THE IMPORTANCE OF WILD POLLINATORS FOR FOOD SECURITY AND NUTRITION

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CONTRACT INFORMATION
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COVER PHOTO (LEFT): A hummingbird pollinates an Aloe arborescens flower in South Africa. Plant reproduction in the tropics is generally more dependent on vertebrate pollinators like birds compared with plants at higher latitudes.

COVER PHOTO (RIGHT): A strawberry farmer in Honduras holds his harvest. Strawberries that are grown in the presence of wild pollinators are heavier and have fewer malformations compared with strawberries grown without access to wild pollinators. Photo by USAID-ACCESO/Fintrac Inc.

INTRODUCTION

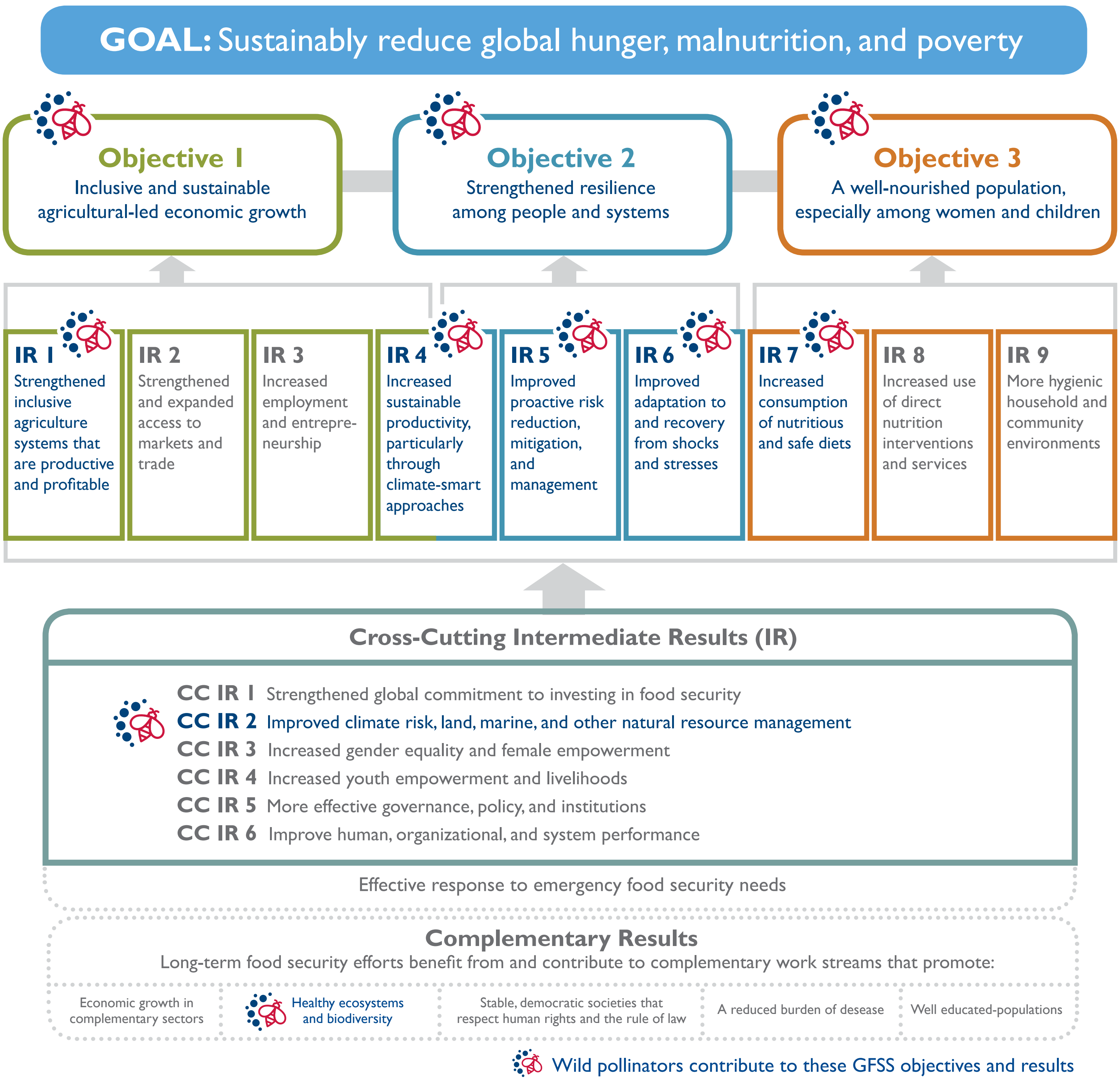
A butterfly pollinates a sunflower. Wild pollinators enhance crop yield and quality of some oilseed crops like sunflower and rapeseed.

Healthy natural systems such as forests, grasslands, and wetlands provide critically important ecosystem services that are essential to food security. Ecosystem services that support food security include the provision of clean water, maintenance of soil structure and fertility, biological pest control, and the focus of this report, pollination. Wild pollinators like bees, birds, butterflies, and bats transfer pollen among flowers to enable crop fertilization and reproduction. While many important staple crops such as maize and rice are wind pollinated and/or can self-pollinate, over 75 percent of leading food crops rely at least in part on pollinators. These crops contribute significantly to human nutrition and food security, livelihoods, and sustainable economic growth.

Nearly 800 million people suffer from chronic hunger and two billion suffer from micronutrient deficiency in the world today. Much of this hunger and malnutrition is concentrated in rural areas in developing countries, where the majority of people rely on small-scale agriculture for food production and livelihoods. At the same time, widespread environmental degradation threatens biodiversity and the natural ecosystems on which food production relies. The 2016 United States Government Global Food Security Strategy (GFSS) recognizes the importance of healthy ecosystems and biodiversity in achieving long-term food security and the Strategy's three main objectives of 1) inclusive and sustainable agriculture-led economic growth, 2) strengthened resilience among people and systems, and 3) a well-nourished population (Fig. 1).

Wild pollinators are declining in diversity and abundance globally due to several interacting threats such as habitat loss, pesticide misuse, climate change, invasive species, and pests and pathogens. One group of wild pollinators – insects – are experiencing significant reductions in abundance that have been described in the media as an "insect apocalypse" (Jarvis, 2018; Forister et al., 2019). The 2016 Assessment Report on Pollinators, Pollination, and Food Production of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the first global study of its kind, noted that in regions where data are available such as North America and Northwest Europe, wild pollinators have declined in occurrence and diversity. The assessment also identified significant data gaps on the status of wild pollinators in Latin America, Africa, Asia, and Oceania, although local declines have been documented. Population declines are expected to limit the provision of pollination services and have spurred increased international and national attention on pollinator conservation.

