STEP ONE: CHARACTERIZING CURRENT PRODUCTION SYSTEMS

1.1 IDENTIFYING CHALLENGES THAT FARMERS FACE

This step will already have been done in many cases as part of a Farmer Field School or as part of the organization's work with the farmers. Low yields, and/or inadequate pollination may have been identified as areas for improvement. But it is often the case that the main problems listed by farmers do not appear to be related directly to pollination. A fine balance is required, in respecting the priority challenges as identified by farmers for their experiential learning, and helping farmers to perceive and manage an ecosystem service such as pollination that generally operates in the background, with little public awareness. Farmer Field School formats have shown great value in addressing problems, situations and opportunities that, *inter alia*:

- Require a location-dependent decision or management.
- Entail articulation and implementation of changes in behaviour within the farm enterprise, household, or community or among institutions at varying scales of interaction.
- Can be improved through development and application of location-dependent knowledge (Braun *et al.* 2006).

As these situations apply well to the introduction of pollination management, it is suggested that it is important to be flexible in the entrypoint for the discussion, starting from the critical constraints or problems as perceived by farmers.

In almost all cases, with respect to pollinator-dependent crops, practices to address critical constraints also have implications for pollination management. It is also often the case that many pollinator-friendly practices have benefits for other aspects of the farming system and can also help to address these problems. For example, irregular rainfall or lack of access to irrigation water are problems that many farmers face (see Box 1.1).

Box 1.1

PRACTICES TO ADDRESS WATER PROBLEMS AND IMPROVE POLLINATOR HABITAT

The Kilimambogo site in Kenya, approximately 80 km from Nairobi, is an area of small-scale farming with mixed cropping. One of the main constraints mentioned by farmers is the unreliable rainfall resulting in poor crop yields. Farmers are increasingly concerned about the impacts of climate change. The draft pollination management plan for the Kilimambogo, Kenya site identifies a number of measures that can be taken to both address water-related problems and improve pollinator habitat.

- **Introduction of soil management techniques such as composting to help hold water better may also assist the agroecosystem to sustain more vegetation that benefits pollinators.**
- **Introduction of small-scale water harvesting structures will store water for use by farmers in periods of drought and also provide water to pollinators.**
- **Integration of plant varieties into cropping systems that can both prolong the period in which forage is available for pollinators and provide some resilience against climate change.**
- **Encourage indigenous hedgerow plants as live fence and uncultivated section of the farm as refugia for pollinators.**

Figure 1.1

CHILLI PEPPER FARMERS IN KILIMAMBOGO, KENYA

Pollinator-friendly practices cannot resolve these water-related problems directly but mixed cropping and mixed crop varieties - with differences in growing cycle and different tolerances to drought - may reduce the risk of total crop failure in the event of a prolonged period of low rainfall. Moreover, efforts to increase efficiency of water use through replacing flood irrigation by drip irrigation could also be beneficial for pollinators as they will reduce the potential for damage to ground-nesting bee nest sites.

This identification of challenges may also indicate some of the likely constraints to farmers' adoption of certain pollinator-friendly practices. For example if farmers are concerned about labour shortages, they are not likely to favour practices such as manual weeding that increase the amount of labour requirements (Figure 1.2).

Figure 1.2

VEGETABLE FARMER IN KOSI-WATERSHED, ALMORA (UTTARAKHAND, INDIA)

For many farmers, labour costs are an important factor that will help to determine whether pollinator-friendly practices can be readily incorporated in their farming systems.

While there are some commonalities in problems facing farmers, the examples given in Box 1.2 show that each local situation has its particularities.

It is important therefore to go beyond generalizations and understand the particular situation. In many cases, where farmers are producing for the market, the most obvious challenges may be commercial or economic. There are difficulties in competing with large scale farmers who can produce at low cost, in getting products to market and getting a good deal from intermediaries, and dealing with the paradoxical situation that in seasons of high production, overall revenue may actually go down because of the downward pressure of abundant supply on prices.

In such circumstances the increase in yield associated with improved pollination may seem of little consequence. But some of the practices and the effect of improved pollination may lengthen the production period and allow production outside of the peak season. Pollinator-friendly practices are likely to reduce the cost of purchased inputs as pesticide use is reduced or made more effective per unit. For some small farmers that rely on family labour, it is the cost of the purchased inputs that is critical for viable operation.

Figure 1.3

PRODUCING IN A HOME GARDEN

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Kosi-Watershed, Almora (Uttarakhand), Patharkot village, India

Figure 1.4

DISCUSSING PRODUCTION ISSUES

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Jutpani village, Chitwan, Nepal

Figure 1.5

HIGHLIGHTING ISSUES RELATED TO ACCESS TO WATER

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Mwampko Mpya Womens' group, Tala District, Thika, Kenya

Box 1.2

HOW FARMERS PERCEIVE THEIR MAIN PROBLEMS – SOME EXAMPLES

INDIA – KOSI-WATERSHED, ALMORA (UTTARAKHAND)

Patharkot village has nearly 53 families and until recently was not accessible by road. The farmers - who are mainly women - primarily cultivate wheat, mustard and lentils, but also millet, local pulses and sesame seeds. In their home gardens they grow a wide variety of fruit and vegetables: curcurbits, pumpkins, bananas, cabbage, onion and garlic amongst others. Land is very limited, and agriculture is rainfed. This means that a family's crop production is sufficient to cover only 2-3 months of their needs over a year. Other activities are livestock rearing and milk production.

