



## Chapter 8

The contribution of Plant  
Genetic Resources for  
Food and Agriculture  
to food security and  
sustainable agricultural  
development

## 8.1 Introduction

Over recent decades, agriculture has undergone enormous changes as a result of both technological advances and changing human needs and desires. On the one hand, yields per unit area have increased dramatically through a combination of improved crop varieties and a greater use of external inputs.<sup>1</sup> On the other hand, there has been increasing pressure on land for uses other than the production of food, as well as growing concerns about the sustainability and safety of some modern practices.

In spite of advances in food production, food insecurity and malnutrition are still widespread. The latest FAO figures indicate that in 2009 there were around 1 billion chronically hungry people in the world, an increase of about 200 million since the World Food Summit in 1996. It is estimated that the number of hungry people increased by over 100 million due to the food price crisis of 2007-2008 alone. Most of the worst affected people (about 75 percent) live in rural areas of developing countries and depend directly or indirectly on agriculture for a large part of their livelihoods. A 70 percent increase in world agricultural production over today's levels will be required to meet the food demands of the estimated 9.2 billion people in 2050. A major share of this productivity increase will have to come from the use of PGRFA to produce higher yielding, more nutritious, more stable and more eco-efficient crop varieties.

In 2000, the United Nations Millennium Declaration was adopted, committing nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound targets, with a deadline of 2015, that have become known as the Millennium Development Goals (MDG) (see Box 8.1). All countries and all of the world's leading development institutions have agreed to these goals, two of which, in particular, will require the conservation and use of PGRFA if they are to be reached: the eradication of poverty and hunger and the achievement of environmental sustainability.

The aim of this chapter is to discuss the role and contribution of PGRFA to food security, sustainable agriculture, economic development and poverty alleviation. The chapter will not review or interpret

### Box 8.1 The Millennium Development Goals

1. Eradicate extreme poverty and hunger.
2. Achieve universal primary education.
3. Promote gender equality and empower women.
4. Reduce child mortality.
5. Improve maternal health.
6. Combat HIV/AIDS, malaria and other diseases.
7. Ensure environment sustainability.
8. Develop a global partnership for development.

these four concepts or their inherent complexity and interlinkages. Instead, it will look at the role of PGRFA in the context of some of the emerging and difficult challenges now facing agriculture. Unlike the other seven chapters, this one does not have a counterpart in the first SoW report and so there is no baseline upon which to build. It thus aims to provide an overall review of the current status of PGRFA in relation to sustainable agriculture, food security and economic development, concludes with a summary of some of the main changes that have occurred in recent years and identifies some of the key gaps and needs for the future.

## 8.2 Sustainable agriculture development and PGRFA

Since the United Nations Conference on Environment and Development (UNCED) in 1992 and the subsequent World Summit on Sustainable Development (WSSD) in 2002, 'sustainable development' has grown from being a concept focusing mainly on environmental concerns, to a widely recognized framework that attempts to balance economic, social, environmental and intergenerational concerns in decision-making and action at all levels.<sup>2</sup>

Within the context of overall sustainable development, agricultural systems are extremely important. There are, however, many concerns about the non-sustainability of many agricultural practices, for example: the overuse or misuse of agrochemicals,

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water, fossil fuels and other inputs; the shifting of production to more marginal land and encroachment into forested areas; and the increased use of monocropping, more uniform varieties and a reduced use of crop rotations. MEA<sup>3</sup> undertaken between 2001 and 2005 reported that about 60 percent of the ecosystems studied were being degraded or used unsustainably, while the demands of a continually expanding human population, climate change and increasing demand for biofuels are all putting new additional pressure on land. The wise use of agricultural biodiversity in general and PGRFA in particular, offers a way forward on many of these inter-related issues. The following sections look at two aspects: the role of genetic diversity in sustainable agriculture and the role of PGRFA in the provision of ecosystem services.

### 8.2.1 Genetic diversity for sustainable agriculture

PGR are a strategic resource and lie at the heart of sustainable agriculture. The link between genetic diversity and sustainability has two main dimensions: firstly the deployment of different crops and varieties and the use of genetically heterogeneous varieties and populations, can be adopted as a mechanism to reduce risk and increase overall production stability; and secondly, genetic diversity is the basis for breeding new crop varieties to meet a variety of challenges.

A large number of the country reports expressed concern about the increasing use of genetically uniform varieties and the trend for them to be grown on ever larger areas, resulting in increased genetic vulnerability (see Section 1.3). Many called for a greater use of genetic diversity to counter this. The deployment of diversity at the farm and field level helps provide a buffer against the spread of new pests and diseases and the vagaries of weather. In the case of pests and diseases, for example, while some individual component might be susceptible, there is a strong possibility that other components will be partially or totally resistant or tolerant. In such situations, the resistant or tolerant component can produce some yield, thus avoiding total crop failure, and in many circumstances such genetic diversity can also significantly slow the overall rate of spread of a disease or pest. Thus, production

strategies that include the deployment of diversity are likely to be more stable overall than monocultures of uniform varieties, they reduce the risk of crop failure and require fewer pesticides. There is also evidence that in cases where heterogeneous varieties are able to exploit a given environment more efficiently and effectively, this can even result in higher yields.

The development and production of appropriate crop varieties provides one of the best mechanisms for addressing many of the most important agricultural challenges related to sustainability. Varieties that are pest and disease resistant require fewer fungicide and insecticide applications; varieties that compete better with weeds require less herbicide; varieties that use water more efficiently can produce higher yields with less water; and varieties that use nitrogen more efficiently require less nitrogenous fertilizer, with a concomitant saving in fossil fuel. While varieties having many of these characteristics already exist, the situation is far from static. Agricultural environments change as do farming systems; new pests and diseases arise and the demand for specific products is constantly shifting. The result is that there is a continual need for new varieties. A variety that performs well in one location may not do so in another and a variety that produces a good yield this year may be knocked out by a new pest next year. In order to be able to continually adapt agriculture to ever changing conditions, plant breeders need to develop and maintain a pipeline of new varieties. Genetic diversity underpins the whole process of producing new varieties; it is the reservoir that enables breeders to maintain a full pipeline.

The country reports cite several examples of the use of PGRFA to improve pest and disease resistance. In Pakistan, for example, two million cotton bales were lost from 1991 to 1993 due to a crop failure caused by Cotton Leaf Curl Virus. Resistant cotton types were subsequently identified and were used to develop new virus resistant cotton varieties adapted to the growing conditions in Pakistan.<sup>4</sup> Morocco was able to release the first Hessian fly resistant durum wheat varieties, derived from interspecific crosses with wild relatives.<sup>5</sup> There are countless such examples and all depend on the existence of PGRFA and the ability of plant breeders to access and use it. While genetic diversity represents a 'treasure chest' of potentially valuable traits, as

shown elsewhere in this report, it is under threat and special efforts are needed to conserve it both *in situ* (see Chapter 2) and *ex situ* (see Chapter 3), as well as to develop a strong capacity to use it, especially in the developing world (see Chapter 4).

