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The International Treaty
ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE
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POLLINATORS: NEGLECTED BIODIVERSITY OF IMPORTANCE TO FOOD AND AGRICULTURE

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I. INTRODUCTION

1. The International Treaty on Plant Genetic Resources for Food and Agriculture highlights the importance and need for sustainable use. This is emphasized by the wide range of measures covered under Article 6 including policy development, strengthening research, plant breeding, broadening the genetic base of crops, expanding use of local crops and improving regulations on variety release and seed distribution.

2. The need for ensuring continued emphasis on sustainable use of plant genetic resources for food and agriculture (PGRFA) is also fully acknowledged in the supporting component of the Treaty: the *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture* through a number of Priority Activities, in particular 9, 10, 11,12, 13, and 14 that cover characterization, evaluation, genetic enhancement, diversification of crop production, promotion of underutilized crops and species, support for seed production and distribution, and developing new markets for local varieties and diversity-rich products.

3. In responding to this need, FAO provides in the *Annex 1* to this document information on pollinators and their role as an element of agricultural diversity supporting human livelihoods.

4. The *Appendix 1* of the annex indicates the degree of dependence on animal pollinators for the *Annex 1 List of Crops Covered under the Multilateral System* of the International Treaty on Plant Genetic Resources for Food and Agriculture.[1]

[1] This information complements the documents on the Implementation of Article 6: IT/GB-3/16 and IT/GB-3/09/Inf. 5.

ANNEX 1
POLLINATORS: NEGLECTED BIODIVERSITY OF IMPORTANCE TO FOOD AND AGRICULTURE

1. Introduction

Agricultural biodiversity is often understood as crop genetic resources, yet agroecosystems hold a wide diversity of other organisms that contribute toward their productivity and sustainability. Amongst these are pollinators, being animals that carry pollen from the male to the female parts of plants and thus ensure that fruit or seeds are formed. Over the past decade, the international community has increasingly recognised the importance of pollinators as an element of agricultural diversity supporting human livelihoods. Yet mounting evidence points to a potentially serious decline in populations of pollinators. Maintaining and increasing yields in horticultural crops, seeds and pastures through better conservation and management of pollinators is critically important to health, nutrition, food security and better farm incomes for poor farmers.

In this document, we present the role of pollinator diversity in healthy ecosystem functions (Section 2); its value for crop production (Section 3), seed production (Section 4), and forage resources (Section 5) and its role in adaptation to changing environments and minimizing risks for farmers, in Section 6. Section 7 considers the threats and risks to pollination services, and Section 8 suggests measures that are recommended to avert the loss of the services pollinators provide to food and agriculture.

In the Appendix 1, the degree of dependence on animal pollinators for the Annex 1 crops of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is indicated.

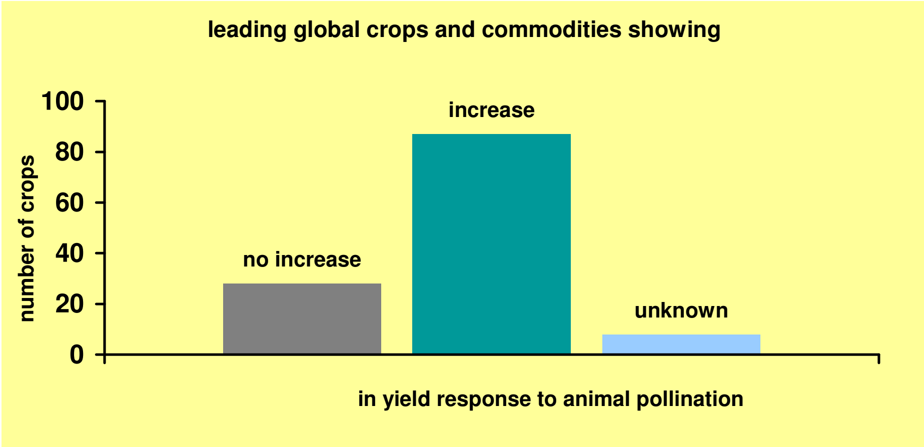
2. Pollination and Ecosystem Functions

In nature, the vast majority of flowering plant species only produce seeds if animal pollinators move pollen from the anthers to the stigmas of their flowers. Without this service, many interconnected species and processes functioning within an ecosystem would collapse. With well over 200,000 flowering plant species dependent on pollination from over 100,000 other species, pollination is critical to the overall maintenance of biodiversity. Approximately 80 percent of all flowering plant species are specialized for pollination by animals, mostly insects.