FIGURE 1: THE CONTRIBUTIONS OF WILD POLLINATORS TO GFSS OBJECTIVES AND RESULTS



A moth pollinates a pumpkin flower. Many crops that supply major proportions of vitamin A, iron, and folate like pumpkin, mango, avocado, and melon are pollinator dependent.

KEY FINDINGS

The GFSS recognizes the importance of healthy natural ecosystems and the services they provide in meeting its goals. In particular, the strategy highlights how ecosystem services are critical to the effectiveness, sustainability, and resilience of food security investments and the role of healthy ecosystems and robust agroecosystems in mitigating risks and aiding recovery from shocks or stresses. The strategy also emphasizes the importance of environmentally sound agricultural and food security activities in contributing to better environmental outcomes through careful management of soil, water, and other resources that use ecosystem services sustainably.

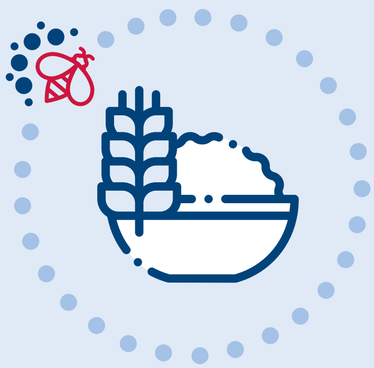
The Office of Forestry and Biodiversity at the U.S. Agency for International Development (USAID) commissioned this report to explore the potential implications of wild pollinator decline in the context of the three objectives of the GFSS. This report summarizes the contributions of wild pollinators to each of the three GFSS objectives, describes the current status of pollinator populations and threats to their conservation, and highlights how strategies to conserve pollinators can strengthen food security investments while improving broader environmental conditions.

The review of the current evidence base on pollinators identified four main conclusions:

- Wild pollinators are critical to meeting U.S. Government global food security and nutrition goals.
- Wild pollinator populations are declining globally due to multiple threats that often act synergistically, which often amplifies the risk presented by any one threat.
- Experts have identified a number of strategies to safeguard pollinator populations and secure pollination services.
- USAID has the tools, experience, and knowledge to effectively integrate strategies to safeguard pollinators into the Agency's food security and nutrition activities.

FINDING 1

WILD POLLINATORS ARE CRITICAL TO MEETING U.S. GOVERNMENT GLOBAL FOOD SECURITY AND NUTRITION GOALS



A farmer in Kenya stands next to her mango tree. Wild pollinators are important to mango production and can significantly increase yield per plant. Photo by Mwangi Kirubi/USAID.

Wild pollinators are essential for agriculture-led economic growth

Pollinators are critical for global crop production, with an annual market value attributable to pollinators ranging from $235 to $577 billion (IPBES, 2016). Over three-quarters of leading food crops and more than one-third of global production volume comes from crops that depend in some part on pollinators. In terms of USAID agricultural investments, the majority of 31 value chains identified in GFSS country plans from 2018 are pollinator-dependent to varying extents, including tomato, cowpea, coffee, soybean, and avocado (Table 1; Figure 2). Pollinator-dependent crops have experienced fast global expansion, accounting for the majority of agricultural expansion over the last several decades (IPBES, 2016). Over the last five decades, the proportion of total agricultural production globally that depends on pollinators has increased four-fold compared with a two-fold increase in production that does not – these figures suggest that global agriculture's dependence on pollinators has doubled over the last 50 years (Potts et al., 2016).

The value of pollinator-dependent crops is five times higher than crops that do not depend on pollinators (FAO, 2018). High-value pollinator-dependent commodity crops such as coffee, oilseed rape, and cocoa contribute significantly to developing country economies and provide employment and income for millions of people. For example, coffee is an important value chain in Guatemala, where it is the second largest export behind bananas, and in Honduras, which is the largest producer of coffee in Central America and the third-largest in Latin America (USDA, 2018). Latin America produces more coffee than any other region, with 80 percent produced by smallholder farms less than four hectares (Imback et al., 2017). Bat-pollinated durian fruit commands the highest unit price of any fruit in Indonesia, with an export value of more than $250 million in 2013. Researchers estimate that bat pollination is worth $117 per hectare each fruiting season for durian, suggesting bat conservation can support local farming economies (Sheherazade et al., 2019). Pollinator declines could trigger loss of important export incomes and shifts in agricultural production, as farmers in "pollinator-poor" regions would be forced to reduce or abandon pollinator-dependent crops such as coffee (Lautenback et al., 2012).

Regions like sub-Saharan Africa where smallholder, subsistence farmers produce the majority of food in rural areas are particularly dependent on wild pollinators. A recent analysis found that enhancing pollinator density and richness on farms less than two hectares can close yield gaps (defined by researchers as the difference between high- and low-yielding farms) by a median of 24 percent. Improved yields were primarily due to more pollinator visits per flower (Garibaldi et al., 2016). Conversely, pollinator decline may lead to decreased crop production. For example, a study in Tanzania showed that a reduction in pollinator habitat from 2008 to 2013 contributed to a 29 percent loss of crop revenue (Tibesigwa et al., 2019).

From an ecological standpoint, more than 90 percent of flowering wild plants in the tropics and 78 percent in temperate zones are dependent in some part on wild pollinators for reproduction (IPBES, 2016). Pollinator-dependent wild plants are vital for maintaining food webs and are important components of healthy ecosystems that provide a range of services that support food security and nutrition (IPBES, 2016).

TABLE 1: **SUMMARY OF THE ECONOMIC AND NUTRITIONAL IMPORTANCE OF SELECT POLLINATOR-DEPENDENT CROPS FROM GFSS VALUE CHAINS IDENTIFIED IN 2018 COUNTRY PLANS**

Cowpea – a GFSS value chain in Ghana, Niger, and Nigeria

Cowpea (blackeye pea) is used as food, animal feed, and as a cash crop, particularly in Central and West Africa. Both the seed and leaves are edible – the seed is a good source of protein, vitamins A and C, and potassium, while the leaves are rich in beta-carotene and iron. Cowpea is a low-cost source of protein for more than 200 million people in sub-Saharan Africa (da Silva, 2018; OECD, 2016). It is drought-tolerant and well adapted to a diverse range of climate and soil types. Wild pollinators enhance crop yield quality and quantity – for instance, a study in Cameroon found that pollination by wild bees increased the fruiting rate by 32 percent and number of seeds by 30 percent (Pando et al., 2014).