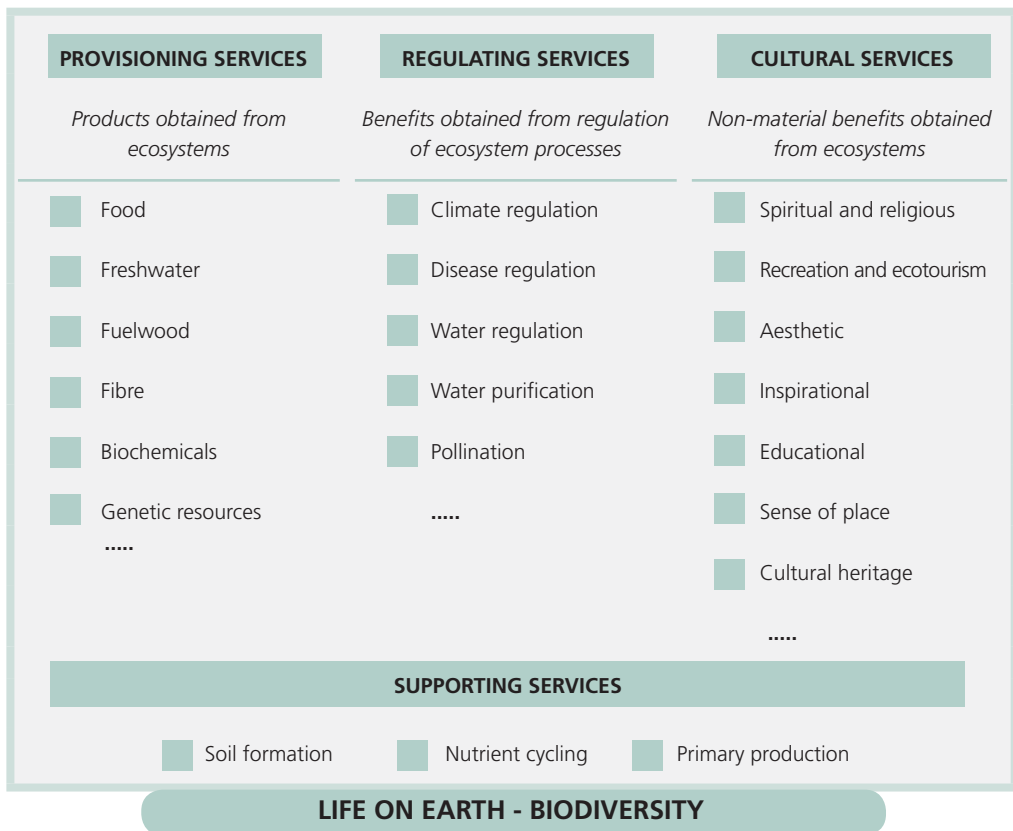
### 8.2.2 Ecosystem services and PGRFA

Agriculture contributes to development not only as an economic activity and as a source of livelihoods, but is also an important provider of environmental services.

Figure 8.1 illustrates the four broad categories of services provided by ecosystems:

- provisioning services: the supply of products from ecosystems, such as food and genetic resources;
- regulating services: the benefits, such as water purification obtained from the regulation of ecosystem processes;
- cultural services: non-material benefits obtained from ecosystems such as recreation, education and ecotourism;
- supporting services: the services needed for the production of all other ecosystem services. These

**FIGURE 8.1**  
Categories of ecosystem services



Source: Adapted from Ecosystem and Human Well-being: a framework for assessment by the MEA. Copyright © 2003 World Resources Institute. Reproduced by permission of Island Press, Washington, DC.

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include such things as nutrient recycling and soil formation.

PGRFA plays an important role in all of the four categories. In addition to being a direct 'provisioning service', genetic resources provide the raw material for improving the production of more and better food, either directly or through providing better feed for livestock. They are also important as the basis for improving fibre, fuel or any other crop product. In the area of 'regulating services,' PGRFA are the basis for improving such services as carbon sequestration by crops, for example, deeper-rooted rangeland species and the control of water run-off and soil erosion. The diversity of traditional crops and foods can provide an important cultural service, e.g. through its importance in agrotourism or ecotourism; and as a 'supporting service' PGRFA can underpin the development of new varieties, for example food and forage legumes, having an enhanced ability to recycle nutrients such as nitrogen within an agro-ecosystem.

In recent years, many programmes have been initiated that seek to enhance these services, in particular, through rewarding those responsible for managing the underlying resource through PES schemes. However, implementing PES is a challenge as many of the services arise from complex processes, making it difficult to determine which actions affect their provision, who is responsible for these actions and who are the beneficiaries who should pay for them. This is particularly true in the case of agrobiodiversity. If, for instance, the on-farm conservation of a particular traditional crop variety is considered eligible for PES, the challenge is to determine which farmer or farmers should be compensated for its conservation. How much should they receive, for how long, who should pay and what mechanisms are in place for monitoring and ensuring that payments are actually made and that the expected service is actually provided? This is a dilemma that also underlies the debate over how to implement farmers' rights (see Chapters 5 and 7). Nevertheless, PES raises hopes and expectations for the development of a more environmentally-friendly agriculture and the PGRFA sector has a critical role and a responsibility to be part of the debate and action.

### 8.3 PGRFA and food security

Food security and related issues were put firmly on the global agenda in the Rome Declaration on World Food Security in 1996, which called for "the right of everyone to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger." Later, in 2002, the 'World Food Summit: *five years later*' led to the development of voluntary guidelines to support the progressive realization of the right to adequate food in the context of national food security.<sup>6</sup> These guidelines were adopted by the 127th Session of the FAO Council in 2004.

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The four pillars of food security are: availability, stability of supply, access and utilization.<sup>7</sup> The PGRFA sector has multiple roles to play in helping ensure food security, for example: producing more and better food for rural and urban consumers; providing healthy and more nutritious food; and enhancing income generation and rural development. There is, however, need for a greater recognition of the multiple roles and contributions that PGRFA can play and for a strengthening of the linkages among all relevant institutions dealing with food security at the global, regional, national and local levels.

#### 8.3.1 Crop production, yields and PGRFA

Agricultural production in general and crop production in particular, must increase substantially in order to meet the rising food demand of a population that is projected to expand by some 40 percent over the period from 2005 to 2050. According to one projection by FAO, an additional billion tonnes of cereals will be needed annually by 2050. As on average, only 16 percent<sup>8</sup> (15 percent of cereals and 12 percent of meat) of the world's agricultural production enters international trade, much of the increase will have to be met through expanding production in those, mainly

developing countries that experience the greatest increase in demand.