a. *Greater dependence on animal pollination in the tropics and mountainous regions*

The dependence of ecosystems on animal pollinators is even stronger in the tropics than the global average: less than 3% of all tropical lowland plants rely on wind for pollination. In the tropical forests of Central America, insects may be responsible for 95 percent of the pollination of canopy trees, and vertebrates (bats and a diversity of other taxa) may pollinate 20 to 25 percent of the subcanopy and understory plants, and insects a further 50 percent. Arid and mountain ecosystems often have highly diverse pollinator communities as well, with finely tuned adaptations to ensure that pollination is effective even when climatic conditions are erratic.

Not only are tropical areas of the world more dependent on animal pollinators, but they may also be more susceptible to pollinator loss. An international working group has shown that plants are especially likely to suffer lower pollination and reduced reproductive success in areas with high plant diversity, presumably due to an intense competition for pollinators in these diverse ecosystems[2]. These include South American and South-East Asian forests and the rich fynbos shrublands of South Africa



b. Diversity of pollinators

The diversity of pollinators and pollination systems is striking. Most of the 20,000 or so species of bees (Hymenoptera: Apidae) are effective pollinators, and together with moths, flies, wasps, beetles and butterflies, make up the majority of pollinating species. Vertebrate pollinators include bats, non-flying mammals (several species of monkey, rodents, lemur, tree squirrels, olingo and kinkajou) and birds (hummingbirds, sunbirds, honeycreepers and some parrot species). Current understanding of the pollination process shows that, while interesting specialized relationships exist between plants and their pollinators, healthy pollination services are best ensured by an abundance and diversity of pollinators.

3. Pollination as a Crop-related Genetic Resource

a. Contribution of pollination to food security

In agro-ecosystems, pollinators are essential for orchard, horticultural and forage production, as well as the production of seed for many root and fibre crops. Pollinators such as bees, birds and bats affect 35 percent of the world's crop production, increasing outputs of 87 of the leading food crops worldwide1, plus many plant-derived medicines in the world's pharmacies[3].

b. Role of pollination in expanding horticultural production

Food security, food diversity, human nutrition and food prices all rely strongly on animal pollinators. This is particularly the case of horticultural crops. Diversification into horticultural crops is becoming an avenue to poverty alleviation amongst many farmers around the world. The

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[2] Vamosi, J.C., T.M. Knight, J. Streets, S.J. Mazer, M. Burd, and T–L. Ashman. 2006. Pollination decays in biodiversity hotspots. Proeceedings of the National Academy of Sciences 103:956–961.

[3] Klein, A.M., B. E. Vaissière, J. H. Cane, I. Steffan-Dewenter, S. A. Cunningham, C. Kremen, T. Tscharntke. 2006. Importance of pollinators in changing landscapes for world crops. The Proceedings of the Royal Society of London, Series B, October 2006.

trade in horticultural crops accounts for over 20% of developing countries' agricultural exports, more than double that of cereal crops[4]. Unlike the historical increase in cereal production, the expansion of production in fruits and vegetables has come primarily from increases in the area cropped, not from yield increases. The consequences of pollinator declines are likely to impact the production and costs of vitamin-rich crops like fruits and vegetables, leading to increasingly unbalanced diets and health problems. Thus, maintaining and increasing yields in horticultural crops under agricultural development is critically important to health, nutrition, food security and better farm incomes for poor farmers.

