help promote sustainable use.

The challenge of ensuring 'sustainable access'

The challenge in any effort to improve access to germplasm is in ensuring that the appropriate incentives are present within communities in order to allow sharing of germplasm and associated knowledge in a sustainable way. For example, the development of enhanced community seed networks may on its own be an unsustainable intervention, unless some commercial incentive drives the process, e.g., through linkage to product value chains (see next section). Recent experiences show that the development of decentralised, small-scale, commercial seed suppliers for locally developed and maintained varieties can be a more effective means of enhancing germplasm availability than simple 'barter'. Market-oriented approaches for germplasm supply may work best when UPS businesses are coupled to supply systems for major agricultural crops. For example, Nathan *et al.* (2005) 'bundled' the seed distribution of fodder species with other more widely used crops in Nepal, by providing both together through 'agro-vet' dealers (commercial enterprises dealing with agricultural and horticultural seed). As a result, farmers purchased increased quantities of the seed of fodder species. In such situations, it is important that germplasm collectors receive the training they need in small enterprise development. Policy interventions are also important to support innovation at a local level and to allow access to germplasm sources that are otherwise inaccessible to communities, e.g., in government-managed protected areas and centralised genebanks, whether national or international.

'Intelligent markets' to support diversity

Experience shows that improved market access often increases diversity loss, through intensification and an emphasis on short-term productivity rather than longer-term sustainability. This does not, however, have to be the case, and tools are available to align market, societal and conservation goals in product value chains in better ways than are commonly practised at present (Smale *et al.,* 2002; Hellin and Higman, 2005). It all depends on how a particular market develops, whether suitable interventions to support diversification are possible in any given situation, and how susceptible the wider biodiversity present within current farm ecosystems is to displacement by newly marketed crops.

In reviewing the relationships between markets and diversity for three crops (potato, coffee and argan oil), Nill and Böhnert (2006) assessed the development opportunities and biodiversity implications of different value chains (Box 6). They showed that the way in which product value chains can support diversity depends on the level of operation of various markets, and the access of communities to these markets. Markets locally, nationally and globally will generally only be effective in supporting diversity if: emphasis is placed on educating consumers about diversity, sufficient consumers are willing to pay premium prices for products that support diversity; and attention is given to higher-value niche market development. Product markets at all scales often lack transparency, with premiums paid for particular crops, varieties and products frequently not filtering down to farmers, who would receive benefits and could diversify their farms if market opportunities were evident to them. Increasing transparency and awareness are thus important considerations at all levels.

In cases where markets can contribute positively to diversity, it is crucial that local farming communities be properly empowered in order to benefit from such developments. This means ensuring that farmers can organise themselves into groups that can negotiate their interests, can become formal shareholders, and can properly liase with other participants

Box 6. The relationships between markets and diversity for three crops: potato, coffee and argan oil

Nill and Böhnert (2006) reviewed the work processes and actors involved in the production, processing, trade and end consumption of three species grown in low-income countries – potato, coffee and argan oil – and assessed development opportunities and biodiversity implications of different value chains for each. The results for each crop are summarised below:

Potato in Peru

Around 2,000 varieties of potato are grown in the Peruvian Andes, a centre of diversity for the crop. Potatoes cultivated in Peru enter different value chains: for immediate fresh consumption, in the form of traditionally processed preserved potato (e.g., chuño and tunta, for 'bitter' varieties); and for industrial processing (e.g., into chips and crisps). All three chains can support farmer livelihoods, but only the first two make any noteworthy contribution towards the conservation of biodiversity. Local markets for immediate fresh consumption contain many different varieties, while traditional products are made from several dozen types, which are generally grown by smaller farmers. Only a few varieties of potato are, however, considered suitable for industrial processing nationally. This market is generally supplied by bigger farms, which can meet large volume requirements. Market measures to support potato diversity include the sale of mixed varieties as branded products in Peru's biggest supermarket chain, and the organisation of farmers into groups to supply such products.