Many country reports from all regions have documented the vital role of sound PGRFA management in strengthening national food security and improving livelihoods. In China, for example, varieties of rice, cotton and oilseed crops have all been replaced four to six times throughout the country since 1978, each replacement representing the introduction of a new variety that was an improvement over the one it replaced. Yield increases of 10 percent and more were associated with each replacement and with every 10 percent yield increase, the level of poverty was reduced by six to eight percent.<sup>9</sup> According to Malawi's country report, adoption of improved varieties of sorghum and cassava has led to higher yields and greater food security at both the household and national level. The increased use of improved varieties has also opened up business opportunities for farmers and the extra income derived from marketing cash crops and value added products, such as cassava snacks, has helped to boost local industry such as the fabrication of cassava processing equipment, increased the use of cassava in livestock feed and provided funds for the development of local on-farm seed programmes.<sup>10</sup>

Recent experience with crop productivity growth gives reason for both optimism and concern. When growth in yield per unit area has been assessed for key staple crops over the past several decades, it is apparent, particularly for wheat, that productivity growth has levelled off in recent years (see Figure 8.2). Rice and maize productivity have continued to increase on a world scale, although rice yield increases have also levelled off in East and Southeast Asia. In Africa, yields of major crops like rice, maize and wheat are still far below those typically seen in other regions. However, good progress is being made, for example through the development and fast dissemination of NERICA<sup>11</sup> rice (see Box 8.2). While much of the yield increase is attributable to a combination of factors including an increased use of inputs and good weather conditions, a major factor has been the development and dissemination of improved crop varieties.

The production of staple food crops remains the largest agricultural subsector in most countries and will continue to play an important role in meeting food security and agricultural development objectives in the future. Sustaining productivity growth in 'breadbasket' zones, where new, high-yielding varieties and associated practices have already been widely adopted, will remain an important strategy for meeting future

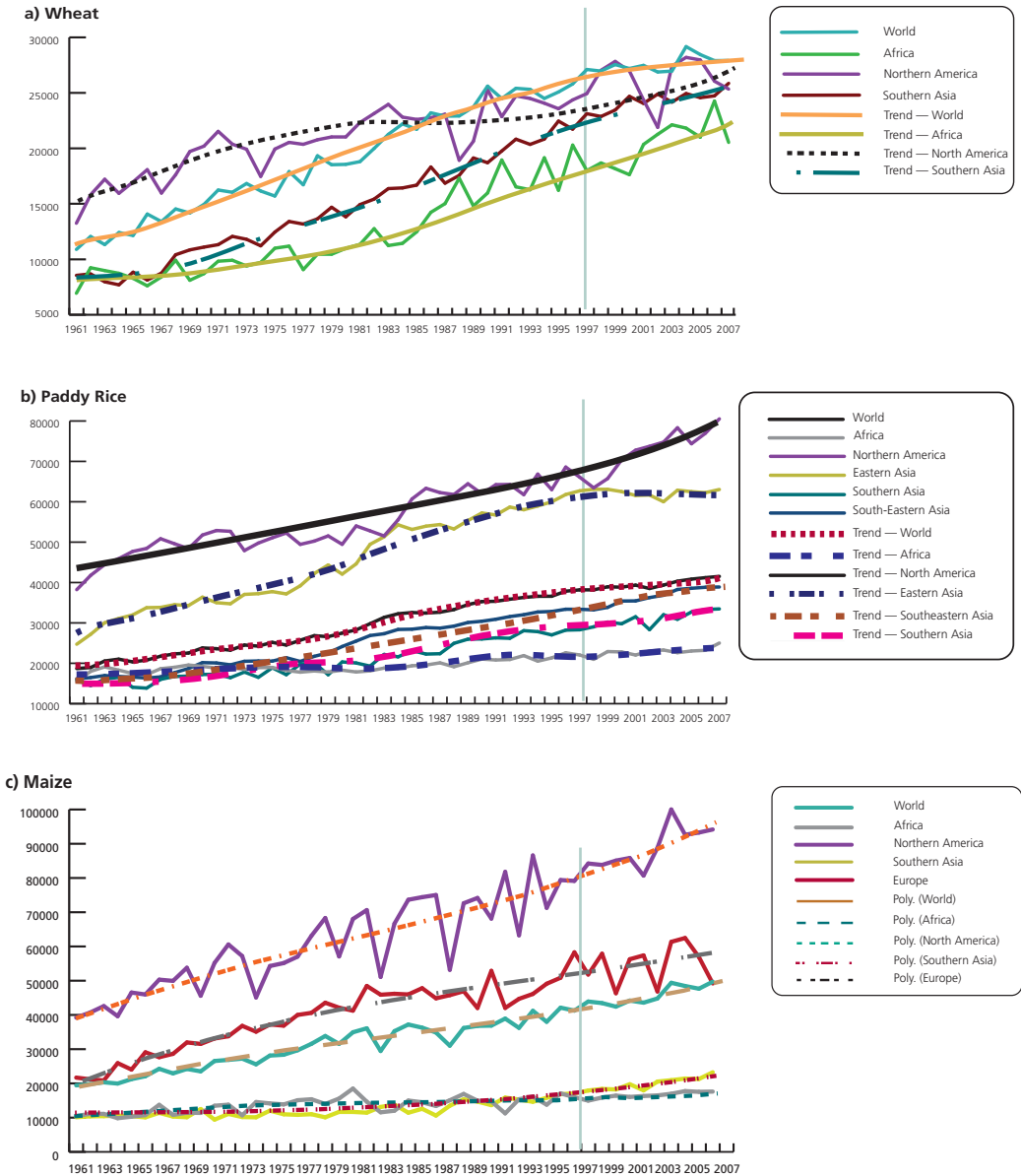
### Box 8.2 NERICA Rice

The term NERICA, 'New Rice for Africa', is used to refer to the genetic material derived from the successful crossing by WARDA in the early 1990s, of the two species of cultivated rice, the African rice (*O. glaberrima* Steud.) and the Asian rice (*O. sativa* L.), to produce progeny that combine the high yielding traits from the Asian parent and the ability to thrive in harsh environments from the African parent. The *O. glaberrima* accessions used in the breeding programme came from the WARDA genebank and simple biotechnological techniques (anther culture and doubled haploids) were used to overcome sterility barriers with *O. sativa*.

NERICA is a new group of rice varieties that adapt well to rainfed ecologies in Sub-Saharan Africa, where 70 percent of smallholder farmers cultivate rice. The new varieties have a higher yield potential than the traditional varieties grown and have spread at record rates, covering more than 200 000 hectares in West, Central, East and Southern Africa by 2006. The NERICA varieties offer hope to millions of poor rice farmers and consumers.