Pollination services make important contributions to other aspects of crop production. Improvements in quality of both fruit and fiber crops, such as cotton, are the result of good pollination. Deliberate management of pollination contributes to yields of oil for biofuels from new and alternate source (castor oil, and croton in Brazil, for example). Pollination in chilli peppers will contribute to an increased speed of ripening that can translate into getting peppers to market at a higher off-season price, and for one additional flush of fruit over the course of a growing season.

c. Growing awareness of the importance of pollination

In the past, pollination has been provided by nature at no explicit cost to human communities. As farm fields have become larger, and the use of agricultural chemicals has increased, mounting evidence points to a potentially serious decline in populations of pollinators under agricultural development. The domesticated honeybee, *Apis mellifera* (and its several Asian relatives) have been utilized to provide managed pollination systems, but for many crops, honeybees are either not effective or are suboptimal pollinators. Managed honeybee populations are also facing increasing threats of pests, disease, and reluctance among younger generations to learn the skills of beekeeping. The process of securing effective pollinators to "service" agricultural fields is proving difficult to engineer, and there is a renewed interest in helping nature provide pollination services through practices that support wild pollinators.

Conventional wisdom has held that crops such as tomatoes and coffee are self-pollinated, and growers need not concern themselves with insect visitors. But when crops are grown under increasingly industrialized conditions, such as in greenhouses for tomatoes, or high-input sun coffee, the contribution that animal pollination can make to yield--or conversely, the losses when native pollinators can no longer reach the crops--become more evident.

d. Economic estimates of the value of pollination services

A recent assessment of the contribution of animal pollination services to the global economy, places the total economic value of pollination worldwide at €153 billion, representing 9.5% of the value of the world agricultural production used for human food in 2005[5]. Those crops that depend on pollination services are high-value, averaging values of €761 per ton, against €151 a ton for those crops that do not depend on animal pollination.

These figures do not include the contribution of pollinators to crop seed production (which can contribute many-fold to seed yields), nor to pasture and orage crops. Nor do these figures include the value of pollinators to maintaining the structure and functioning of wild ecosystems, important values that remain uncalculated.

[4] Lumpkin, T.A., K. Weinberger, S. Moore. 2006. Increasing income through fruit and vegetable production opportunities and challenges. CGIAR Science Council paper.

[5] Gallai, N., Salles, J-M., Settele, J., Vaissière, B.E. 2008. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics (doi:10.1016/j.ecolecon.2008.06.014)

Pollination is also of economic value to farmers from the standpoint of quality, not just quantity. For pyrethrum, derived from the flowers of *Chrysanthemum cinerariifolium*, a more potent insecticide is produced when the flower heads have been visited by insects[6]. In many countries, quality is vitally important, because well-shaped fruit fetches much higher prices in the selective export market. If such quality considerations can enter into market share and market prices, pollination may contribute significantly to the income per unit area for farmers conserving pollinator services.

e. The ecosystem context

Increasingly, it is realised that not just genetic resources alone, but the interactions between them create healthy agroecosystems. Pollination knowledge is distinctly ecological knowledge, and needs to be placed in an ecosystem context to be properly understood; it is neither solely about plant reproduction or insect visitation patterns, but rather about the interrelations. The interlinkages, while extremely important, make knowledge of pollination complex, and more like a network or information system than discrete bodies of knowledge. Often the most critical interactions that determine reproductive success of plants are often not the most obvious ones, and actions taken to conserve plants do not necessarily conserve their pollinators. Therefore, an ecosystem approach is needed, and information dissemination on pollination services should reflect an ecosystem context. Thus pollinator conservation entails promoting the awareness that not just species, but also the interactions between species merit conservation and careful management, as a way to strengthen key ecosystem linkages. Pollinator conservation underlines the importance of linkages between conservation of ecosystem functions, sustainable production systems, and poverty reduction.