The farmers indicated the following problems in order of priority:

1) Kurmula, or white grubs that attack crop roots.
2) Lack of water – with more water the farmers could produce enough for subsistence and sell cash crops.
3) Wild animals – wild boar which goes after potato and corn, porcupines which go for the kurmula grubs and in the process destroy the crops (mainly pulses) and monkeys which go for the fruits, vegetable, pulses and other crops. But the underlying problem is that the wild animals do not have enough food in the forest because of deforestation.

NEPAL - CHITWAN

The farmers' group in Jutpani village has 21 farmers of whom half are women. This is a resettlement area, where farming has been going on for 30-35 years. In the beginning it was famous for production of potatoes and mustard as well as traditional staples, maize and rice. But very few farmers grow mustard now because of pest problems.

Farmers cited the declining yields with both open and hybrid seeds, increasing problems of pests, requiring expensive outlay on pesticides and subsequent soil fertility declines. The general feeling was that they were producing less and less with more and more costs.

KENYA - THIKA

In Tala District on the eastern slope of Ol Donyo Sabuk national park, there are a number of self-help farmer groups. The Mwamko Mpya Womens' group (which can be translated as 'working early in the morning' or 'new beginning') started in 2005 with a focus on widowed and elderly women and orphans. The group has a 2 acre plot on which they grow tomatoes, green beans and chillies, experimenting with new varieties and planting methods.

The main problem this farmers' group highlighted was the lack of convenient access to water. The women have to carry water to the plots in jerry cans.

1.2 FARMERS' CURRENT USE OF POLLINATOR-FRIENDLY PRACTICES

It is also necessary to understand the practices that farmers currently use, and the extent to which they are pollinator-friendly as this will indicate areas for improvement. If current practices already seem pollinator-friendly to the extent that areas for improvement cannot be identified, it will not normally be appropriate to follow the steps in this Handbook (Box 1.3).

However, it may be the case that current practices are about to change in that farmers are contemplating, or starting to experiment with, new crops or varieties or new practices in an effort to increase production or address other problems. This may threaten the continued use of pollinator-friendly practices. In such situations, it could be helpful to incorporate pollinator-friendly practices in tests of new crops and practices.

Box 1.3

POLLINATOR-FRIENDLY PRACTICES IN KAKAMEGA, KENYA

Farmers in the densely-settled Kakamega district in western Kenya do not deliberately manage the pollination of their crops. However, farms are close to the highly diverse Kakamega rainforest, with an exceptionally rich mixture of flora and fauna. Farmers also have long-standing practices that benefit pollinators, such as planting hedgerows of flowering plants to separate their fields. As a result, the levels of pollination service observed in farmer's fields seem to be amongst the highest possible. But one force that is changing cultivation practices in this area is the opportunity for farmers to grow sugar cane under contract; in this case, the sugar milling company buys the output from the farmers and also provides them with planting material, inputs and harvesting equipment, at rates charged to farmers against their sales revenue. In such schemes, pollinator-friendly practices such as hedgerows and small fields may not be favoured. Comparing different practices for growing sugar cane in terms of their effect on other pollinator-dependent crops grown by the farmers could be an interesting use of the socioeconomic assessment.

1.3 COLLECTING BASELINE INFORMATION

If this information has not already been collected as part of the organization's previous work with the farmers, a survey could be conducted of a random sample of farmers in the area. This survey would include questions about cropping systems, practices used and main challenges faced by farmers. Alternatively a rapid assessment could be done by means of focus group discussions – see Box 1.4.

Figure 1.6

FOCAL GROUP MEETINGS AMONGST FARMERS IN PEPEASE, GHANA, AND MANAGEMENT PRACTICES SELECTED TO BE TESTED

© P. Kwapong

Focal group meeting, Pepease, Ghana

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Farming practices promoting pollinators, Mankessim area of Ghana

Farmers in the Mankessim area of Ghana have discussed ways to improve the pollination of their horticultural crops, and have decided to focus on:

- **Encouraging field borders with flowering plants or crops (such as cassava)**
- **Protecting sacred groves for pollination as well as religious values**
- **Protecting riparian vegetation for pollinator resources as well as flood control**
- **Reducing pesticide applications**

Box 1.4

BASELINE RAPID ASSESSMENT

The aim of the focus group discussion is to get a rapid assessment of the current situation of the farmers, the agricultural production systems and practices they use and the challenges that face them in pursuing their livelihoods. This will indicate the extent to which improved pollination and the introduction of pollinator-friendly practices in agriculture could be relevant to these farmers.

QUESTIONS/TOPICS FOR DISCUSSION

Current livelihood strategies and conditions

It is necessary to know how important agriculture is to the farmers' livelihoods as this will affect their willingness to take risks and to try out new approaches. If agriculture is the main source of livelihood, farmers may be unwilling to take risks unless there are good safeguards, e.g., participation in a group-based activity using group land.