Coffee – a GFSS value chain in Ethiopia, Guatemala, and Honduras

Coffee is one of the most economically important crops globally (Davis et al., 2019). There are up to 25 million households that grow coffee all over the world and millions more people are employed in the industry. Almost two-thirds of global coffee production takes place on farms under 10 hectares in size. Wild pollinators like birds and bees improve coffee quality and quantity. The value of services provided by wild pollinators for coffee production can be significant – for example, pollination services are valued at an estimated $1.9 billion per year for Brazil's coffee industry (Chain-Guadarrama et al., 2019).

Avocado – a GFSS value chain in Kenya

Avocado, which originated in Central America, is now widely cultivated and internationally traded. Consumption of avocado has increased over the last decade, due in part to increased awareness of its health benefits. Avocado is a good source of monounsaturated fatty acids that have the potential to decrease the risk of heart disease, diabetes, and some cancers. Wild pollinators improve avocado yield and quality. For instance, a study in Kenya found that nine different species of insect pollinators visited avocado flowers; exposure to pollinators increased fruit yield by over 200 percent and improved seed quality (Mulwa et al., 2019).

Tomato – a GFSS value chain in Nepa, Kenya, and Guatemala

Tomato is a widely cultivated and economically important crop. Tomato consumption, whether fresh or in sauces, juices, soups, and powders, is steadily increasing globally. It is a good source of vitamins A and C, beta-carotene, and lycopene, an important antioxidant (Gerszberg et al., 2015). Wild pollinators improve crop yield and quality – for example, a study in Brazil found that plants pollinated by native bees produced heavier and larger tomatoes that also had more seeds compared to plants not visited by pollinators (Bergamini et al., 2013).

Soybean – a GFSS value chain in Ghana and Nigeria

Soybean is a legume that is cultivated all over the world and provides food for humans and animals as well as biofuel. It is among the most traded commodities globally. Wild pollinators increase the quality of the seed as well as the oil. Pollination by bees can increase the productivity of some varieties of soybean by 20 percent (Roubik, 2018). In a study in Argentina, researchers found that proximity to forest remnants, which provided habitat for wild pollinators, led to higher soybean crop productivity (Monasterolo et al., 2015).

Mango – a GFSS value chain in Kenya and Senegal

Mango is a good source of potassium, dietary fiber, and vitamins A, C, and B6. Wild pollinators are important to mango production and can significantly increase yield. In a study in India, open pollination increased yield per plant by 17 percent compared with plants without access to pollinators. Pollination by a local honeybee species increased yield per plant from 29 to 45 percent, depending on the number of hives per hectare (Deuri et al., 2018). In an analysis of smallholder crops in Tanzania, researchers estimated that production of mango would decrease by 40-90 percent in the absence of pollinators (Tibesigwa et al., 2019).

Beans – a GFSS value chain in Uganda and Guatemala

Beans are rich in nutrients including protein, potassium, magnesium, folate, iron, and zinc. They are among the only plant foods that provide lysine, an essential amino acid (Messina, 2014). Wild pollinators enhance the yield and seed quality of many bean species. For instance, poor pollination of runner beans in Kenya led to missing seeds and misshapen beans that did not meet criteria for the export market (Vaissiere et al., 2010). In a study of field beans, open pollination increased yield by 185 percent compared with self-pollination (Nayak et al., 2015).

Oilseeds – a GFSS value chain in Mali

Oilseed crops such as rapeseed and sunflower are economically important, with about 580 million tons grown annually worldwide. Wild pollinators enhance crop yield and quality of some oilseeds (Woodcock et al., 2019). Conversely, oilseed crops provide forage resources for wild pollinators and can reverse pollinator decline when added to other crop rotations (Thom et al., 2016). The contributions of pollinators to crop yield can be significant – for instance, insect pollinators contributed an estimated 30 percent to crop yield of oilseed rape in a recent field study. Bee species diversity was positively correlated with yield (Perrot et al., 2018).

Vegetables – a GFSS value chain in Bangladesh and Kenya

Vegetables provide a range of essential nutrients and are a crucial component of a healthy diet. The production of many commonly consumed vegetables including cabbage, cauliflower, okra, pumpkin, squash, lettuce, and carrot is dependent on pollinators. Pollinator decline can have significant impacts on vegetable production. In India, one of the world's largest vegetable producers, researchers found that production of pollinator-dependent vegetables declined over a 45-year period, which they suggested could be due to intensification of vegetable farming using practices that contribute to pollinator decline. They did not find a similar decline in the production of crops that are not dependent on pollinators (Basu et al., 2011; Das et al., 2018).

Shea – a GFSS value chain in Ghana

Shea, extracted from the seeds of *Vitellaria paradoxa* trees, is the primary edible oil for about 80 million people in sub-Saharan Africa. Local communities use the wood from the tree for firewood and as a building material and consume the fruit. Shea butter is also in demand internationally for the cosmetics industry. Wild pollinators are important in improving yield of the fruit and kernel. In a study from Ghana and Burkina Faso, researchers found that pollination provided by native bees on average doubled fruit yield across all the field sites (Stout et al., 2018). In another study from Ghana, scientists found that pollination by insects significantly increased kernel size (Nasare et al., 2019).

Wild pollinator diversity increases crop resilience

Over 100,000 animal species provide pollination services to at least 250,000 species of flowering plants worldwide (FAO, 2008; Calderone et al., 2012). Of these, only about a dozen insect species are managed for agriculture. Besides bees, many other insect species including wasps, flies, butterflies, moths, and ants are pollinators. A global analysis involving 39 field sites from five continents estimated that non-bee insect pollinators performed 25-50 percent of the total number of flower visits, suggesting they play a critical role in global crop production (Rader et al., 2016). Vertebrates including birds (e.g. hummingbirds, honeycreepers, and some parrots), bats, non-flying mammals (e.g., some primates, rodents, and tree squirrels), and reptiles also provide pollination services (IPBES, 2016; Potts et al., 2016).