Because restoration is far more difficult than conservation of existing interactions, a strong argument can be made in favour of conserving wild and indigenous pollination services in other systems before they are similarly lost. Management of wild pollination services requires an ecosystem approach with boundaries of the system drawn beyond fields, into the broader agroecosystem. Defining management concerns beyond the field limits is a relatively new concept amongst the agricultural community.

f. Example of Wild Pollinators Servicing Crops

Papaya (Carica papaya) is a widespread fruit crop throughout the tropics. It is a perennial tree crop, that requires adequate pollination in order to set fruit. In tropical and sub-tropical climates, fruit set occurs throughout the year. Sale of fresh papaya provides regular income across the season for many smallholder farmers; for example in Kenya provides single fruits are sold for between 20-100 Kshs ($ 0.26- 1.3), depending on the location and local abundance/availability of fruit. Most smallholder farms produce at least fifty individual saleable fruits a season. The trees are often grown in riparian areas as well as the edges of cultivated fields and as hedgerows within farmsteads. Papaya is pollinated primarily by hawkmoths (Sphingidae). The species of hawkmoths vary from site to site, but in general, any medium-to-large-bodied, relatively long-tongued species of hawkmoth can serve as a pollinator. Hawkmoths require adequate areas of habitat for larval food-plants, sheltered diurnal nesting sites, areas for courtship and mating, and other high-energy floral resources in the form of wildflowers. Farmers need to protect and encourage hawkmoths for adequate fruit set on papaya. Farms located within wild areas have high yields and traditionally produce the best-tasting fruit. In addition, as many of these moths travel long distances, they provide benefits to farmers from wild or protected areas adjacent to agricultural landscapes. Yet farmer awareness of the importance of pollination for quality papaya production, and of the need to maintain male trees even though they do not produce fruit, is weak.

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6 Crane, E. and P. Walker. Pollination Directory for World Crops. London: International Bee Research Association, 1984

g. Consumer concerns with pollination

Any valuation has to be done from the perspective of both consumers and producers of pollination services. While one usually thinks of pollination as being of value to farmers, the consumer perspective should not be left out. An analysis of the economics of pollinator deficits concluded that consumers of a commodity affected by a pollinator deficit may suffer because the commodity costs more and becomes less available[7]. Consumers may thus have to pay more for traded commodities because of pollinator declines.

The foodstuffs for which pollinators are important are largely the fruits and vegetables that provide critical nutrients and minerals, and that in an increasingly industrialised world are disappearing from people's diets. This is a concern, not just to the developed world, but to the developing world, in a number of respects. When any population is surviving on limited caloric intake due to poverty, natural disasters or political instability, the contribution and quantities of pollinator-dependent fruits and vegetables in their diet may be of critical importance to their health[8]. Secondly, despite a conception (from many surveys of consumers) that fruits and vegetables are expensive compared to other foods, the comparative cost per serving of more than 50 common fruits and vegetables has been calculated as far below almost all other, (and many less nutritious) foodstuffs[9].

As noted above, well-pollinated crops can be of noticeably better quality, and consumers and markets are sensitive to quality considerations: in Canada, good pollination in apple orchards resulted in about one extra seed per apple, which produced larger and more symmetrical apples. These improved apples were estimated to provide marginal returns of about 5–6%, or about Can. $250/ha, compared to orchards with insufficient pollination[10].

4. Pollination's Contribution to Seed Production and Plant Genetic Diversity

Many crops, through the selective breeding and replication practices of humans, lose their genetic diversity over time. Exposure to pollinators may be one means of introducing a selective influence to maintain genetic diversity. Studies on bottle-gourd in Kenya have shown how important a diverse pollinator community is to maintaining the extraordinarily diverse forms of gourds[11].

Plant breeders have traditionally not been concerned with selecting plants for their attractiveness to pollinators. Yet plant genetic make up can affect the level of pollination a crop plant may receive. In many cases, pollinators favour one variety over another, despite the close proximity of different varieties. Farmers may benefit from understanding that strategic plantings, alternating different varieties of chilli peppers in a checkerboard pattern for example, can optimize effective pollination visits to two varieties of different attractiveness, and at the same

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[7] Kevan, P.G., and Phillips, T.P., 2001, The economic impacts of pollinator declines: an approach to assessing the consequences. Conservation Ecology 5: 8.