- **Main activities and sources of income**
- **Extent of dependence on agricultural production**
- **Size of landholdings and tenure system – formal land title, informal, rented, communal**
- **Average area under cultivation per farmer**
- **Access to forest resources (distance and rights of access)**

Agricultural systems

This section aims to assess whether farmers are growing pollinator-dependent crops, whether their practices are pollinator-friendly and whether there are clear areas for introducing pollinator-friendly practices. By examining changes in crops and practices over the last few years, the discussion will reveal the extent to which farmers are accustomed to innovating and the factors driving this.

- **What are the main crops grown?**
- **How much of production is for own use, how much for local markets, national, export?**
- **What type of cropping system and agricultural practices are used, e.g., mixed cropping, use of chemical fertilizers and pesticides, irrigation, tractors?**
- **How have these changed if at all over the last five years?**
- **What are the reasons/motivations for farmers' current cropping systems and production practices? E.g., response to land or labour scarcity, promotion by extension services, community initiative**

Challenges and constraints

This aims to identify problems or challenges that improved pollination and the introduction of pollinator-friendly practices could address.

- **What do farmers consider to be the main challenges facing them in crop production?**
- **How have these challenges changed over the last few years?**
- **What challenges do farmers see in the future?**
- **What other challenges are farmers facing in their livelihood strategies? E.g., difficulties in collection of animal fodder or fuel wood.**

STEP TWO: IDENTIFYING APPROPRIATE POLLINATOR-FRIENDLY PRACTICES TO TEST

2.1 DRAWING UP A SHORTLIST OF PRACTICES

There are a wide range of pollinator-friendly practices which could be introduced. Figure 2.1 profiles a village in Ghana that has considered practices that they would like to test. The scope of some other possible practices are illustrated in Figures 2.2 through 2.8. A more complete, but not comprehensive list of practices for which there is either evidence in scientific literature of effectiveness in improving pollination, or reasonable empirical evidence is given in Box 2.1. Farmers may already be using some of these practices, not always with the aim of promoting pollination explicitly. Practices such as mixed cropping may be part of traditional agricultural systems, while avoidance of pesticide use may reflect financial constraints rather than a specific choice.

Farmers may as well have additional practices to suggest based on their own observations. For example, one organic farmer in Nepal stakes his plants to increase accessibility for the bees. There may not be evidence in scientific literature of the effectiveness of practices suggested by farmers in improving pollination, but it would be important not to ignore this local knowledge, if there is interest from other farmers in testing these practices. There is the possibility though that any positive change in production systems identified when these farmer-led practices are employed have little to do with pollination. It would be good therefore to ensure that some tests of the impacts of these practices on pollinators are also carried out - for example, observation of pollinator visitation rates for plants that are staked and for those that are not staked.

Box 2.1

POLLINATOR-FRIENDLY PRACTICES

FORAGE FOR POLLINATORS

- **Mixed crop types over a growing season to reduce or eliminate dearth period with no crops in flower**
- **Mixed crop types within a field to attract pollinators**
- **Mix of crop varieties to extend the foraging period**
- **Patches of non-crop vegetation, flower-rich field margins, buffer zones and permanent hedgerows**
- **Shade tree cultivation**
- **At landscape scale conservation of natural and semi-natural habitat providing pollen sources for pollinators**

REDUCE USE OF CHEMICALS

- **Selective weeding to conserve weeds good for pollinators**
- **Use of less toxic pesticides and better application procedures**

MANAGING FOR BEE NEST SITES

- **No till agriculture**
- **Leave dead trees and branches standing**
- **Leave patches of bare ground undisturbed**
- **Avoidance of flood irrigation**

MANAGED POLLINATORS

- **Introduce managed pollinators**
- **Improve traditional beekeeping – modern hives and increased number of colonies per ha**

Key questions in selection of practices to shortlist

- Is the practice relevant to current production systems of the majority of farmers in the group? e.g. if only a few members have access to irrigation, avoidance of flood irrigation will not be widely relevant.
- Does the practice address perceived aspects of production systems where improvement is needed?
- Could the practice address challenges in other aspects of farmers' livelihood strategies: e.g. introducing more legumes into farming systems to attract pollinators can also address problems of insufficient fodder crops for livestock.
- Is the practice a realistic decision variable for the farmers (do they have sufficient control over this)? e.g., farmers cannot change their proximity to natural habitat, but they can allocate small areas on-farm for biodiversity or habitat restoration. Alternatively, if farmers opt to manage for bee nest sites by leaving patches of bare ground along roads undisturbed, will road maintenance personnel support this choice?
- Is the practice sufficiently different from current practice to enable comparison?

Box 2.2

SELECTING PRACTICES IN PAKHUDA VILLAGE, INDIA

The farmers in this village which is located in District of Almora, Uttarakhand State in the West Himalaya of India cultivate rice, potato and coriander as cash crops and mustard for own consumption as well as keeping livestock. They have a series of small terraces separated by bunds with very few trees. To prevent soil erosion the farmers keep *Rumex* and some other grasses on the bunds.