In general, a diverse community of pollinators provides more stable and effective crop pollination compared with a single species (FAO, 2008; Potts et al., 2010; IPBES, 2016). The combined actions of different pollinators in agro-ecosystems improve fruit number, size, quality, and shelf life for many important crops, even when managed species are abundant (Klein et al., 2003; Isaacs and Kirk, 2010; Klatt et al., 2014; Rader et al., 2016). For instance, research on the importance of managed and wild pollinators for commercial apple production in New York found that more abundant and diverse wild bee communities led to increased harvest seed set, a measure of crop productivity. Increased abundance of managed honeybees did not affect harvest seed set, leading the research team to conclude that management of diverse pollinator communities may decrease reliance on managed honeybees for pollination services and enhance crop yields (Blitzer et al., 2016).

For some crops, wild pollinators are more effective than managed bees; for other crops, wild pollinators provide complementary functions by visiting flowers in different parts of the plant, at different times of the day or year, and under different weather conditions (Wilmer et al., 1994; Klein et al., 2007; Brittain et al., 2013; Brittain et al., 2014; Rader et al., 2016). This complementarity ensures more stable crop yields and increases resilience against population declines in a single pollinator species (Ricketts, 2004; Winfree et al., 2011; Lautenback et al., 2012; Rader et al., 2016).

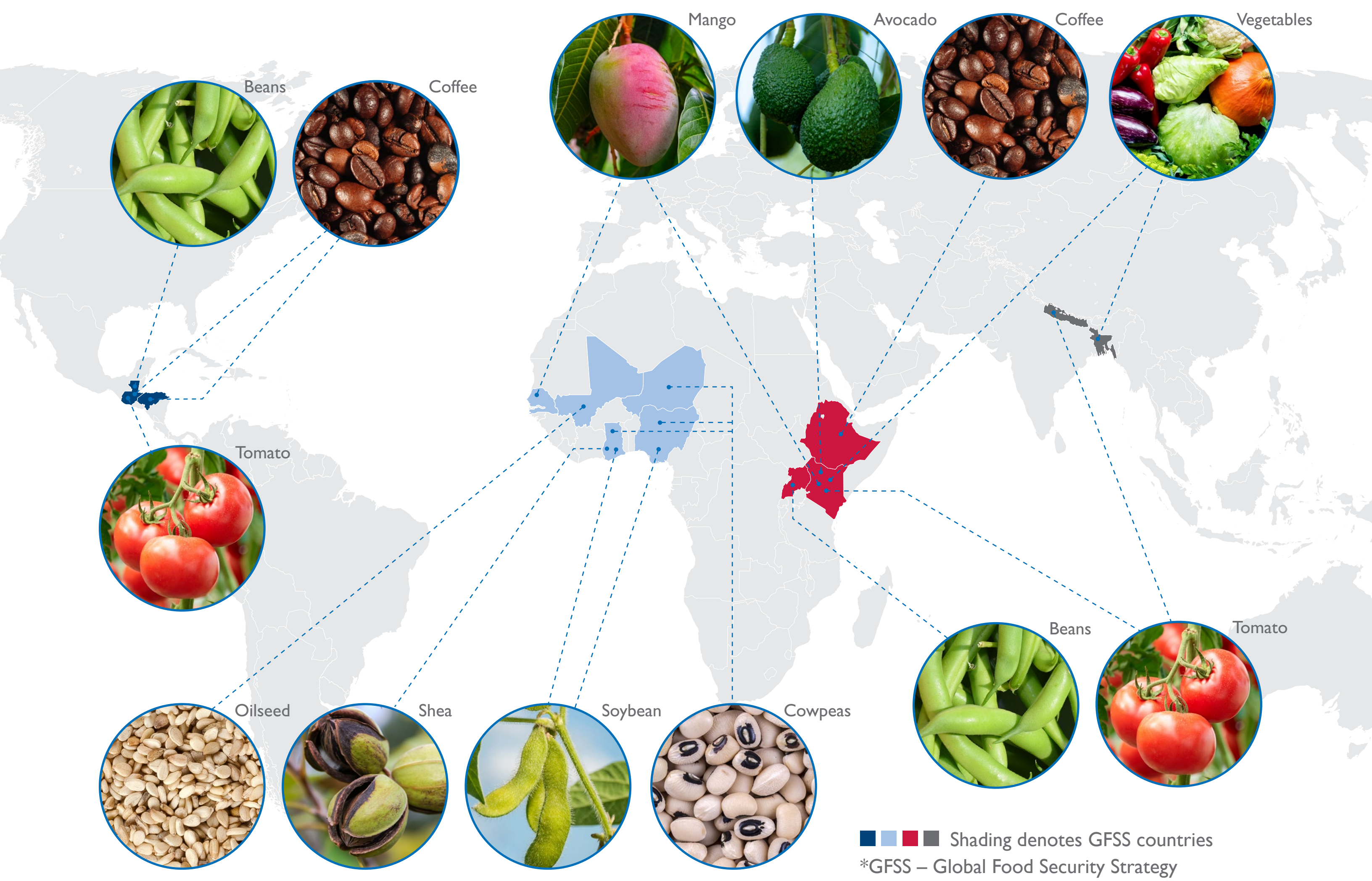
Conversely, crops that depend on a narrow range of pollinator species (e.g. passion fruit) are at greatest risk of production losses if wild pollinators decline (Klein, 2007). In one global analysis, non-bee insect pollinators were not as reliant as bees on remnant natural or semi-natural habitat in nearby landscapes, suggesting that their crop pollination services may be more stable in the setting of land use change (Rader et al., 2016).

Pollinator-dependent crops are among the most nutritious

Pollinator-dependent crops, including many fruits, vegetables, seeds, nuts, and oils, supply major proportions of micronutrients, vitamins, and minerals to the human diet. For example, almost three-quarters of crops that produce fruits and seeds for human consumption are dependent on pollinators in some part (FAO, 2018). In particular, many crops that supply major proportions of vitamin A, iron, and folate like pumpkin, mango, avocado, and melon are pollinator dependent; of these nutrients, vitamin A production is most dependent on wild pollinators (Chaplin-Kramer et al., 2014). Many of the pollinator-dependent GFSS value chains identified in 2018 country plans are nutrient dense, including beans, cowpeas, avocado, tomato, and mango, among others (Figure 2).