Coffee in Ethiopia

Several hundred 'arabica' types of coffee grow in their centre of origin in Ethiopia, where most production centres on smallholder plantations, though some coffee is collected directly from the wild and from mixed wild-cultivated systems. Successful support measures for coffee production from the 1970s initially involved activities such as the breeding of disease-resistant varieties and the development of centralised washing stations. These measures have not, however, been able to maintain farmer incomes during periods of coffee oversupply on the world market. More recently, emphasis has been placed on increasing quality and promoting access to specialised global markets, including through various certification initiatives (e.g., through Fair Trade and the Rainforest Alliance). These activities support community organisations and use the uniqueness of Ethiopian arabica types, and certified adherence to social and ecological standards, as selling points to achieve higher prices. These measures target poverty reduction measures to smallholder producers, and help conserve the diversity of the arabica types that these farmers' manage.

Argan oil in Morocco

Argan oil is pressed from the nut of the argan tree that grows in the Arganeraie region of Morocco. The oil is a premium product for food use and skincare, and is traded locally, nationally and internationally. However, argan populations are being reduced through inadequate regeneration and deforestation. Argan oil can be produced both by hand-extraction and mechanical pressing: in the first case, harvesting and oil extraction are undertaken in rural areas, whereas in the latter case rural communities only collect the nuts for processing elsewhere. Measures implemented to help rural communities in production include training local women in processing, helping them to organise into groups, and the establishment of new argan stands. Through certification and partnership with international buyers, higher prices will be achieved, while new plantings based on improved markets, and the recognition of the Arganeraie as a UNESCO biosphere reserve, will facilitate conservation of the species.

in value chains (KIT *et al.,* 2006). Such producer organisations can also reduce transport and processing costs through economies of scale, may allow sharing of business skills, can guarantee consistent product volumes, and are able to provide social support when market failures occur.

Local, national and international markets

Some of the issues that are particularly important for promoting diversity in different types of markets are summarised in Table 1. Whilst many interventions are of general importance, at a local level particular emphasis may be placed on supporting collective action that facilitates exchange of community knowledge and innovations. At a national level, there may be a particular focus on the promotion of a more diverse range of attractively presented and/or processed products through radio and other media, and through strategic placements in large commercial outlets, such as supermarkets catering to urban populations and the developing middle-classes. In addition, training in value chain development and increasing the availability of credit to small producers and micro-processors, although also important at other levels, may be key here. Training may be required in processing, packaging, book keeping, reaching economies of scale, accessing market information (e.g., through novel channels such as text messaging on mobile phones), negotiating with different actors and in how to respond to market changes.

Internationally, there is rising interest in new foods and other products that can contribute in novel ways to human health and nutrition, an interest that can be exploited for UPS promotion and can benefit poor communities, if the right approaches to promotion are applied. Particular emphasis may be placed on promoting niche market arrangements through Denomination of Origin (DO), Eco-labelling, Fair Trade, Organic, and Slow Food, initiatives (see Box 7 for the example of DO). In different ways, all of these initiatives can support biodiversity and provide livelihood opportunities for smallholder producers, when consumers become more interested in the varieties, land, supply chains and farming communities that produce what they eat. Also key is to reduce constraints to market entry, by lowering the costs involved in 'process' and 'product' certification and by modifying restrictive tariff and non-tariff barriers. For example, the premiums paid for niche products by consumers often have to be high in order to cover the technically complex, time-consuming and financially burdensome nature of certification procedures. Less costly schemes are required if major benefits through DO and other niche market initiatives are to be realised for livelihoods and diversity. One option is to more directly link farm communities with consumers in order to guarantee product quality and origin;

Box 7. Developing niche markets: the example of Denomination of Origin (DO)

Denomination of Origin is about helping farmers build and maintain brand recognition for particular crops and products. It re-values biodiversity as a crucial element in high-value product differentiation; the higher revenues received for DO products provide the incentive to maintain and increase diversity in farmland. It is the explicit links between a geographic territory, a specific variety (or varieties) and its product, and a particular community with its traditional practices, which are key. Assigning particular products to particular geographic origins involves certification for variety, process and location, and should involve 'Fair Trade' or similar arrangements that link production with particular communities.

Denomination of Origin is used widely in high-income countries (e.g., a number of European nations each have several hundred formally-recognised DO arrangements for various products) and is also being applied to crops from low-income nations. For low-income countries, it appears currently to be most relevant for supporting diverse varieties of products that are already being traded widely in international markets, such as coffee and cacao. For these crops, a number of DO arrangements are already in place; e.g., the world's top chocolate makers have sought to give exclusive cachet to their products by using beans originating from single sources. For UPS, a key intervention will be to develop brand recognition for different sources and types of product in order to allow application of the DO process.