OPTIONS FOR POLLINATOR-FRIENDLY PRACTICES

Incorporating more trees in the farming system would be beneficial to pollination but farmers do not want to do this because it would take up too much land in their already small landholdings. Another option to improve pollination is to replace *Rumex* by a plant that is more attractive to pollinators, while still providing protection against soil erosion and providing other products such as fodder and medicinal plants.

It is suggested that the group facilitator review the practices in Box 2.1 together with any identified by the farmers and draw up an initial shortlist that would be considered further and narrowed down in Step 2.2.

2.2. DISCUSSING IMPLICATIONS OF SHORTLISTED POLLINATOR-FRIENDLY PRACTICES TO MAKE FINAL SELECTION

The pollinator-friendly practices can be associated with changes to outputs and to inputs and ultimately the viability of production systems for farmers. Table 2.1 sets out these impacts for a range of pollinator-friendly practices and is a way of systematically organizing and comparing the possible impacts to be investigated by farmer groups.

The introduction of pollinator-friendly practices can affect farmers' livelihoods and well-being in less tangible ways. It is important to be aware of these and examine how important they are relative to the impacts that have more clear-cut financial and resource implications. These impacts may affect a farmer's decision to take up a pollinator-friendly practice. They may be difficult to measure though. These impacts could include:

- Reduced risk and diversification through planting of mixed crop types and/or mixed crop varieties.
- Reduction in health risk, with the application of less toxic pesticides.
- More tiring work - for example manual weeding rather than applying herbicide.

Some of these impacts such as reduction in health risk will be difficult to quantify in the course of the trial. What can be assessed are the perceptions of the farmers. Some impacts may be more associated with the process of learning and trying out new approaches than the practice *per se*. Table 2.2 gives some examples of less tangible impacts that might be associated with each of the main pollinator-friendly practices. Tables 2.1. and 2.2. can be a prompt in a discussion with the farmers on the implications of the shortlisted pollinator-friendly practices at a specific site to narrow them down further. Farmers' views on the implications for yield, costs and less tangible impacts will help in the filtering process. The two tables are of course only meant to be indicative of possible practices and their implications. Farmers should be encouraged to do their own thinking on what the implications are, and facilitators should not be bound by these tables.

The aims of this step are to ensure that any obvious non-starters are avoided, for example where the level of risk is considered too high, and to record the reasoning behind the final selection. At the end of this step, the group should have a selection of practices to test, perhaps ranked in order of priority, and a list of practices that were considered but not taken further with the reasons why. At a later stage after a cycle of testing, the group may want to return to the list and review the choices made.

2.3 KEY ISSUES IN THE SELECTION OF PRACTICES

How many practices should be tested?

It is recommended to keep the evaluation simple by selecting one or two practices only to test, or one practice with different gradients of application. This means that it is important to select practices carefully. Some possible comparisons might be:

- Planting of pulses such as blackgram or beans on the bunds separating rice paddies where vegetables are grown before or after rice, versus no such planting.
- Planting of hedgerows versus no such planting.
- Intercropping of pollinator-dependent crops with crops attractive to pollinators versus mono-cropping of pollinator-dependent crops.

These types of comparisons are relatively simple to test. Whether all the farmers should select the same practice will depend on the size of the group and the size of the plots available for testing. There may not be consensus within a group on the pollinator-friendly practices to try out. If there is sufficient land for testing, and if plots are sufficiently far apart to avoid spillover effects (see Step 3) it would be good to accommodate different interests within the group. Ultimately it is important that the farmers are happy with the choice so that their motivation to see the test through is high.

There may be situations where a package of practices is preferred by the farmers and/or is likely to have a more discernible impact on pollination than a single practice. In such cases there are advantages in examining the whole package. However, it will not be possible to attribute the impacts on yields to a single practice within the package. This would be appropriate therefore where it makes sense to introduce the practices in combination (for example introduction of organic farming techniques versus continuous application of pesticides over the growing season and where it will not be necessary to understand the contribution that each component of the package makes).

Box 2.4 gives a checklist of factors to consider in making the decision whether to evaluate a single practice or a package of practices.

Box 2.3

EXAMPLE – KWOSAU VILLAGE KENYA (MATUNGULU DISTRICT)

Kwosau village, in Kyanzave Division is located on the border of Kenya's Central and Eastern Provinces near to the Ol Donyo Sabuk National Park. The Sustainable Agriculture Community Development Programme (SACDEP), a Kenyan NGO, is working in this village to raise farmers' awareness of pollination as well as promoting sustainable agriculture. The park management as part of a benefit-sharing programme is promoting bee-keeping. Declines in the bee population have been observed by the villages as trees have been cut down. SACDEP has started giving training to the farmers on planting hedgerows to provide food and nesting sites for bees. The farmers have also started to leave patches of native vegetation amongst their crops, with the specific aim of providing habitat to pollinators. These two practices, hedgerows and patches of native vegetation could be good candidates for farmer-led testing.