Pollinator declines may increase the risk of nutrient deficiency across the developing world. Human

FIGURE 2: WILD POLLINATORS ARE CRUCIAL TO THE PRODUCTION OF MANY GFSS* VALUE CHAIN CROPS



Almost two-thirds of value chains identified in 2018 GFSS country plans depend at least in part on wild pollinators, including crops that are important sources of protein, micronutrients, dietary fiber, and antioxidants and that support livelihoods for millions of households worldwide.

FIGURE 3: WILD POLLINATORS CAN IMPROVE THE QUALITY AND QUANTITY OF CROPS THAT HAVE THE ABILITY TO SELF-POLLINATE

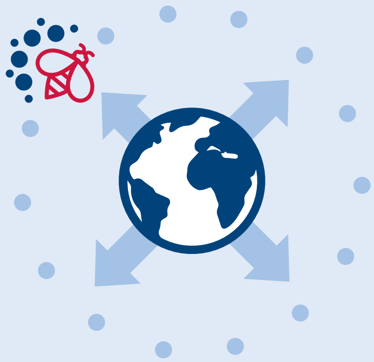
The top row shows strawberries grown in the presence of wild pollinators. The bottom row shows strawberries grown without access to wild pollinators (photo adapted from Wietzke et al., 2018)

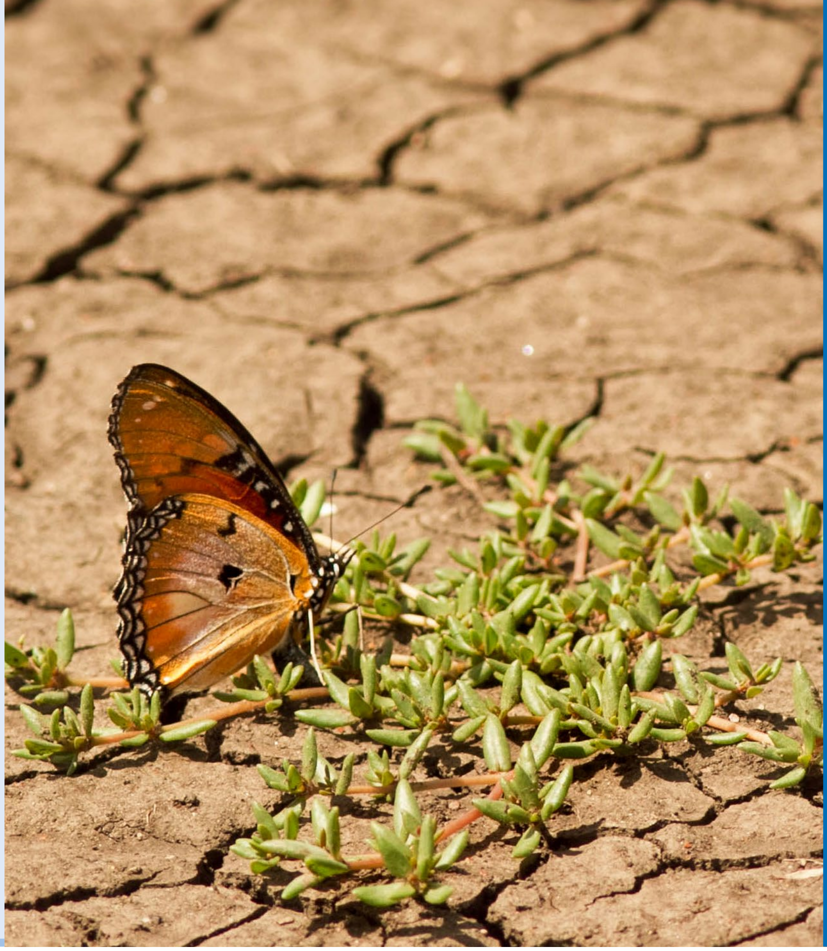
populations with high micronutrient deficiencies often live in regions where micronutrient-rich crops depend on pollinators and are therefore vulnerable to pollinator decline. For example, vitamin A deficiency is three times higher in areas with relatively high (greater than 30 percent) pollinator dependence for this nutrient. Likewise, iron deficiency in pregnant women is three times higher in areas with at least 15 percent pollinator dependence for iron derived from plants (Chaplin-Kramer et al., 2014). Pollinator decline in these areas can have serious implications for public health given the critical role of these nutrients in preventing disease. In Uganda and Mozambique, the loss of all pollinators could increase the risk of vitamin A deficiency by 15 and 56 percent, respectively (Ellis et al., 2015). A loss of pollinator services could result in an additional 1.4 million deaths annually from malnutrition-related and non-communicable diseases (Smith et al., 2015).

Biotic pollination also influences the nutritional content and commercial quality of some foods. For example, almond trees that were cross-pollinated produced nuts that had a healthier monounsaturated fatty acid profile compared with trees that self-pollinated (Brittain et al., 2014). For strawberries, bee-pollinated fruits were heavier and had fewer malformations (Figure 3); they were also found to last longer and have firmer consistency, leading to longer shelf life, compared with self- or wind-pollinated fruits (Klatt et al., 2014).

FINDING 2

WILD POLLINATOR POPULATIONS ARE DECLINING GLOBALLY DUE TO MULTIPLE INTERACTING THREATS





A butterfly rests on drought-stricken ground. Over the last several decades, changes in the seasonal activity, abundance, and range of some wild pollinator species (e.g. butterflies) have been linked to observed climate change.

Trends in pollinator populations

Comprehensive assessments of wild pollinator populations in developing countries are currently lacking and were identified as an important need by scientists (IPBES, 2016). However, population trends in better-studied regions and in managed bee populations are believed to also apply to wild pollinators globally (IPBES, 2016). Bees, both managed and wild, are the most significant group of pollinators, visiting over 90 percent of the world's 107 leading crops. An estimated 20,000 bee species have been identified globally, of which 12 managed species are commonly used for crop pollination. Over the last century, a number of North American and European countries have documented declines in bee diversity and abundance (Potts et al., 2016). The western honeybee *(Apis mellifera)*, the most widespread managed pollinator, has experienced large-scale seasonal losses in the Northern Hemisphere in recent years. For example, honeybee colony losses in the U.S. have averaged 33 percent per year since 2006, a significant increase from historic levels of 12 percent annually. Some countries in Europe and Asia have also experienced high annual losses of honeybees (Brutscher et al., 2016). Similarly, declines in wild bee populations have been documented, primarily in Europe and North America. For instance, scientists using a spatial habitat model estimated that wild bee abundance declined between 2008 and 2013 across 23 percent of land area in the United States (Koh et al., 2015). A study from 2020 (Soroye et al., 2020) found that bumblebee populations fell by 46 percent in North America and 17 percent in Europe between the study periods 1901 to 1974 and 2000 to 2014.