[8] Gallai, N., Salles, J-M., Settele, J., Vaissière, B.E. 2008. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics (doi:10.1016/j.ecolecon.2008.06.014)

[9] http://www.ers.usda.gov/data/fruitvegetablecosts/

[10] Kevan, P. G. 1997. Honeybees for better apples and much higher yields: study shows pollination services pay dividends. Canadian Fruitgrower (May 1997): 14, 16.

[11] Morimoto, Y., M. Gikungu, and P. Maundu. "Pollinators of the bottle gourd (*Lagenaria siceraria*) observed in Kenya." International Journal of Tropical Insect Science 24.1 (2004): 79-86

time promote cross-hybridization and better fruit production[12]. Nectarless cultivars of melon have little attraction for pollinators, and need to be planted in fields with cultivars providing nectar in order to achieve sufficient pollination[13]. Landraces and cultivars that have retained characteristics attractive to pollinators is a little-appreciated aspect of plant genetic diversity that merits conservation.

While good pollination is not a factor in the production of leafy vegetables and root crops, it does have a greatly underappreciated importance in the seed production of such commodities. Estimates of increased seed set due to pollinators have been made in different parts of the world; assured pollination has been variously responsible for increases in seed yield of 22-100 percent (radish), 100-300 percent (cabbage), 100-125 percent (turnip), 91-135 percent (carrot) and 350-9 000 percent (onion)[14].

5. Pollination as a Forage/Livestock-related Genetic Resource

Globally, the most important forage crop- alfalfa- relies almost entirely on insect visitors for seed production. Many other sown pasture crops such as clovers that are expected to self-seed, also produce far greater quantities of seed when they receive visits from bees[15]. Grazing systems that depend on livestock obtaining their feed from native vegetation may have a strong dependence on pollinators, for forb and browse species reproduction and tree pods that are eaten by grazing animals. In the Horn of Africa, for example, the short-lived browse plant *Indigofera* which forms the basis of camel diets in arid rangelands, is pollinated by a least five wild bees. In the same region, *Acacia* seed pods are resource of high, and sometimes unrecognised potential, contributing directly or indirectly to pastoral communities' livelihoods and survival. Their main use is for livestock fodder, but they also are bought and sold and form a food of last resort in times of drought. The pods depend on visits of a diversity of visitors- bees, ants, wasps, butterflies, moths, sunbirds and beetle to *Acacia* flowers[16].

Successful rangeland revegetation may be enhanced by strategies that consider the role of pollination, seed-dispersal and other plant-animal interactions in ecosystem health and recovery. Many perennial forbs and shrubs require animals for successful pollination, reproduction, and subsequent maintenance of species on a site; however, pollination biology of many rangeland plants and pollinator abundances at potential revegetation sites are largely unknown[17]. Large-area aerial insect control programmes, such as desert locust control in Africa or rangeland grasshopper control in North America may have impacts on non-target species such as bees that need to forage over wide areas in arid ecosystems, and such impacts should be minimized[18]. The

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[12] Kubisova, S. & H. Haslbachova, 1991. The Sixth International Symposium on Pollination (Tilburg, The Netherlands). p. 364–370.

[13] Bohn, G.W. and Mann, L.K. 1960. Nectarless, a yield-reducing mutant charcter in the muskmelon. Proc. Am. Soc. Hort. Sci. v. 76, p. 455-459.

[14] Sharma, H. K. Cash Crops Farming In The Himalayas: The Importance Of Pollinators And Pollination In Vegetable Seed Production In Kullu Valley Of Himachal Pradesh, India. 2006. FAO. Case study submitted for Rapid Assessment of Pollinators'Status Report, available at (http://www.fao.org/ag/AGP/AGPS/Default.htm - then go to C-CAB Group>Pollinators>Case studies on pollinators and pollination)

[15] Free, J.B. 1993. Insect Polination of Crops. Academic Press, London. 684pp.