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**FIGURE 8.2**  
Average yields (kg/ha) for a) wheat; b) paddy rice (1961-2007); and c) maize (1997-2007) by major regions (the vertical bar marks the date on which the first SoW report was published)



Source: Faostat (<http://faostat.fao.org>)

food needs, particularly for rapidly growing urban populations. This will require a continued stream of new varieties to meet the changing needs and environments in these 'breadbasket' areas. A significant share of the increase in staple foods will also have to come from more marginal environments, home to many of the world's poorest people. A pipeline of new varieties will also be needed for these areas.

### 8.3.2 Use of local and indigenous PGRFA

While local landraces and farmers' varieties provide the genetic diversity that underpins much modern plant breeding, for many agrarian countries, such varieties still provide the basis for local food production and security. Indeed, this generally remains their main use in situations where they are still grown by the communities that developed them. Furthermore, they may have a number of advantages, especially in the absence of appropriate alternatives: they are adapted to local environmental conditions, fit in with local farming systems, meet local taste and other preferences and their diversity can bring greater production stability. Local varieties may also command premium prices in niche markets and for agrotourism. There are many examples to illustrate this in the country reports and in other publications. In lowland areas of Viet Nam, for example, many traditional varieties are maintained because of their adaptation to local climate, soils and other conditions and are appreciated for their cultural value, productivity, taste and cooking qualities.<sup>12</sup> An analysis of maize landraces in Mexico<sup>13</sup> found that even though new, high yielding varieties were available and supported by the Government, farmers maintained complex populations of landraces in order to cope with environmental heterogeneity, combat the effects of pests and diseases, meet cultural and ritual needs and satisfy dietary and food preferences. There are a number of programmes, such as the "Programa Nacional do Desenvolvimento Rural do Continente" of Portugal,<sup>14</sup> that support on-farm conservation of PGRFA, promote the use of local varieties and build on local and indigenous knowledge to add value. Latin America has reported several programmes<sup>15</sup> that link small farmers and indigenous communities with

governmental agricultural research institutions and genebanks to carry out joint activities on collecting PGRFA, on-farm conservation, reintroduction, evaluation and participatory breeding.

Niche markets for regional and local products have expanded and with them, the role and importance of local crops. The international Slow Food movement,<sup>16</sup> for example, has had a significant impact on raising awareness in many developed countries of the role of traditional food in local culture, the nutritional value of many local foods and the importance of dietary diversity and reduction of 'food miles'. Several international initiatives have also supported this trend, such as the growth of 'fair trade' systems and the increasing use of 'geographical indications' to designate the specific geographical origin of a food item possessing qualities or a reputation that are related to the place of origin.<sup>17</sup> Finally, organic crop production, requiring varieties that are adapted to organic growing conditions, has gained in importance globally and is often associated with initiatives aimed to promote traditional and local food.

### 8.3.3 Climate change and PGRFA

While the effects of climate change are only now beginning to be felt, there is a growing consensus that unless drastic measures are taken its future impact could be enormous. This topic was the main theme of a seminar held in 2009 on the occasion of the First Anniversary of the SGVS. The importance of taking immediate action was addressed in a Summary Statement arising from the seminar<sup>18</sup> that concluded: *"...we ask the nations of the world to recognize the urgency of adapting agriculture to climate change, that crop diversity is a prerequisite for this adaptation and therefore that the importance of ensuring that the genetic diversity of our crops is properly conserved and available is a basic prerequisite for feeding a warming world"*.

Prediction models of the IPCC<sup>19</sup> as well as other reports<sup>20</sup> indicate that there will be severe effects on agricultural productivity in many parts of the world. The news is not all bad, however; some regions, especially those further away from the equator, are expected to have longer growing seasons and will



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become more productive, as long as high yielding varieties that are adapted to the new environmental conditions are available.

Unfortunately, it is expected that regions such as South Asia and Southern Africa are likely to be most affected by climate change; areas of the world that are home to the largest number of poor people and that are least able to cope.<sup>21</sup> In many regions, adapting agriculture to the new conditions will require a shift to more drought-tolerant or heat-tolerant varieties or even to other crops. Changes in pest and disease patterns are likely to take place and indeed may be already happening, resulting in the need for new resistant or tolerant varieties. Less predictable weather patterns may also require the development of new varieties that are adapted to a wider range of more extreme conditions.

New varieties will also be needed for agriculture to be able to play a greater role in mitigating climate change. For example, varieties with greater biomass, e.g. that have deeper rooting, coupled with appropriate agronomic practices, can result in the capture of more carbon in the soil. Feed and forage varieties that result in less methane being emitted by ruminants can be bred as well as varieties that are able to use nitrogen more efficiently and need less fertilizer and hence less total energy, but also result in reduced emissions of the potent greenhouse gas nitrous oxide. Although bioenergy crops were mentioned in only relatively few country reports, there have been significant moves to increase the production of biofuels in many countries in response to growing concerns about climate change and in the face of fossil fuel scarcity.

Overall, the difficulties of mitigating against and adapting to climate change are likely to make it considerably more difficult to meet the increased demand for food in the future. The challenge will be exacerbated further by growing competition for land for other uses, such as urban development or for growing new crops. In order to meet such challenges it is essential that greater attention be devoted to conserving genetic diversity and in particular, to targeting the collection and conservation of landraces and CWR that have traits that are likely to become more important in the future. Coupled with this, it is essential that plant breeding efforts be stepped

up around the world, especially in those developing countries likely to be hardest hit by climate change. This will require greatly enhanced attention to capacity building in traditional as well as modern crop improvement techniques.

### 8.3.4 Gender dimensions of PGRFA

Gender is an important determinant of the extent and nature of the diversity of crops and varieties grown and is a key aspect of sustainable crop production and food security. Rural women are responsible for half of the world's food production and produce between 60 and 80 percent of the food in many developing countries. Women often have a particular responsibility for managing home gardens and these tend to include a wider variety of vegetables, fruit, spices, medicinal and other crops than is generally the case for fields producing staple-crops and for which men often have a primary responsibility.<sup>22</sup> Gender differences are further evident in varietal choices and the importance placed on different traits. Research in the United Republic of Tanzania, for example, showed differences between male and female farmers in the different importance and ranking they gave to various traits in sorghum.<sup>23</sup>

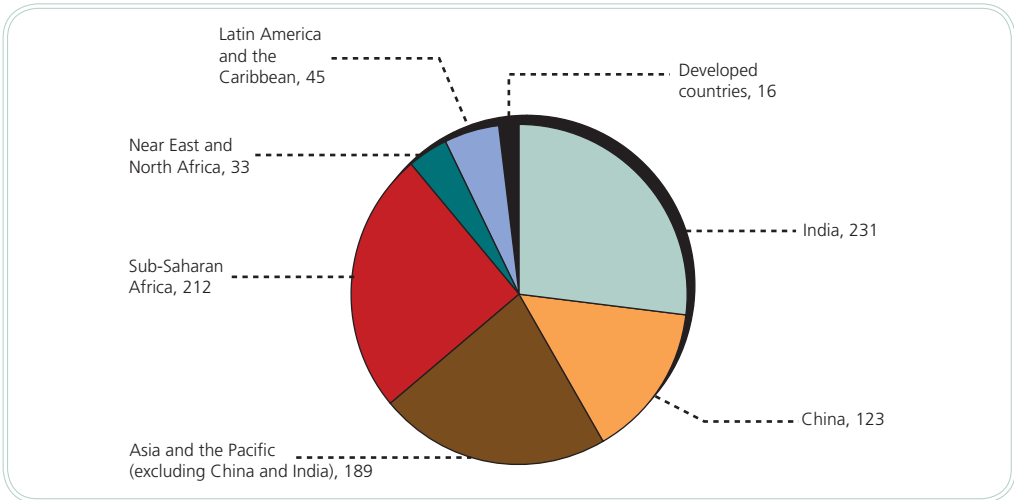
While overall this did not come across clearly in the country reports, it is critical that the role of rural women be better understood and taken into account in policy-making and in all relevant PGRFA initiatives.