Box 2.4

SINGLE PRACTICES VERSUS COMBINED PRACTICES

WHEN TO EVALUATE A PACKAGE OF PRACTICES

- **When farmers are interested in the whole package and not individual practices within the package.**
- **When some of the individual practices are likely to have only a small effect.**
- **When practices go well together and have synergistic effects e.g., hedgerows and small field sizes, or organic farming techniques as a package.**
- **When certain combinations of practices make sense to the farmers, e.g., contributing to restoring bee forage trees in a nearby protected area, and also planting some of these same trees on farms.**
- **When all the practices in the package are practical for all of the farmers in the group to adopt.**

WHEN TO EVALUATE A SINGLE PRACTICE

- **When it is possible to identify a single practice that is likely to make a significant difference.**
- **When farmers are not willing to make too much of a change to their practices.**
- **When the scope for change in practice is very limited as farmers may already be employing pollinator-friendly practices.**
- **When farmers in the group have different interests with some for example wanting to reduce pesticides and others wanting to plant hedgerows.**

Table 2.1

Potential (hypothesized) impacts on inputs and outputs of using pollinator-friendly practices

PRACTICE	CONTROL/ COMPARISON	IMPLICATIONS (OTHER THAN POLLINATION)	OUTPUTS: YIELD PER PLOT/QUALITY	MATERIAL INPUTS	LABOUR INPUTS
FORAGE FOR POLLINATORS					
Mixed crop types over a growing season sustaining population over a season	Mix of crops that have a dearth period with no crops in flower	Greater diversification of income; greater income with multiple harvests (but these may be true even if the specific crops do not favor pollinators) Better disease control (best remedy for disease is usually crop rotation; again, benefits are not specific to pollination) Nitrogen-fixing crops planted earlier may reduce fertilizer need for subsequent crops	Higher level of pollination service, thus increases in yields and quality	Diversity of crop seeds	Probably more labour with more diversity over a season
Mixed crop types within a field, one or more which attracts pollinators to the other (and probably also natural enemies and, if a legume, improves soil fertility)	Single crops	Crop combination reduces fertilizer and pesticide requirements (nitrogen-fixing plants and companion planting) Different crop types may require production activities at different times in the season	Overall yields are usually higher Higher levels of pollination service may increase yield per plant	Diversity of crop seeds Lower fertilizers and pesticides	Possibly higher with more complex harvesting times and needs
Greater crop genetic diversity with varieties that flower at different times	Plot with single variety of crop(s)	Varieties have different yields Varieties may require production activities at different times in the season Builds in resilience, risk mitigation if varieties have different tolerances	Lower yield than if all high yielding varieties used, and meet their yield potential If varieties flower at different times, may extend the foraging period leading to higher level of pollination service and increased yield and quality	Diversity of seed sources, farmer saved or purchased	Affects the timing of labour inputs and harvest

TABLE FOLLOWS ON THE NEXT PAGE >>

PRACTICE	CONTROL/ COMPARISON	IMPLICATIONS (OTHER THAN POLLINATION)	OUTPUTS: YIELD PER PLOT/QUALITY	MATERIAL INPUTS	LABOUR INPUTS
Patches of non-crop vegetation Flower-rich field margins, buffer zones and permanent hedgerows (See Figure 2.1 Strips of non-crop vegetation)	Whole or agreed conventional proportion of the plot used for crops	Reduces the proportion of the plot that is used for crops unless not possible to use for cropping anyway May support natural pest control along with pollination, buffer zones may reduce farm runoff and pollution from farm chemicals	Possible lowers yield per plot, although higher levels of pollination service (or natural pest control) may increase yield per plant	Lowers inputs per plot for some production stages (if a lower proportion of the plot is used for crops)	Lowers inputs per plot for some production stages (if a lower proportion of the plot is used for crops)
Shade tree cultivation (See Figure 2.2 Sequential bloom management practice from India)	Whole or agreed conventional proportion of the plot used for production crops	Reduces the proportion of the plot that is used for production crops	Lowers yield per plot for main crop as lower proportion is used for main crop Higher levels of pollination service may increase yield per plant Shade trees may provide other commercial and own consumption products	Often lower than under sun cultivation	Could be lower if material inputs are reduced
Strip crops e.g. coriander to attract pollinators and natural enemies of crop pests (see Figure 2.3 Strip cropping of coriander)	Conventional cropping system with crops chosen for commercial and own consumption value	Reduces the proportion of the plot that is used for main crops. Strip crops may not have same commercial or nutritional value as main crops Inputs (seeds) and labour required	Lowers yield per plot for main crops but additional output from the strip crops Higher levels of pollination service may increase yield per plant	Higher per plot if it means greater cropping intensity but lower for main crop	Higher per plot if it means greater cropping intensity but lower for main crop