[16] African Pollinator Initiative. 2004. Crops, Browse and Pollination in Africa: An Initial Stocktaking. published in PDF format by the API

[17] Archer, S. and D.A. Pyke. 1991. Plant-animal interactions affecting plant establishment and persistence on revegetated rangeland. Journal of Range Management 44(6):558-565.

[18] USDA. Grasshoppers, their Biology, Identification and Management. III.5 The Reproductive Biology of Rare Rangeland Plants and Their Vulnerability to Insecticides (by Vincent J. Tepedino)

loss of pollination services due to bee mortalities in Senegal following aerial spraying with pesticides for locust control have been estimated at around two million dollars annually[19].

6. Pollination as a Tool in Adaptation to Changing Environments and Minimising Risk

Climate change is causing changes in the distribution of many species. There is an interest in identifying crop genetic resources that help crops adapt to climate change. Pollinators, however, will largely respond by contracting or expanding their ranges according to new climatic patterns. Thus the possibility of crops losing key pollinating species, or mismatches in the ranges of crops and their pollinators, is a real threat.

Such effects have already been felt in the seed industry of India. . Since seed production requires a certain degree of chilling to induce seed formation in temperate crops, many vegetable seed farms are located in mountainous regions, such as the Hindu-Kush Himalayas. While mountainous regions can provide such a climate, they also make farmers increasingly vulnerable to the effects of climate change. Farmers in the Kullu valley of Himachal Pradesh state in India are finding that overall temperatures have been rising, while rains have become more unpredictable, leading to several crop failures. Vegetable seed yields have been decreasing, yet the challenge of ensuring sufficient natural pollination under changing climatic conditions has not been addressed by researchers, much less farming communities[20].

Resilience is built in agroecoystems through biodiversity. Crops produce optimally with a suite of pollinators possibly including, but not limited to managed honeybees. Different pollinators become most active at different times of the day or under different weather conditions, and even between years the most abundant and effective pollinators of a crop may shift from one pollinator to another[21]. A diverse assemblage of pollinators, with different traits and responses to ambient conditions, is one of the best ways of minimizing risks due to climatic change. The "insurance" provided by a diversity of pollinators ensures that there are effective pollinators not just for current conditions, but for future conditions as well. A biodiverse agroecosystem, with many more facilitative interactions between crops and crop-associated biodiversity, may also contribute significantly to carbon sequestration[22].

Pollination may also help to counteract the tendency of crops, through the selective breeding and replication practices of humans, to lose their genetic diversity over time. Exposure to pollinators may be one means of introducing a selective influence to maintain genetic diversity. For example, the vast fields of blue agave grown for tequila production that cover the western state of Jalisco in Mexico have been hard-hit by disease. The disease could cause such decimation in part because, through a long and sophisticated process of artificial selection,

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http://www.sidney.ars.usda.gov/grasshopper/

[19] Leach, A.W., W.C. Mullié, J.D. Mumford and H. Waibel. 2008. Spatial and Historical Analysis of Pesticide Externalities in Locust Control in Senegal- First Steps. FAO, Rome.

[20] Sharma, H. K. Cash Crops Farming In The Himalayas: The Importance Of Pollinators And Pollination In Vegetable Seed Production In Kullu Valley Of Himachal Pradesh, India. 2006. FAO. Case study submitted for Rapid Assessment of Pollinators'Status Report, available at (http://www.fao.org/ag/AGP/AGPS/Default.htm - then go to C-CAB Group>Pollinators>Case studies on pollinators and pollination)

[21] Kremen, C., N. M. Williams, and R.W.Thorp. "Crop pollination from native bees at risk from agricultural intensification." PNAS 99 (2002): 16812-16.