### 8.3.5 Nutrition, health and PGRFA

The majority of food-insecure and undernourished people live in rural areas. They are most numerous in Asia and Sub-Saharan Africa. Seven countries comprising Bangladesh, China, the Democratic Republic of the Congo, Ethiopia, India, Indonesia and Pakistan account for 65 percent of the world's food insecure people (see Figure 8.3).

PGRFA underpin not only total food production but also nutritional well-being (see Section 4.9.4). The best insurance against nutrient deficiencies is through eating a varied diet, thereby ensuring an adequate intake of all the macro and micronutrients needed for good health. However, many poor people

**FIGURE 8.3**  
**Number of undernourished people in the world, 2003-2005 (millions)**



Source: FAO, 2008, *The State of Food Insecurity in the World*, Rome

do not have access to, or are unable to afford, an adequately diverse diet and have to rely heavily on just a few staple food crops for most of their food. In recognition of this, a number of breeding efforts are underway to improve the nutritional quality of staple crops, for example, by producing rice, maize, cassava and sweet potato with higher levels of beta-carotene (the precursor of Vitamin A), pearl millet and beans with higher levels of available iron and rice, wheat and beans with higher levels of zinc.<sup>24</sup>

In addition to the important direct relationship between PGRFA, nutrition and human health, there are various indirect effects. For example, for resource poor populations in countries faced with the problems caused by HIV/AIDS, the consumption of diverse diets represents an important way of boosting human resistance and tolerance.

Plants are also an extremely important source of pharmaceutical products and, as for all crops, the current production of medicinal crops as well as their future improvement is dependent on their genetic diversity. In some African and Asian countries, up to 80 percent of the population depends on traditional, mainly herbal,

medicine. In Kenya, for example, a recent World Bank study indicated that 70 percent of the population is not covered by the national healthcare system and depend on traditional forms of medication.<sup>25</sup> Herbal medicines are highly lucrative: annual revenues in Western Europe reached USD 5 billion in 2003-2004, in China sales totalled USD 14 billion in 2005 and revenues of USD 160 million were generated from herbal medicines in Brazil in 2007.<sup>26</sup>

### 8.3.6 Role of underutilized and neglected PGRFA

Since the first SoW report was published, many studies have documented the importance of neglected and underutilized species for the food security and income of local communities (see Section 4.9.2). By definition, the area sown to these crops is relatively small worldwide;<sup>27</sup> there are few marketing opportunities and relatively little effort at crop improvement. Nevertheless, country reports from all regions have described the role and uses of different species, ranging from those that are important for dietary diversity or

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have the potential to make a greater contribution to generating income, to those that are likely to become more important in local farming systems as climate changes.<sup>28</sup> They emphasize the importance of many of these species in the social and cultural fabric of local societies and call for increased efforts to conserve and use them. Many countries have reported efforts made over the past decade to collect, characterize, evaluate and conserve samples of underutilized species in their NPGS<sup>29</sup> as well as efforts to promote and market them.<sup>30</sup>

While much has been done in this area, much more still needs to be done, in particular, in developing markets for the products of neglected species. Efforts of institutions such as Crops for the Future (see Section 6.3.3)<sup>31</sup> can make a very valuable contribution to ensuring that neglected and underutilized crops play a greater role in sustainable agriculture and livelihood systems in the future.

### 8.4 Economic development, poverty and PGRFA

The economic health and prosperity of a country depends on a large number of factors of which agricultural productivity and growth is one. The importance of agriculture varies by region, from only 1.9 percent of the population dependent on agriculture in North America to over 50 percent in Africa and Asia. However, taken overall, agricultural production is the main source of income for about half of the world's population. The choice of crops, varieties, planting materials and associated production methods have a significant influence on productivity and livelihoods. Generally, farmers grow a number of different crops and varieties, each of which provides a set of benefits in the form of income, food and other products. In addition, benefits may arise from the overall portfolio of crops and varieties, including mitigation against the effects of failure of any one crop or variety, spreading production through the year and achieving a greater intensity of land use.

Marketed values vary by crop, variety and marketing channel. In many countries the growth of a dynamic food-marketing sector has created high-value po-

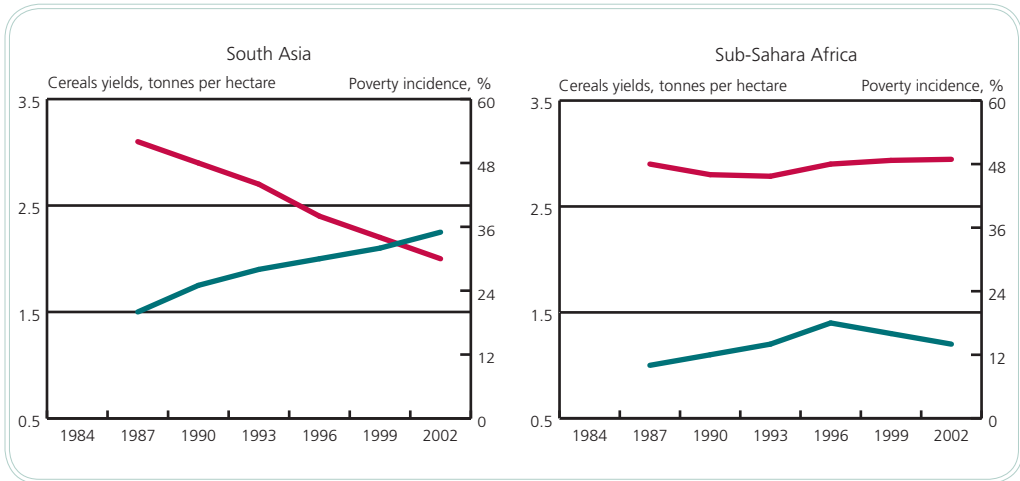
tential market outlets, representing an important means of increasing farm incomes and achieving food security. Several studies have indicated that agricultural productivity growth has had an important effect on poverty reduction<sup>32</sup> and plant breeding has played a predominant role in this. Nonetheless, while this is certainly the case for Asia and Latin America, the relationship is less clear in Sub-Saharan Africa where agricultural yields have generally stagnated, making it more difficult to clearly establish a relationship with poverty reduction (see Figure 8.4).