While non-bee insect pollinators have not been assessed globally, regional assessments suggest high levels of threat for some species like butterflies. Monitoring programs for butterflies in North America, the United Kingdom, and Europe found up to a 50 percent decline in species abundance in some sites accompanied by significant decreases in geographic ranges for some species. An assessment of 636 butterfly species in the United States and Canada found that almost one in five species is at risk of extinction. Monitoring of other invertebrate pollinators such as moths and beetles in the United States, Canada, and Europe also documented significant declines in populations. For instance, a 27-year study in Germany found a 70 percent decrease in insect biomass across 63 study locations (Forister et al., 2019).

Non-insect pollinator groups like birds and bats have also experienced declines. The International Union for Conservation of Nature (IUCN) Red List assessment estimates that 16.5 percent of vertebrate pollinators (e.g. birds, bats) are threatened with extinction (up to 30 percent for island species). Among IUCN regions, sub-Saharan Africa, South America, and South and Southeast Asia had significant data gaps ("data deficient" category) regarding the status of vertebrate pollinators. The data that are available suggests that Latin America, sub-Saharan Africa, and South and Southeast Asia have the highest proportions of vertebrate pollinators in the "endangered" and "critically endangered" risk categories (Potts et al., 2016).

Declines in vertebrate pollinator populations are of particular concern for plant reproduction in the tropics since that area is generally more dependent on vertebrate pollinators compared with plants at higher latitudes. A global assessment on the importance of vertebrate pollinators found that their exclusion would reduce fruit and/or seed production by an average of 63 percent. Bat-pollinated plants such as agave, durian, and dragon fruit experienced a greater loss in fruit/seed production compared with bird-pollinated plants when these pollinators were excluded, an 83 and 46 percent reduction, respectively (Ratto et al., 2018).

A rambutan fruit tree is part of an agroforestry system in Honduras. Agroforestry systems can extend the amount of usable habitat available to pollinators. Photo by USAID/Honduras.

Threats to Wild Pollinators

A variety of threats, acting independently and synergistically, affect both wild and managed pollinators. These threats affect pollinator species differently depending on the traits of each species. For example, generalist species that feed on a variety of plants, insects that nest above ground, and species that can travel longer distances are generally better able to adapt to changing environmental conditions (Williams et al., 2010). Threats to pollinators often act synergistically – for instance, pesticide exposure can impair immune response among some pollinators like wild bees, which in turn can make them more susceptible to pathogens (Goulson et al., 2015). Different pollinator species respond differently to conservation and management strategies, and some species may even benefit from anthropogenic environmental change (Williams et al., 2010; Burkle et al., 2013; Silva et al., 2015). Below is more detail on each of the priority threats to pollinators:

- **Land management practices:** Habitat loss and degradation are the principle drivers of wild pollinator decline (Ricketts, 2004; Winfree et al., 2007; Potts et al., 2010). The destruction, degradation, and fragmentation of habitats in which many wild pollinators thrive has disrupted plant-pollinator communities and pollination function globally over the last several decades (Goulson et al., 2015). Loss of connectivity at the landscape level and the loss of floral and nesting resources negatively affect wild pollinator abundance, diversity, and community stability (IPBES, 2016). Similarly, conversion of diversified farming systems into large, homogeneous fields that rely on agrochemical inputs and intensive tillage can decrease habitat for pollinators and expose them to pesticides that may be harmful (see below). Decreased plant diversity not only affects the total supply of floral resources but also the nutritional quality of the pollen available to pollinators (Di Pasquale et al., 2013; Kovács-Hostyánszki et al., 2017). Although some monocultures provide floral resources, these are less diverse and often flower in short and synchronous pulses. Therefore, they are unlikely to support diverse wild pollinator communities over the long term (Vanbergen, 2013). The impacts of these land management practices include decreased

A hoverfly is covered in pollen. Hoverflies are frequent flower visitors to a wide range of wild plants and are known to visit over 70 percent of global food crops (Doyle et al., 2020).

pollinator density and increased homogeneity of pollinator communities (Potts et al., 2016). For example, a study in the Philippines comparing two different land use systems—agroforests and rice fields—found that bee abundance, species richness, functional diversity, and plant-pollinator interactions were all higher in agroforests (Hass et al., 2018).

- **Pesticides and herbicides:** The widespread use of pesticides, particularly to intensify agricultural productivity, and application practices that facilitate pesticide drift, present significant risks to pollinators (IPBES, 2016). The level of risk to pollinators from pesticide use depends on the species' biological characteristics, level of exposure, and properties of the chemical such as toxicity and spectrum of targeted pests (Potts et al., 2016). In general, broad spectrum pesticides present a higher risk to pollinators compared with narrow spectrum pesticides (IPBES, 2016). A study on the impacts of neonicotinoid pesticides on both wild and managed bees in three European countries found that pesticide use resulted in smaller colonies (24 percent decline) several months after exposure (Woodcock et al., 2017). In the United Kingdom, researchers found lower pollinator abundance, diversity, and group richness associated with higher pesticide use – specifically, they found lower populations of honey bees, hoverflies, and wasps (Evans et al., 2018). A meta-analysis found that pesticide use also had negative effects on bee memory and learning at realistic exposure levels (Siviter et al., 2018). The widespread use of herbicides to control weeds can also affect pollinators by decreasing the diversity and abundance of flowering plants that provide pollen and nectar (IPBES, 2016). Risks to pollinators are increased by inappropriate pesticide use, faulty or unfit application equipment, and lack of robust risk assessments and regulations.

- **Pests and pathogens:** Pollinators, particularly insects, are susceptible to viral, bacterial, and parasitic infections that can negatively affect their health and function. One pathogen that is a major threat to bees is the *Varroa* mite, which feeds on developing larvae and can lead to colony loss. The mite can also transmit viral infections to bee species that can result in physical deformities, paralysis, or death. One significant factor that supports the spread of pests and pathogens is the large-scale transport of managed pollinators beyond their original range, which can lead to the translocation of pathogens. For example, the worldwide movement of the western honeybee transmitted the deformed wing virus to wild bees (Brutscher, 2016; IPBES, 2016). High floral diversity is associated with increased immunocompetence in honeybees, suggesting that landscape simplification can increase disease susceptibility (Alaux et al., 2010).