[22] Hajjar, R., D. I Jarvis, and B. Gemmill-Herren. 2008. The utility of crop genetic diversity in maintaining ecosystem services. Agriculture, Ecosystems and Environment 123 (2008):261-270.

virtually all the blue agave grown in this region are actually clones of only two plants. It has been suggested that the disease impact on these agaves was particularly severe due to the low genetic diversity. It has been proposed to manage a small portion of the blue agave plantations in a way that will permit exchange of pollen (through bat pollinators) with wild agave types in the nearby barrancas, so that selection of genetic material with resistance to various environmental stresses is conserved[23].

7. Threats and risks to pollination services

The value of pollinators for sustainable livelihoods has thus been detailed, for crop production, for seed production and maintenance of crop genetic diversity, for forage resources and for adaptation to climate change and environmental stress. The risk of losing pollinators' services stem from the following driving forces:

Habitats required by many pollinators are being lost through ***changing land-use patterns*** such as increasing agricultural intensification[24]. Pollinators require a range of resources from their environment for foraging, nesting, reproduction and shelter. The loss of any one of these requirements can cause pollinators to become locally extinct[25].

Excessive use or inappropriate application of ***pesticides*** and other agro-chemicals is known to have negative impacts on a range of pollinators[26].

Climate change may potentially be one of the most severe threats to pollinator biodiversity[27]. Substantial distribution changes are predicted for groups such as butterflies[28].

Invasive species are globally recognised to have major negative impacts across a wide range of taxa. Two major causes of honeybee declines globally are parasitic mites (*Varroa jacobsoni* and *Acarapsis woodi*) and the expansion of the range of Africanized honeybees in the US[29].

8. Recommended measures to avert the loss of the services pollinators provide to food and agriculture.

[23] Medellin 2004. Lesser long-nosed bat. RAPS Case study contribution, available at: http://www.fao.org/ag/AGP/AGPS/C-CAB/Caselist.htm

[24] Osborne, J.L., Williams, I.H. & Corbet. S.A. (1991) Bees, pollination and habitat change in the European Community. Bee World 72: 99-116; Banaszak, J. (1995) Changes in Fauna of Wild Bees in Europe. Pedagogical University, Bydgoszcz, Poland

[25] Westrich, P. (1989) Die Wildbienen Baden-Württembergs. Stuttgart, Ulmer.

[26] Kevan P.G. (1975) Forest application of the insecticide Fenithrothion and its effect on wild bee pollinators (Hymenoptera: Apoidea) of lowbush blueberries (Vaccinium spp.) in southern New Brunswick, Canada. Biological Conservation 7: 301-309; Batra, S.W.T. (1981) Biological control in agroecosystems. Science 215: 134-139.

[27] Kerr, J. T. 2001. Butterfly species richness patterns in Canada: energy, heterogeneity, and the potential consequences of climate change. Conservation Ecology 5: 10. [online] URL: http://www.consecol.org/vol5/iss1/art10

[28] Cowley, M.J.R., Thomas, C.D., Thomas, J.A. & Warren M.S. (1999) Flight areas of British butterflies: assessing species status and decline. Proceedings of the Royal Society of London (B) 266: 1587-1592; Hill, J.K., Thomas, C.D., Fox, R., Telfer, M.G., Willis, S.G., Asher, J. & Huntley, B. (2002) Responses of butterflies to twentieth century climate warming: implications for future changes. Proceedings of the Royal Society of London (B) 269: 2163-2171; Thomas et al 2004 Nature 427:145-148

[29] Allen-Wardell, G., Bernhardt, T., Bitner, R., Burquez, A., Cane J., Cox, P.A., Dalton, V., Feinsinger, P., Ingram, M., Inouye, D., Jones, C. E., Kennedy, K., Kevan, P., Koopowitz, H., Medellin, R., Medellin-Morales, S., Nabhan, G.P., Pavlik, B., Tepedino, V., Torchio, P., and Walker, S. (1998) The potential consequences of pollinator declines on the conservation of biodiversity and stability of crop yields. Conservation Biology 12, 8-17