TABLE FOLLOWS ON THE NEXT PAGE >>

PRACTICE	CONTROL/ COMPARISON	IMPLICATIONS (OTHER THAN POLLINATION)	OUTPUTS: YIELD PER PLOT/QUALITY	MATERIAL INPUTS	LABOUR INPUTS
At landscape scale conservation of perennial grasslands, old fields, shrubland, woodlands comprised of (often wind-pollinated) plants providing pollen sources for bees (see Figure 2.4 Wind pollinated plants may provide pollen forage for pollinators at critical times)	Complete clearing or larger proportion of land cleared at the landscape level	Lower yield per landscape area as not all of it will be cultivated	Lower yield per landscape area/ collection of fields Higher levels of pollination service may increase yield per plant	No effect at the plot level	No effect at the plot level
REDUCING USE OF CHEMICALS					
Selective weeding to conserve weeds good for pollinators (see Figure 2.5 Weeds and Pollinators)	Weeding with herbicides	Replace herbicides by manual weeding	Lowers yield if remaining weeds compete with crops for nutrients Higher levels of pollination service may increase yield per plant	Lower as less herbicide used	Higher labour inputs with manual weeding Labour inputs for harvesting per plot may be lower / higher if yield per plot lower/higher
Use of less toxic pesticides and better pesticide application procedures in intensively farmed areas	Conventional use of pesticides	May lower yields if less toxic means less effective but reduces amount of material inputs	Yields may be lower Higher levels of pollination service may increase yield per plant	Lower cost as reductions in amount used	Could decrease if less applied but could increase if application procedure is more careful or complicated
Less use of purchased fertilizers, using legumes to restore soil fertility	Conventional use of fertilizers	Improvement in soil health, soil biodiversity, no disturbance of ground nesting bees.	Over long term yields may be higher, short term they may decrease	Seed sources of legumes	Higher labour inputs to establish legume cover crop
MANAGING FOR BEE NEST SITES					
No-till agriculture, reduced tillage or hand tillage	Land preparation with tillage	Lower labour for land preparation Possibly more weeds so more material inputs (herbicides) or labour inputs/ or lower yields	Lowers yield if remaining weeds compete with crops for nutrients Higher levels of pollination service may increase yield per plant	May be higher (unless weeding is manual)	Lower for land preparation May be higher for weeding unless herbicides used

TABLE FOLLOWS ON THE NEXT PAGE >>

PRACTICE	CONTROL/ COMPARISON	IMPLICATIONS (OTHER THAN POLLINATION)	OUTPUTS: YIELD PER PLOT/QUALITY	MATERIAL INPUTS	LABOUR INPUTS
Leaving standing dead trees and fallen branches undisturbed a) On the fields, or b) Adjacent to the fields	a) Plot is completely cleared b) Adjacent dead trees/branches cleared	Minimal interference with crop growth	Minimal interference with crop growth Higher levels of pollination service may increase yield per plant	a) Lowers inputs pro-rata for some production stages b) No difference if not in field	a) Lowers inputs pro-rata for some production stages b) No difference if not in field
Conserving sites where cavity-nesting bees may nest, such as in structural timbers, bamboo stems, or other large culms	Remove all such nesting sites, or kill the bees nesting in the cavities	Minimal interference with crop growth; sites not usually in farm fields May cause damage to structural timbers	Minimal interference with crop growth Higher levels of pollination service may increase yield per plant	None, unless bamboo or other vegetation needs to be planted	None, unless bamboo or other vegetation needs to be planted
Managing for bee nest sites – leaving patches of bare ground (such as along road and path sites) undisturbed a) On the plot b) On adjacent land not used for cropping	a) No bare ground left on the plot b) No management of adjacent land not used for cropping	a) Reduces the proportion of the plot that is used for production crops	a) Lowers yield per plot b) No effect as nests are on unused land But, higher levels of pollination service may increase yield per plant	a) Lowers inputs pro-rata for some production stages b) No effect	a) Lowers inputs pro-rata for some production stages b) No effect
Avoidance of flood irrigation; Rain fed or drip irrigation (see Figure 2.6 Irrigation practices and pollinators)	Flood irrigation		Ground nesting pollinators may be impacted, leading to lower yields.	Considerable one-time investment for equipment if drip Less water use	High initial labour cost, high maintenance costs, but possibly lower costs over time
MANAGED POLLINATORS					
Introduce managed pollinators	No managed pollinators	Costs of establishment and management and benefits from honey output	Higher level of pollination service, thus increases in yields and quality	Not for the crops but necessary for the managed pollinators	Not for the crops but labour needed for the managed pollinators
Improve beekeeping practices	Traditional beekeeping – low density	Costs of improvement and benefits from increased output – honey and colonies	Higher level of pollination service, thus increases in yields and quality	Not for the crops but likely for the beehives	Not for the crops but likely for the beehives
Introduce nesting sites for wild pollinators (i.e. nesting blocks or “bee hotels” for leaf cutter bees, sand playgrounds for ground-nesting bees) (see Figure 2.7 Offering nesting sites for cavity-nesting bees)	No introductions	Costs of establishment	Higher level of pollination service, thus increases in yields and quality	Not for the crops but necessary for establishing the nesting sites	Not for the crops but labour needed for establishing the nesting sites

Table 2.2

Potential (hypothesized) non-financial/less tangible impacts (other than pollination) of using pollinator-friendly practices