- **Alien invasive species:** The introduction of alien invasive species can affect native pollinator networks through several mechanisms including causing direct harm to pollinators through, for example, predation, damaging or killing native plants, and outcompeting native pollinators (IPBES, 2016; Potts et al., 2016). For example, the accidental introduction of the yellow-legged hornet (*Vespa velutina*) from Asia to Europe harmed European honeybees; the hornets prey directly on honeybees and weaken their colonies. The impacts of invasive species can be significant; for instance, beekeepers in southwest France reported that the yellow-legged hornet destroyed up to 30 percent of hives in some areas in a single year (Monceau et al., 2013). In the Ogasawara archipelago of Japan, alien invasive lizardsconsumed endemic bee species and led to their local extinction. This in turn left an alien honeybee (*A. mellifera*) to dominate, which preferred flowers of invasive plants and resulted in a shift in the ecology of the archipelago (Vanbergen et al., 2018).
- **Climate change:** Over the last several decades, changes in the seasonal activity, abundance, and range of some wild pollinator species (e.g. butterflies) have been linked to observed climate change (Potts et al., 2016; Soroye, 2020). An analysis of bumblebees in North America and Europe found that despite warming of some southern areas of bumblebee ranges, the bees are not moving northward to compensate, raising concerns about overall shrinking of their range (Kerr et al., 2015). The drastic decline in bumblebee abundance in North America and Europe is thought to be caused largely by their physiological intolerance of rapidly increasing temperatures (Soroye, 2020). A study on climate change and pollination services provided by bees and birds on coffee plantations concluded that diversified agroforestry systems could improve the climate resilience of these plantations by providing habitat for key pollinators (Chain-Guadarrama et al., 2019). Climate change is also implicated in reduced nutritional quality of pollen, with health implications for wild pollinators (Ziska et al., 2016).

Deforestation in Madagascar. Habitat loss and degradation are the principle drivers of wild pollinator decline. Photo by Olaf Zerbock, USAID.

FINDING 3

EXPERTS HAVE IDENTIFIED A NUMBER OF STRATEGIES TO SAFEGUARD POLLINATOR POPULATIONS AND SECURE POLLINATION SERVICES

A farmer near Gorongosa National Park in Mozambique discusses conservation farming. Pollinator-friendly conservation farming practices such as intercropping and integrated pest management can support wild pollinators. Photo by USAID/Mozambique.

Strategies to safeguard pollinator populations and secure pollination services need to take a multi-pronged approach to address individual and converging threats. Opportunities for action, both within the policy realm and from the farm to landscape level, are highlighted below:

- **Improve habitat protection, restoration, and connectivity:** Management practices that protect, restore, and connect habitat for pollinators are among the most important conservation strategies to support wild pollinators. Three specific approaches with proven success are sustainable intensification, diversification of farming systems, and maintenance of ecological structure. Sustainable intensification focuses on improving the efficient use of natural resources and ecosystem services for agriculture, with the goal of producing more food on the same amount of land but with reduced use of agrochemicals and less land conversion. Sustainable intensification includes practices such as intercropping, planting targeted flower strips, and rotating crops (Kovacs-Hostyanszki et al., 2017). Diversification of farming systems refers to approaches such as agroforestry and the planting of forest and home gardens. Maintenance of ecological structures involves protecting, restoring, and connecting patches of natural and semi-natural habitats within agricultural and urban landscapes (IPBES, 2016). Added benefits of these three approaches are that they can help maintain pollinator diversity and pollination services under climate change and increase the overall resilience of natural habitats so they can continue to provide ecosystem services essential for agriculture such as soil nutrient cycling and natural pest control (Potts et al., 2016).

- **Decrease risks from pesticides and herbicides:** A number of actions such as improving the rigor of pesticide risk assessments, employing alternative forms of pest control, and adopting specific application practices to reduce pesticide drift can lower risks to pollinators. Pesticide risk assessments should consider the different levels of risk among both managed and wild pollinators and take into account each species' unique biology. Reducing herbicide use by allowing weeds to grow in farms, residential areas, and gardens can also support pollinators (IPBES, 2016). Adoption of alternative forms of pest control such as integrated pest management (IPM), which employs biological pest control and manages pest pressure through approaches such as crop rotation and mixed cropping, can also significantly decrease the need for pesticides (Kovacs-Hostyanszki et al., 2017).

- **Strengthen disease prevention, surveillance, and treatment:** Promoting better husbandry of managed bees to reduce pathogen spread among both managed and wild species is an important measure in preventing diseases that affect pollinators, as is selective breeding for genetic diversity (Potts et al., 2016). Improved pathogen surveillance coupled with better regulation of the movement of bee colonies can contribute to isolating outbreaks of infections in pollinators and avoiding widespread pollinator losses. Other measures include using certified disease-free managed colonies and implementing strategies to prevent the escape of commercially bred pollinators into the wild, such as the use of escape-proof greenhouses (Paxton et al., 2015).

- **Address alien invasive species:** Eradicating invasive species can be difficult and expensive and is seldom successful except in island ecosystems. Focusing on preventing new invasions and rapidly containing existing ones is often more feasible. Close monitoring of trade in managed pollinators and improved surveillance to detect new invasions quickly are also key to minimizing the impacts of invasive species. More research on topics such as the community dynamics of invasions, the impact of invasive alien species on different plant-pollinator networks, and the role of genetic diversity in native populations on the success and failure of invasions is also needed (Morales et al., 2017; Vanbergen et al., 2018).

- **Support farmers to adopt pollinator-friendly agricultural practices:** Farmers, especially smallholders and family farmers in rural areas, are highly dependent on pollination services to maintain productivity; they can also be among the most effective stakeholders in implementing pollinator-friendly agricultural practices. Educating and learning from farmers on a variety of topics ranging from appropriate use of pesticides to pollinator-friendly farming practices such as agroforestry and intercropping is critical to pollinator conservation. Promoting and demonstrating pollinator-friendly practices via agricultural extension services can help increase adoption of beneficial approaches (IPBES, 2016; Potts et al., 2016). Economic incentives to promote pollinator-friendly practices such as payment for ecosystem services schemes, crop insurance plans that offer lower rates for farmers who adopt these practices, and participation in certification programs that offer higher prices for pollinator-friendly products can also help farmers conserve pollinators (Dicks et al., 2016).