Table 1. Different markets with some of the possible advantages and disadvantages of each for promoting livelihoods and biodiversity

	Local market	National market	International market
Possible advantages	▪ Traditional use and acceptance of products mean a ready market, with local use helping to maintain the identity of societies and reinforcing conservation ▪ No or minimal regulatory requirements in bringing products to market ▪ Generally, the value chain from producers to consumers is short, meaning farmers should benefit more ▪ Direct farmer consumption is possible in the absence of a market	▪ Some traditional use and acceptance of products, possible access to higher value 'internal' markets than those available locally ▪ Although some regulatory/ certification barriers, likely to be lower than for international markets ▪ Provides good opportunities for 'value addition' through processing (e.g., to improve longevity, spread the period of sale, facilitate transport)	▪ For specialised market niches (e.g., DO, Fair Trade), products may be of high value and bring considerable economic benefits to communities ▪ Specialised markets not only support diversity locally, but educate and interest the global economic community in the value and promotion of diversity ▪ Specialised value chains are generally built around best practice' that 'ensures 'fair play' between producers and consumers
Possible disadvantages	▪ Farmers may not receive the same premium for their crops as in other markets, especially with 'gluts' and low value during peak production	▪ An absence of proper certification may make producers vulnerable to unscrupulous practice (e.g., 'misnaming' of lower quality product by large suppliers) ▪ Longer value chains than for local markets may decrease the benefits for farmers ▪ Generally, markets at this level are more 'industrial', requiring more uniform product	▪ Barriers to trade may be high, due, e.g., to regulations for market entry (e.g., the EU NFR), and/or certification costs (to certify product is sustainably produced, of a particular variety/origin, etc.) ▪ International markets may be very sensitive to health scares (stringent health and safety regulations may come into operation if, e.g., disease or pollution problems) ▪ Generally, entry into more 'industrial' (not niche) markets requires more uniform product
Key ways to promote diversity	▪ Develop local networks that support exchange and innovative practice for germplasm and knowledge at a local community level (collective action)	▪ Increase consumer interest in products through the media and links with key commercial outlets (e.g., supermarkets) ▪ Training in value chain development (e.g., processing, packaging, book-keeping, accessing market information, dealing with different actors) ▪ Provision of credit to producers and micro-processors	▪ Lower barriers to markets (reduce costs and speed up processes) by developing simpler certification procedures and through relaxation of existing ` regulatory frameworks to food entry
Effectiveness for diversity	May work best for promoting relatively modest increases in use in a wide range of species, in a manner that balances diversity in farming systems (no one crop comes to dominate through displacement)	May work best for those crops that have some history of use at a national level and are not yet internationally traded. Probably effective for only a relatively small number of species, though more than for international markets	May currently work best for a relatively limited number of high value species, especially when promoting varieties of products that are already exposed to the international market. 'Major' crop examples are cocoa and coffee (e.g., DO, Fair Trade)

another is joint certification serving more than one market niche. An example of a non-tariff barrier for UPS is the European Union 'Novel Food Regulation', which restricts the access of 'new' foods into member states (Box 8). Suggested revisions to the Regulation include recognition of exotic traditional foods as a separate 'novel food' category with less stringent requirements for market entry.

Box 8. Reducing restrictive barriers to trade: the example of the European Union 'Novel Food Regulation' (EU NFR)

Hermann (2004) describes some of the obstacles to importing new food and herbal products into Europe due to the EU NFR, which regulates the entry of 'novel foods' into the member states of the European Union. This Regulation was introduced to ensure food safety and protect human health in the Union, and defines 'novel foods' as ingredients that were not used for human consumption to a significant degree within the Union before 15 May 1997. Since many traditional foods of tropical and subtropical countries, including the products of many UPS, fall within the 'novel food' category, the costly and lengthy safety assessment procedures imposed by application of the Regulation can place high barriers to market entry for these species. In this situation, traders either do not even consider trying to obtain entry for new food products, or simply ignore regulations, putting the status of producers on a risky footing.