PRACTICE	CONTROL/COMPARISON	POSITIVE IMPACTS	NEGATIVE IMPACTS
FORAGE FOR POLLINATORS			
Mixed crop types over a growing season sustaining population over a season	Mix of crops that have a dearth period with no crops in flower	Reduced risk of total crop failure Improved nutrition as wider range of food grown for own consumption	
Mixed crop types within a season, one or more which attracts pollinators to the others	Single crops	Reduced risk of total crop failure Diet diversity	
Greater crop genetic diversity with varieties that flower at different times	Plot with single variety of crop(s)	Reduced risk of total crop failure	
Patches of non-crop vegetation Flower-rich field margins, buffer zones and permanent hedgerows	Conventional proportion of the plot used for crops	May be useful resources – medicinal plants, fodder, and safety net food resources if crops fail	Encourages snakes
Strip crops e.g. coriander to attract pollinators and natural enemies of crop pests	Conventional cropping system with crops chosen for commercial and own consumption value	May provide useful resources for the household and food safety net	
Shade tree cultivation	Whole plot used for production crops	Microclimate – reduces heat making agricultural work less arduous; trees may provide medicinal resources, fodder, and safety net food sources	
At landscape scale conservation of perennial grasslands, old fields, shrubland, woodlands comprising wind-pollinated plants providing pollen sources for bees	Complete clearing or larger proportion of land cleared at the landscape level	Medicinal resources, fodder, and safety net food sources	
REDUCE USE OF CHEMICALS			
Selective weeding to conserve weeds good for pollinators	Weeding with herbicides		Tiring work which has to be done on regular basis
Use of less toxic pesticides and better pesticide application procedures in intensively farmed areas	Conventional i.e. intensive use of pesticides	Reduced health risks to farmer and family	
MANAGING FOR BEE NEST SITES			
No-till agriculture, reduced tillage or hand tillage	Preparation with machinery		More arduous work to do hand tillage
Leaving standing dead trees and fallen branches undisturbed	Plot is completely cleared		Fire hazard Less available for firewood
Leave patches of bare ground (such as along road and path sites) undisturbed	No bare ground left on the plot		
Avoidance of flood irrigation	Rain fed or drip irrigation	More water available for other household uses	
MANAGED POLLINATORS			
Introduce managed pollinators (honeybees)	Reliance on wild pollinators	Diversification of food and income sources – consumption and sale of honey	Hazard for children
Improve traditional beekeeping	Traditional beekeeping practices	Increased honey production	

Figure 2.1

STRIPS OF NON-CROP VEGETATION

Left: *French bean production, Kenya;* right: *Persephone Farm, Lebanon, Oregon*

Commercial farmers in a number of places have learned to apply "farmscaping practices" to encourage beneficial insects, including pollinators and natural enemies. They seed and transplant crops or plants that will encourage beneficial insects – such as alyssum, cosmos, mexican marigold or calendula - in rows next to their cash crop.

Figure 2.2

SEQUENTIAL BLOOM MANAGEMENT PRACTICE FROM INDIA

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Farmers in southern India select shade trees to keep pollinators on-farm between flowering of coffee and flowering of cardamom. Trees are selected that are economically important and maintain floral resources throughout the a season.

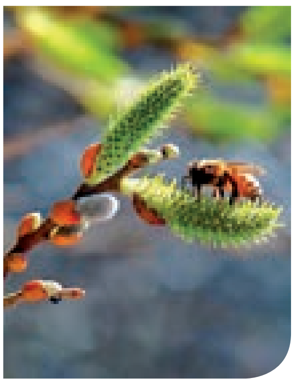
Figure 2.3

STRIP CROPPING OF CORIANDER

Insectary plants, such as coriander, are plants that provide nectar and pollen that are attractive to beneficial insects such as natural enemies of crop pests and pollinators. They may also provide shelter to natural enemies. If carefully planned, insectary plantings can attract, retain, and enhance the presence of a wide range of beneficial insects. Often, insectary plants, which have feathery leaves that will not interfere with crop plant growth, can be planted in strips next to crops.

Figure 2.4

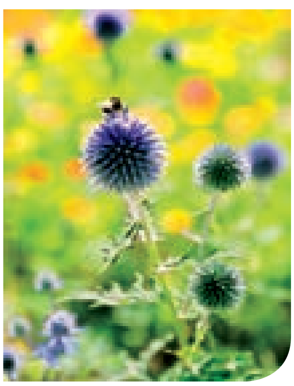
WIND POLLINATED PLANTS MAY PROVIDE POLLEN FORAGE FOR POLLINATORS AT CRITICAL TIMES



Willows are one of the first major spring nectar and pollen sources over many countries in the Northern Hemisphere. Pollinators are not needed for the reproduction of the tree, as it depends on wind for pollination. But the tree, along with many other native trees - some also wind-pollinated - are important for pollinators. Pollinators may gather extensive quantities of pollen from wind-pollinated plants, particularly early in the season before crops begin to flower.

Figure 2.5

WEEDS AND POLLINATORS



Selected weeds may often provide valuable forage resources for pollinators, and increase the level of pollination services to the nearby crops. One mango farmer in Ghana, realizing this, chose to handweed - at four times the price of using herbicides - so as to selectively conserve those weeds that are beneficial for pollination (Gordon 2008).

Figure 2.6

IRRIGATION PRACTICES AND POLLINATORS

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Left: *Ground nesting bee entry tube, Kenya;* right: *Squash bee, Peponapis pruinosa*

Soil nesting bees - including both solitary bees and some social colonies (e.g. sweat bees, stingless and bumble bees) - are among the most important crop pollinators. For example the squash bee *Peponapis pruinosa* is a specialist bee, only collecting pollen from the genus Cucurbita (squash, pumpkin) and nests in the ground, sometimes amid its host crop plants. Irrigation management is only a concern during the nesting period. Flood irrigation covers the soil with a standing layer of water that may saturate bee nests below.