- **Conduct research to address knowledge gaps:** There are significant knowledge gaps regarding wild pollinators and pollination that need to be addressed through research programs. One priority is to improve monitoring of wild pollinators and threats to their populations in developing countries. Other priority topics include how to improve pest management in pesticide-free and pesticide-minimizing farming systems, how to increase agricultural yields in ecologically intensified farming systems that support pollinators, and how pesticide exposure affects insect colonies and other pollinator groups over the long term and at sublethal levels of exposure (IPBES, 2016; Potts et al., 2016). More research on the impacts of climate change on different pollinator groups is also needed. To ensure that findings are relevant to agricultural communities, the research should prioritize co-production of knowledge and include exchange between scientists, farmers, indigenous communities, and policymakers, among other stakeholders (Dicks et al., 2016).

A bat pollinates an agave plant. Bats pollinate economically important crops such as agave, durian, and dragon fruit – bat conservation can support local farming economies.

FINDING 4

USAID HAS THE TOOLS, EXPERIENCE, AND KNOWLEDGE TO EFFECTIVELY INTEGRATE STRATEGIES TO SAFEGUARD POLLINATORS INTO THE AGENCY'S FOOD SECURITY AND NUTRITION ACTIVITIES

A bee pollinates a coffee flower. Wild pollinators like birds and bees improve the quality and quantity of coffee, one of the most economically important crops in the world.

In response to the U.S. Global Food Security Act, the U.S. Government is renewing its commitment to reduce poverty and hunger through inclusive agriculture-led economic growth, strengthened resilience among people and systems, and improved nutrition, especially among women and children. Strengthening natural resources management, including pollinator conservation, is critical to meeting these goals, as noted in the GFSS. Opportunities to strengthen pollinator conservation within USAID's existing food security and nutrition programming and guidance are:

Pest Management Plans: Include the impacts of pesticides on wild pollinator populations in pest management plans including the Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP). When a USAID project includes assistance for procurement or use of pesticides, the Initial Environmental Examination for the project must include a separate section evaluating the economic, social, and environmental risks and benefits of the planned pesticide use to determine whether the use may result in significant environmental impact. A broader pest management plan might recommend pesticide field use only when there are no good alternatives as part of a robust IPM program.

Research and Development: Incorporate pollination services into agricultural research programs to harness scientific innovation and technology to improve pollinator conservation; for example, by including pollinator-specific research questions into Feed the Future Innovation Lab research agendas. Potential areas for research include the status of wild pollinators in developing countries, how best to integrate pollinator-friendly practices into farming systems to improve yield quality and quantity, the identification of approaches for conservation of wild pollinators important for agriculture, and identification of crop-specific vulnerability to pollinator decline, including under projected climate change.

Capacity Development and Extension Services: Incorporate capacity building to decrease pesticide misuse and increase practices that support wild pollinator populations into agricultural extension services, farmer-to-farmer sharing, and farmer research networks. Effective capacity building to conserve pollinators should focus on sustaining local systems and requires actions at three interconnected levels: individuals, organizations, and the enabling environment. Specific capacity building activities may include training farmers to monitor local pollinator populations (individual), supporting universities to conduct research on threats to pollinators (organizations), and helping local governments develop incentives to support pollinator conservation (enabling environment).

Increased Sustainable Agricultural Productivity: Promote practices that support wild pollinators as a crucial component of sustainable agricultural productivity. The presence of robust, diverse populations of wild pollinators can improve the quality, quantity, and stability of many important crops. Practices that support pollinator conservation include preservation of ecological infrastructure, diversification of farming systems, integrated sustainable intensification, and agroforestry.

Finance – Unlocking Capital Flows: Implement strategies to catalyze private-sector investments that support pollinator conservation. The private sector often focuses on investing in strategies that enhance farm-level productivity and farmers' resilience. Wild pollinators are key to meeting both these objectives through their role in increasing the yield and quality of many important crops and enhancing the resilience of crop production. Financial incentives, such as payment for ecosystem services schemes for farmers and food system suppliers, will work best when integrated into more comprehensive programming to conserve pollinators.

Village women in Ghana carry shea kernels. Wild pollinators are important in improving yields of the shea fruit and kernel. Photo by Douglas Gritzmacher/USAID.

Digitally Enabled Global Agriculture and Food Systems: : Support access to digital technologies that can be used to support pollinator conservation. Digital technologies including remote sensing, mapping, and geospatial analysis can provide important information such as the extent and connectivity of pollinator habitat and variations in pollinator populations and density due to anthropogenic factors. Farmers and other local stakeholders play an important role in the application of these technologies, and training may improve their ability to better manage agro-ecological systems.

Policy Programming: Promote policies that support pollinator conservation. Poor land management practices, misuse of pesticides, and infectious pathogens are among the top threats to wild pollinators. Examples of policy interventions that can address these threats include developing incentives that reward farmers for pollinator-friendly land management practices, promoting rigorous risk assessments for pesticides to minimize harm to pollinators, and promoting trade in certified disease-free colonies.

Young boy standing in an agroforestry landscape in the Philippines. Reforestation through agroforestry approaches can benefit wild pollinators and support livelihoods for local communities. Photo by Gregg Yan, WWF/Philippines

CONCLUSION

Diverse and abundant communities of wild pollinators are critical for a productive, nutritious, and resilient global food supply. The convergence of multiple threats to wild pollinators, including habitat loss, misuse of pesticides, disease, and climate change, pose significant threats to their populations and ultimately, their ability to provide pollination services. USAID has a long history of promoting approaches that conserve pollinators, and there are opportunities to strengthen this work in light of current pollinator declines. A number of strategies to safeguard pollinators can be readily adapted and applied within existing USAID frameworks to improve the conservation and management of wild pollinators. Such strategies include promoting pollinator conservation in extension services, supporting efforts to conserve habitat as part of a landscape approach to agriculture, and promoting research on the status of wild pollinators in key developing countries, including monitoring efforts. The conservation of wild pollinator populations is critical to the success of U.S. Government investments in food security, nutrition, and sustainable livelihoods.

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U.S. Agency for International Development

1300 Pennsylvania Avenue, NW
Washington, DC 20523

Tel. 202–712–0000
Fax. 202–216–3524
www.usaid.gov/biodiversity