Many small farmers experience difficulties in accessing both input and output markets and several country reports indicated that this is one of the most serious constraints to diversifying crop production. Lack of access to good quality seeds of appropriate varieties can prevent farmers from entering specific markets. Numerous country reports, particularly from Africa, referred to the suboptimal state of seed production and distribution systems, noting widespread problems with insufficient availability of seeds of new and appropriate varieties. Overcoming input and output bottlenecks and inequalities in the value chain is a key strategy for increasing the market value of crops and one that has important implications for the management of PGRFA.

While sound crop management (together with land and water management) is critical for success, it is very difficult to place an exact economic value on the underlying genetic resources. Estimating the value of PGRFA by rigorous economic methods summing their direct use, indirect use, option and non-use values underestimates their overall value.<sup>33</sup> This problem hampers efforts to make a case for investing more in PGRFA and is a significant impediment to securing adequate funding. However, some of the most convincing data come from impact studies based on tracing germplasm flows. In one study,<sup>34</sup> for example, it was estimated that conserving 1 000 accessions of rice generates an annual income stream for developing countries that has a direct use value of USD 325 million at a 10 percent discount rate. This calculation also serves to highlight the need for better integration and linkages between conservation, plant breeding and seed delivery for realizing the full potential of PGRFA.

FIGURE 8.4

## Cereal yield and poverty in South Asia and Sub-Saharan Africa



Source: Ravallion, M. & Chen, S. 2004. World Bank, 2006

### 8.4.1 Modern varieties and economic development

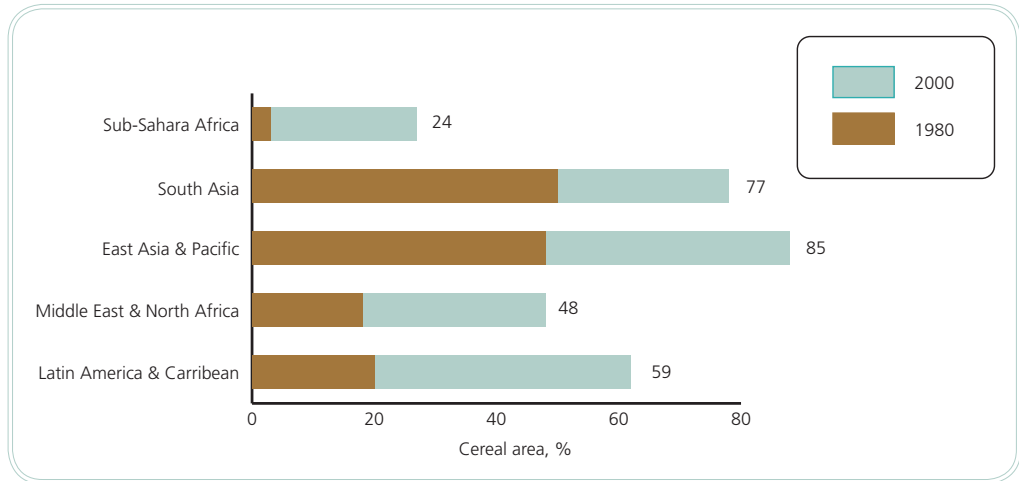
Overall, the contribution of modern varieties to agricultural growth and poverty reduction has been very impressive.<sup>35</sup> The impact has been both direct and indirect: high yields generating higher incomes, but also generating employment opportunities and lower food prices.<sup>36</sup>

However, in a study across 11 food crops in four regions over the period 1964-2000,<sup>37</sup> it was concluded that the contribution of modern varieties to productivity increases was a 'global success, but for a number of countries a local failure.' Many of these countries are located in Sub-Saharan Africa where adoption of improved varieties of cereal crops was very low during the initial phases of the Green Revolution and only began to reach significant levels in the late 1990s (see Figure 8.5). It is interesting to note, in this respect, that the yield growth experienced by Sub-Saharan Africa, although relatively small, has been almost completely attributable to modern varieties, with little contribution from fertilizer and other inputs.<sup>38</sup>

There is considerable variability in adoption patterns of modern varieties within regions as well as across crops. In Latin America, for example, farmer-saved maize seed was grown by 60 to 100 percent of farmers in most Central American countries (with the exception of El Salvador) and by more than 50 percent of the farmers in the Plurinational State of Bolivia, Colombia, Paraguay and Peru.<sup>39</sup> However, hybrid seed maize was more widely used in Argentina, Brazil, Ecuador, Uruguay and the Bolivarian Republic of Venezuela. Similar patterns were evident in Eastern and Southern Africa, where the adoption of modern semi-dwarf varieties of wheat was high in most countries, but adoption of hybrid maize was far patchier (e.g. 91 percent adoption in Zimbabwe compared with 3 percent in Mozambique). Several factors help to explain these trends. One is environmental heterogeneity – e.g. in the harsh and variable highland regions of the Andes, local maize varieties may be better suited than improved hybrids. Another factor may be the availability of a large range of alternative types. Ethiopia, for example, which had lower levels of adoption of semi-dwarf wheat than other countries in the region, is a secondary centre of diversity for durum

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**FIGURE 8.5**  
**The growth in area under improved cereal varieties in 1980 and 2000**



Source: Evenson, R.E. & Gollin, D. (eds.).

wheat and thus greater genetic diversity was available to help farmers in their heterogeneous and difficult growing environments.

Studies at the household level paint a varied picture. Adoption tends to vary by crop rather than by household and depends on such factors as the sources of seed and its cost, the specific agro-ecological conditions encountered and on the demands of the farm and consumption system. In an analysis of modern variety adoption of sorghum and bread wheat in low-income farming communities of Eastern Ethiopia,<sup>40</sup> it was found that the poorest people were significantly less likely to adopt modern varieties of either crop, although higher adoption levels were found for wheat than sorghum. Sorghum is a crop with considerable local diversity available through local seed systems; it is grown for multiple purposes and on-farm seed-storage techniques are well developed. In contrast, bread wheat, unlike durum wheat, is a relatively recently introduced crop in this area of Ethiopia and as a result, the genetic diversity available locally is quite limited.

While modern varieties have been shown to contribute significantly to poverty reduction, they have arguably been less successful in enhancing the

sustainable agricultural development of small-farm systems, especially in more marginal production environments. Key shortcomings cited have been a lack of adaptation to heterogeneous and harsh production areas<sup>41</sup> and the failure, cited in several country reports, of many centralized plant breeding programmes to breed for traits of concern to small-scale and resource poor farmers.