Figure 2.7

OFFERING NESTING SITES FOR CAVITY-NESTING BEES

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© Antonio Felicioli

Left: "*Bee Hotels*"; right: *Nesting sites for Osmiine bees in orchard near Pisa, Italy*

Many bees, such as leafcutters and masons, next in holes in wood, and will readily come to artificially created wooden blocks with holes, or containers of hollow rods or straws that mimic their traditional nesting sites. These photos show some options in creating "bee hotels".

STEP THREE: **SELECTING THE PLOTS WHERE THE POLLINATOR-FRIENDLY PRACTICES WILL BE TESTED**

The selected pollinator-friendly practices need to be tried out in designated plots (treatment plots) and compared with plots where these practices are not used but are as similar as possible in every other respect (control plots).

3.1 LOCATION OF THE PLOTS

The plots where the pollinator-friendly practices will be tried out need to be sufficiently far away from the control plots so that the latter are not affected by any pollination effect of the new practices. This will depend on the flight range of the most likely important pollinators and could be at least 1km (Vaissière *et al.* 2011). Distance between the two types of plot is also needed so that the treatment plot is not affected by any of the conventional practices in the control plot such as heavy use of toxic pesticides.

The control plots need to have similar conditions of soil fertility, slope, altitude, moisture and microclimate so that differences in impacts observed between them and the treatment plots can be attributed to the use of the pollinator-friendly practices.

Ideally each participating farmer should have both a treatment plot and control plot on their farm. This would make it more likely that any difference in inputs and outputs between them reflect the introduction of the pollinator-friendly practice rather than the farm management skills of different farmers. But where farms are small it may not be possible to achieve the necessary distance between the treatment plot and the control plot. The treatment and control plots would then have to be located on different farms.

An alternative would be for farmers to record their current practices, inputs and outputs in the first year or season before introducing any changes. This would then constitute the control or baseline. In the second year/season, the farmers could introduce pollinator-friendly practices and continue to record their inputs and outputs. The disadvantage is that weather conditions may vary considerably from one year to the next. But if the farmers continue their record-keeping over a number of years this may not be such a problem.

For pollinator-focused Farmer Field Schools, where the farmers are likely to have a group plot or plots for testing, the before and after comparison approach discussed in the paragraph above may be the best option. This will be strengthened if the individual members of the group subsequently try out the practice on their own plots and keep records before and after introduction.

3.2 HOW MANY PLOTS ARE NEEDED?

The answer to this question depends on whom the tests are for. Because of the variation in plot conditions, for statistical representativeness it is important to have a number of pairs of treatment plots and control plots or before and after comparison sites, ideally selected through a random sampling process. This would generate information on the impacts of pollinator-friendly practices that could convince an external audience, pollination experts or economists for example.

This is rarely practical, particularly in the context of Farmer Field Schools where group plots will be used. Moreover, the exercise and analyis may end up being so far removed from the farmers that their interest and engagement is reduced.

For the purpose of stimulating interest on the part of farmers, a small number of plots may still be useful. For Integrated Pest Management (IPM), a three by three design (three treatments and three replicates) has been recommended by Van den Berg (2001) as a reasonable compromise which allows observation and analysis by the farmers themselves. For pollination, two treatment levels – for example, with hedgerows and without hedgerows - would be appropriate so this would imply six plots for simultaneous comparison, or three plots for before and after comparisons. Even this number may not be practical for testing pollinator-friendly practices in the Farmer Field School context given the need for at least 1 km distance between treatment and control plots. However, the results from one group plot in a Farmer Field School may be sufficient to persuade other farmers' groups to try out the same practices or to convince the members of the group to try out the practice on their own land.

Thus over time, provided records are kept, there will be a greater chance of producing results that not only are meaningful to the farmers but can also at least partially meet requirements for rigour and statistical representativeness of external audiences, such as government agencies and donors.

The more plots that can be involved the more the effects of natural variation can be taken into account but the more dependence there will be on the facilitating organization for processing and analysis of the data.

Figure 3.1

EXAMPLE OF TESTING BY FARMER'S GROUP IN SHARADANAGAR, CHITWAN

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Left: *Farmer Field School experimental field;* right: *Botanical pesticide*

A Farmer Field School group in Nepal shows the potential for group experiments to test pollinator-friendly practices. While the group is primarily focused on IPM, the practices tested are also relevant to pollination. The group has 28 members of which two-thirds are women. It is lead by a facilitator who has gone through Farmer Field School training on IPM and who is also the owner of the land used by the group. One of the experiments of the group is to compare the use of chemical fertilizers with botanical spray, which acts as a combined 'natural' fertilizer and pesticide. The botanical is a mix of cattle slurry, Artemisia, chilli and garlic, and other plants obtained from the forest. It is believed that the mix of strong smells in the botanical makes it effective in repelling insects.

The lead facilitator is using her own labour and providing some of the inputs but with some help from the group members who observe the experiment with her. The group is taking records including the amount of labour they are putting in.