Over the decade, the international community has increasingly recognised the importance of pollinators as an element of agricultural diversity supporting human livelihoods. Yet mounting evidence points to a potentially serious decline in populations of pollinators. In response to this, the Convention on Biological Diversity has made conservation and sustainable use of pollinators a priority, establishing an International Initiative for the Conservation and Sustainable Use of Pollinators (IPI) and requesting the development of a plan of action coordinated by FAO. The Plan of Action of the IPI, as prepared by FAO and the CBD secretariat and adopted at COP 6 (decision VI/5), is structured around four elements: assessment, adaptive management, capacity building and mainstreaming. The Plan of Action of the IPI presents a cohesive set of actions that address barriers serve to create awareness and build capacity to conserve and sustainably use pollination services.

Many of the measures that are recommended for pollinator conservation are directly linked for to the agriculture sector and to farming practices. Smallholder and subsistence agricultural systems often include practices that promote high diversity on-farm, and can form the basis for a more sustainable path of agricultural growth. The deliberate conservation of pollinators- and its synergy with integrated pest control- offers ways to maintain yields while reducing purchased inputs. Many of the measures that promote pollinators can also promote other ecosystem services such as soil improvement by cover cropping, increasing the abundance of diverse soil functional groups; habitat management of natural enemies for pest management; breaking cycles of damaging pests through greater crop diversity, or erosion control through contour plantings and hedgerows. However, the knowledge base for promoting such pollinator-friendly practices into farming systems is very scarce, and there is a critical need to establish knowledge networks that can promote the exchange of such information across countries and crops.

The viability of rural lifestyles that engage in such practices of maintaining high diversity on farms can be recognised and supported by an enabling policy environment. Conversely the pressures of rapidly commercialising agriculture, such as with the horticultural sector in Africa, can lead to the adoption of practices (intensification, greater use of agrochemicals, larger field sizes) that negatively impact pollination services, if applied in the absence of deliberate efforts to conserve and sustain them. Policy options that support pollinator conservation and use have been little explored.

APPENDIX 1: DEGREE OF DEPENDENCE ON ANIMAL POLLINATORS FOR THE *ANNEX 1* CROPS OF THE INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Common name	**Scientific name**	**Yield response to animal pollination**
Breadfruit	*Artocarpus*	unknown
Asparagus	*Asparagus*	increase- seed production
Oat	*Avena*	no increase
Beet	*Beta*	no increase
Brassica complex	*Brassica* et al.	increase
Pigeon Pea	*Cajanus*	increase
Chickpea	*Cicer*	no increase
Citrus	*Citrus*	increase
Coconut	*Cocos*	increase
Major aroids	*Colocasia*	increase- breeding
	Xanthosoma	unknown
Carrot	*Daucus*	increase- seed production
Yams	*Dioscorea*	increase- breeding
Finger Millet	*Eleusine*	no increase
Strawberry	*Fragaria*	increase
Sunflower	*Helianthus*	increase
Barley	*Hordeum*	no increase
Sweet Potato	*Ipomoea*	increase- breeding

Common name	**Scientific name**	**Yield response to animal pollination**
Grass pea	*Lathyrus*	unknown
Lentil	*Lens*	no increase
Apple	*Malus*	increase
Cassava	*Manihot*	increase- breeding
Banana / Plantain	*Musa*	increase- breeding
Rice	*Oryza*	no increase
Pearl Millet	*Pennisetum*	no increase
Beans	*Phaseolus*	increase
Pea	*Pisum*	no increase
Rye	*Secale*	no increase
Potato	*Solanum*	increase- breeding
Eggplant	*Solanum*	increase
Sorghum	*Sorghum*	no increase
Triticale	*Triticosecale*	no increase
Wheat	*Triticum* et al.	no increase
Faba Bean / Vetch	*Vicia*	increase
Cowpea et al.	*Vigna*	increase
Maize	*Zea*	no increase