#### 8.4.2 Diversification and the use of genetic diversity

The choice of which crops and varieties to plant is driven by a range of economic, social and agronomic factors, including the availability of suitable market outlets, prices, familiarity and societal acceptance, costs of production, the need for and availability of production inputs (including seeds, water, fertilizers, pesticides, labour, etc.), climate, soils and topography.

While for the more market-oriented producers varietal choice is largely driven by yield and market demand, this is not the case for most food-insecure farmers. Studies<sup>42</sup> have shown that household farms in most developing countries produce both for their own consumption as well as for sale,<sup>43,44</sup> and that when

farmers are both consumers and producers of food, this has a major impact on which crops are grown.

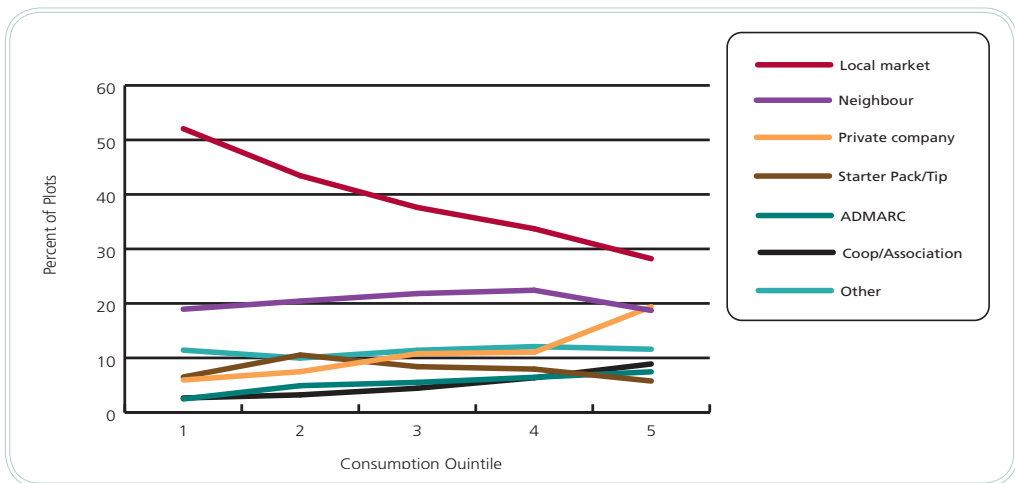
Farm households also tend to draw on a variety of activities to achieve food and income security.<sup>45</sup> Diversification across activities is an important risk management strategy, often one of the very few available to poor farmers. At the crop level, farmers can diversify with respect to the crops and varieties they grow and at the farm level, a diversity of enterprises can be undertaken, e.g. food processing, meat or egg production, agroforestry or agrotourism. Many of these strategies have important implications for genetic diversity and the crops and varieties grown. Households are also increasingly relying on off-farm employment, often with one or more family members taking on paid employment away from the farm and remitting money back home. A recent study looked at data from the FAO Rural Income Generation Project (RIGA) across sixteen developing countries in Africa, Latin America, Asia and Eastern Europe.<sup>46</sup> The study found that income diversification was generally the norm for most of the countries, although less so for those in Africa where off-farm

opportunities are normally fewer. Different income diversification strategies, within and outside of agriculture, obviously have different implications for PGRFA management.

### 8.4.3 Access to seed

Section 4.8 emphasized how, for agriculture to be successful and sustainable, sufficient good quality seed has to be available to farmers at the right time and at the right price. Recent evidence underscores the importance of markets in providing seed to poor farmers.<sup>47</sup> Analysis of the FAO RIGA data for Ghana, Malawi and Nigeria confirms this. In Malawi, for example, purchased seed was used on 30 percent of the plots, a percentage that was essentially the same across all income groups (see Figure 8.6). However, the source of purchased seed varied significantly. While local markets were the most important source of seed for all groups, their relative importance diminished as farmers' wealth status increased and private companies played an increasingly important role in providing seeds to better-off farmers.

**FIGURE 8.6**  
Seed sources by consumption group in Malawi (1=poor; 5=rich)



Source: RIGA Database (available at: [http://www.fao.org/es/esa/RIGA/English/Index\\_en.htm](http://www.fao.org/es/esa/RIGA/English/Index_en.htm)).

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### Box 8.3 FAO Initiative on Soaring Food Prices

FAO launched the Initiative on Soaring Food Prices (ISFP) in 2007 with the immediate goal of raising USD 1.7 billion for rapidly increasing food production in 2008 and 2009, mainly through supporting direct access to inputs for smallholders in the most affected countries. FAO's assistance has taken the form of:

- (i) interventions to increase access by small-scale farmers to inputs (e.g. seeds, fertilizer, animal feed) and improve agricultural practices (e.g. water and soil management, reduction of post-harvest losses);
- (ii) policy and technical support;
- (iii) measures to increase smallholder access to markets;
- (iv) a strategic response to cushion the effects of rising food prices in the short, medium and long term, through increased and sustainable investment in agriculture.

Farmers tend to favour local markets for purchasing seed because 1) locally traded seed is less expensive than seed from industry; and 2) there is a ready availability of locally adapted materials.<sup>48</sup> Many country reports stressed the need for stronger seed production and distribution systems as well as for greater harmonization between the commercial and farmers' seed sectors.

#### 8.4.4 Globalization and PGRFA

Globalization and trade liberalization have increased substantially since the first SoW report was published, leading to rapid economic expansion in many but by no means all countries. Market opportunities have opened up for new products, with the result that the demand for particular crops and varieties has shifted. Many small-scale farming systems that were traditionally self-reliant for seed have increasingly had both the need and the resources to access new varieties. Moreover, a growing share of produce from the small-scale sector is now reaching local, national and even international markets. The privatization of breeding has continued (see Section 4.4) and the commercial plant breeding sector has become markedly more concentrated in the hands of fewer multinational companies.