Application of the EU NFR is a significant disincentive for value chain development and farm diversification in the tropics and subtropics. The Regulation not only applies at the species level, but is also concerned with both varietal and product diversity. This means that high intra-specific variation within a crop may be an undesirable characteristic for obtaining market access, as safety assessors worry about compositional non-uniformity. The effect of the Regulation is to inhibit innovation and limit both the intra- and inter-specific variation of foods and herbal products that farmers can profitably grow.

Methods need to be found to overcome some of the obstacles presented by such regulations if international markets are to support farm diversity in the tropics and subtropics. Efforts by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), the Global Facilitation Unit for Underutilized Species and other parties are currently underway in order to bring about adjustments in the EU NFR. Suggested revisions include: (i) a push for recognition of exotic traditional foods as a separate 'novel food' category with different requirements for market entry, (ii) the development of simplified safety assessments that admit alternative forms of evidence; and (iii) the granting of generic admissions for a range of possible products from the same species.

5. Conclusions and recommendations for UPS promotion

Supporting biodiversity in agricultural landscapes requires both proactive and reactive measures.

Incorporating diversity into farming systems because of the benefits it can bring to rural communities, rather than as an 'end in itself', is at the heart of ICUC's philosophy for UPS promotion. ICUC believes that supporting biodiversity requires both proactive and reactive measures, i.e. promoting the introduction of new biodiversity into farming systems, and ameliorating ongoing biodiversity losses in existing agricultural landscapes.

ICUC recognises that the relationships between biodiversity and outcomes that are important for farmers can be complex. Certain tradeoffs are often necessary, and the promotion of any one species or variety can have implications for wider landscape diversity that may be negative, and that are sometimes difficult to predict and prevent. To minimise any negative consequences of promotion, however, activities should generally focus on those species

for which diversity-friendly management systems are at least conceivable. Intervention should also normally take a 'spear and shield' approach, in which, while certain (or even just one) UPS may be the focus of concerted action, the use of a wide range of other species is also promoted at the same time in 'piggy-back' fashion.

ICUC will support, where possible, the creation of 'intelligent markets' that improve both incomes and environmental management. This will involve educating producers and micro-processors in how to diversify their activities, encouraging value chain development, and supporting DO and related initiatives. At the same time, ICUC is aware that factors other than product markets also contribute to the range of species and varieties that farmers plant. It is concerned in particular that germplasm access needs are met, through measures such as diversity fairs and the development of decentralised, small-scale, seed supply businesses.

When evaluating the institute's involvement in UPS promotion activities, ICUC will give particular attention to the following points with reference to managing biodiversity:

- Before beginning any promotion activity focused on a particular UPS, possible scenarios for associated plants and animals in the landscape, e.g., whether significant displacement of important cultivated variation is expected, and if over-exploitation and damage of natural environments is likely, should be considered and described, in order to assess potential livelihood and conservation risks. When a project is embarking on the domestication of a wild species, or is introducing a crop into an area for the first time, a formal analysis of risks to biodiversity, through a properly conducted environmental impact assessment, may be required, before promotion activities begin.
- When assessment indicates that promotion is likely to carry significant risks for biodiversity, projects should consider specific incentives that support diversification, e.g., by adopting a 'spear and shield' approach for promotion.
- Projects should explain how promotion activities relate to improving germplasm access and supporting 'intelligent markets' for UPS, both being measures that can support biodiversity and enhance livelihoods together. Projects will be considered of highest priority if they have links with decentralised, small-scale, commercial seed suppliers, encourage entry into local markets for a range of products, address niche market development, and reduce barriers to trade.
- Studies that seek to quantify the consequences of promotion activities for biodiversity, and the linked impacts on livelihoods (health, income, etc.), will be encouraged, as there is currently a lack of concrete knowledge in this area for UPS. There is a need to set an objective baseline for future interventions that eliminates the 'counterfactual' – what would have happened without action.

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List of Acronyms

DFID	Department for International Development (UK)
DO	Denomination of Origin
EU NFR	European Union 'Novel Food Regulation'
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)
ICUC	International Centre for Underutilised Crops
IPGRI	International Plant Genetic Resources Institute (now Bioversity International)
KIT	Koninklijk Instituut voor de Tropen (Royal Tropical Institute)
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPS	Underutilised Plant Species
USD	United States Dollar

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