In the first three months of 2008, international food prices of all major food commodities reached their highest level in nearly 30 years (see Figure 8.7). This was the result of a number of factors including:

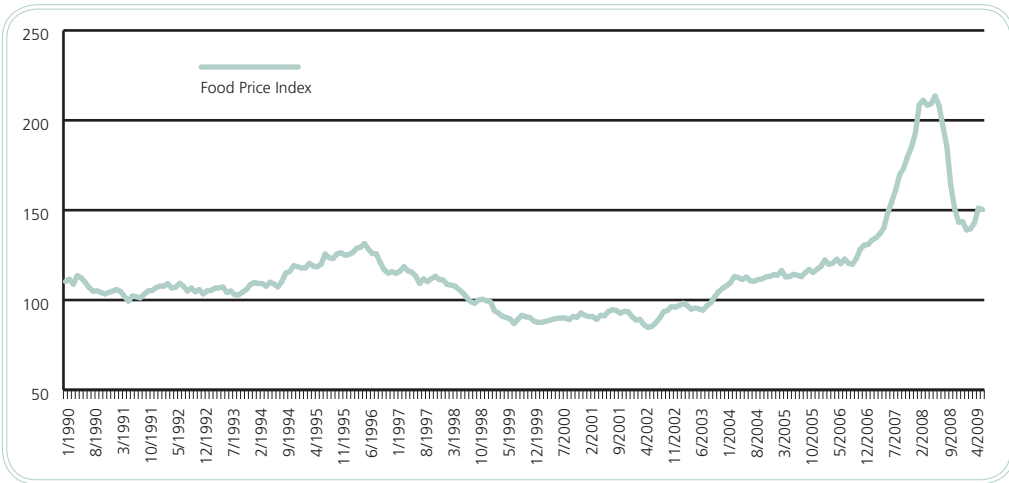
poor harvests in several major producing countries; a marked decline in food stocks; high energy prices; subsidized production of biofuels; speculation on futures markets; the imposition of export restrictions and a lack of investment in the agricultural sector.<sup>49</sup> Although prices of agricultural commodities have come down since then, they remain volatile and as of mid-2009 food prices in the most vulnerable countries remain high, in some cases double what they were just two years before. This has thrown into reverse earlier progress towards achieving the first MDG of eradicating poverty and hunger. In late 2007 FAO launched the ISFP in response to these sudden price increases (see Box 8.3).

While there is no single and easy solution, the wise use of PGRFA, particularly to underpin the breeding of new varieties, can make a very significant contribution to helping the world's poorest people survive and thrive in a world of increasing globalization through helping to expand and stabilize food production and increase the incomes of many of the world's poorest people.

### 8.5 Changes since the first State of the World report was published

Since the first SoW report was published, a number of trends relating to food security and sustainable

**FIGURE 8.7**  
**Volatility of international cereal prices**



Source: RIGA Database (available at: [http://www.fao.org/es/esa/RIGA/English/Index\\_en.htm](http://www.fao.org/es/esa/RIGA/English/Index_en.htm)).

agriculture have become more visible and new issues have emerged. Those having the greatest implications for and impact on, the conservation and use of PGRFA include:

- sustainable development has grown from being a movement focusing mainly on environmental concerns, to a widely recognized framework that aims to balance economic, social, environmental and intergenerational concerns in decision-making and action at all levels;
- there have been growing efforts to strengthen the relationship between agriculture and the provision of ecosystem services. Schemes that promote PES, such as the *in situ* or on-farm conservation of PGRFA, are being set up in an attempt to encourage and reward farmers and rural communities for their stewardship of the environment. However, the fair and effective implementation of such schemes remains a major challenge;
- concerns about the potential impact of climate change have grown substantially over the past decade. Agriculture is both a source and a sink for atmospheric carbon. PGRFA are becoming recognized as being critically important for the

development of farming systems that capture more carbon and emit fewer greenhouse gasses and for underpinning the breeding of the new varieties that will be needed for agriculture to adapt to the anticipated future environmental conditions;

- strong consumer demand for cheap food has continued, resulting in a sustained focus on the development of more cost-efficient production systems. Multinational food companies have gained in influence and, especially in industrialized countries, food is increasingly being produced beyond national borders in order to keep prices low;
- a simultaneous trend has seen the share of so-called niche or high-value markets expand. In many countries, consumers are increasingly willing to pay higher prices for better quality or novel food, from sources they know and trust. Certification schemes such as 'fair trade' and 'organic' or 'protected designation of origin' (PDO) have been established to help ensure standards and provide reliable source information;
- in most developed countries and in a growing number of developing countries, commercial food



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production is responsible for the supply of most food products to the majority of people. Crop varieties have been bred to meet the needs of high-input production systems, industrial processing and strict market standards. There has increasingly been a disconnection between rural producers and growing numbers of predominantly urban consumers;

- in many developing countries, incentives are provided for farmers to shift to more commercial agricultural systems. This is having a major impact on livelihood strategies, culture and on the genetic resources managed by farmers. Initiatives such as the establishment of commodity exchanges in an increasing number of countries, are also resulting in more farming communities being linked to world markets;
- organic agricultural production is receiving greater attention in response to increasing concerns by consumers regarding their diet, health and the environment;
- in spite of the ongoing controversy, GM-crops are being grown on an expanding area in a growing number of countries, but for a limited number of species and traits.

### 8.6 Gaps and needs

Much progress has been made over recent years in linking the conservation and use of PGRFA with endeavours to increase food security and develop more sustainable agricultural systems. However, there are still many gaps in our knowledge and in the range of action required to improve the situation. Attention is needed, for example, in the following areas:

- the growing consensus on the nature, extent and rate of climate change makes it imperative that far greater attention be paid to anticipating and preparing for its effects. Given the time needed to breed a new crop variety (around ten years), it is essential that additional plant breeding capacity be built now, especially in developing countries and that breeding programmes expand their efforts to develop the traits and varieties needed to meet the challenge;
- there is also a need to step up efforts to conserve landraces, farmers' varieties and CWR before they are lost as a result of changing climates. Special efforts are needed to identify those species and populations that are most at risk and that are most likely to harbour traits that will be important in the future;
- there is a need for more efficient, strategic and integrated approaches to the management of PGRFA at the national level. Links need to be strengthened between those individuals and institutions in both the private and public sectors who are primarily responsible for conservation and those who are primarily concerned with genetic improvement and seed production and distribution;
- at the international level there is also a need for greater coordination and cooperation among agencies and institutions concerned with international and intergovernmental aspects of the conservation and use of PGRFA and those concerned with agricultural production, protection, sustainability and food security, as well as related areas such as health and the environment;
- although much progress has been made, enhanced South-South Cooperation has the potential to contribute much more to the conservation and use of PGRFA, and to strengthening its role in achieving food security and sustainable agricultural development;
- in spite of the enormous contribution by PGRFA to global food security and sustainable agriculture, its role is not widely recognized or understood. Greater efforts are needed to estimate the full value of PGRFA, to assess the impact of its use and to bring this information to the attention of policy-makers and the general public so as to help generate the resources needed to strengthen programmes for its conservation and use;
- there is a need for more accurate and reliable measures, standards, indicators and baseline data for sustainability and food security that will enable better monitoring and assessment of the progress made in these areas. Of particular need are standards and indicators that will enable the monitoring of the specific role played by PGRFA;

- greater attention needs to be given to the development of more decentralized, participatory and gender sensitive approaches to plant breeding in order to more effectively generate varieties that are specifically adapted to the particular production environments and socio-economic situations of the poor in less favoured environments;
- agricultural markets play a vital role in helping achieve food security and sustainable agricultural development. They can help increase the diversity of PGRFA in the seed supply chain and provide outlets for the products of neglected and underutilized crops, leading to greater dietary diversity. Better access by resource poor farmers to markets and strengthened market information systems are needed.

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