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A QUANTITATIVE APPROACH TO THE SOCIO-ECONOMIC VALUATION OF POLLINATOR-FRIENDLY PRACTICES:

A PROTOCOL FOR ITS USE

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POLLINATION SERVICES FOR SUSTAINABLE AGRICULTURE

A QUANTITATIVE APPROACH TO THE SOCIO-ECONOMIC VALUATION OF POLLINATOR-FRIENDLY PRACTICES:

A PROTOCOL FOR ITS USE

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This publication provides an approach for the socio-economic valuation of pollinator-friendly practices at a landscape/farm level. The text was prepared as part of the Global Environment Fund (GEF) supported project 'Conservation and management of pollinators for sustainable agriculture, through an ecosystem approach' implemented in seven countries – Brazil, Ghana, India, Kenya, Nepal, Pakistan and South Africa.

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PREFACE

In agro-ecosystems, pollinators are essential for orchard, oilseed crops, horticultural and forage production, as well as the production of seed for many root and fibre crops. Pollinators such as bees, birds and bats affect 35 percent of the world's crop production, increasing the outputs of 87 of the leading food crops worldwide, plus many plant-derived medicines for the world's pharmacies. Pollinators contribute significantly to human health; pollinator dependent crops supply major proportions of micronutrients. In terms of ecosystem health, approximately 90 percent of wild plants rely on pollinators that support wider biodiversity.

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

Considering the urgent need to address the issue of the worldwide decline in pollinator diversity, in 2000 the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) established an International Initiative for the Conservation and Sustainable Use of Pollinators (also known as the International Pollinators Initiative - IPI). One of the objectives of the IPI Plan of Action is to "Assess the economic value of pollination and the economic impact of the decline of pollination services".

Within the context of its lead role in the implementation of the International Pollinator Initiative, FAO established a Global Action on Pollination Services for Sustainable Agriculture. FAO also developed a global project, supported by the Global Environment Facility (GEF) through the United Nations Environment Programme (UNEP) entitled 'Conservation and management of pollinators for sustainable agriculture, through an ecosystem approach'. Within the context of this project, a tool for valuation of pollination services at a national level was developed for assessing, at national level, the value of pollination services and national vulnerabilities to pollinator declines. At the field level, a handbook for participatory socio-economic evaluation of pollinator-friendly practices was also prepared and used as a guide to help farmers evaluate the benefits and costs of applying pollinator-friendly practices. It is hoped that this protocol will provide users with guidance for determining the socio-economic value of pollinator-friendly *versus* unfriendly practices that can be implemented at different spatial levels (e.g. farms or landscapes).

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SECTION 1
THE PROBLEM: DEGRADATION OF ECOSYSTEM SERVICES AND LOSS OF BIODIVERSITY

Human well-being is highly dependent on ecosystems and the benefits they provide – namely, ecosystem services, which are recognized as the process and conditions by which natural ecosystems and species sustain human life (Daily, 1997). This includes provisioning services (freshwater, food), regulation services (those that affect the weather, diseases and water quality), cultural services (art, spiritual benefits) and supporting services (soil formation, photosynthesis) (Millennium Ecosystem Assessment, 2005; Hein *et al.*, 2006).

These benefits, however, are not always accounted for, as many ecosystem services are not traded in markets and thus do not have imputed monetary value. This is a problem for the conservation of natural assets that provide ecosystem services because, when natural assets do not have an assigned monetary value, the market indicates that it is more profitable to convert the asset to other land uses (Pretty and Smith, 2004). This may, at least partially, explain the degradation and unsustainable use of ecosystem services and biodiversity.

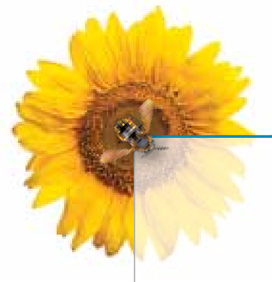
Reversing degradation, while meeting growing demands for agricultural production, can be partially addressed if important changes in policies, institutions and practices are implemented (Millennium Ecosystem Assessment, 2005). The valuation of ecosystem services and biodiversity constitutes a significant advance in this respect and is an issue that is recognized as being central. At the international level, processes such as The Economics of Ecosystems and Biodiversity (TEEB) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) are just some examples of global attention to this issue. At the regional level, an example was provided in 2012, when a workshop was held on ‘Mainstreaming ecosystem services approaches into development: application of economic valuation for designing innovative response policies', for senior level decision-makers from the regions of South and Southeast Asia organized by the United Nations Environment Programme (UNEP) in close cooperation with the Association of Southeast Asian Nations (ASEAN) Centre for Biodiversity. At the national level, countries are interested in valuing ecosystem services to provide financially-based evidence for the conservation and management of services that are important for human well-being, which are addressed by initiatives such as Payment for Environmental Services (PES).

SECTION 2
OBJECTIVES OF THIS PROTOCOL

Values are generally quantified by contrasts. This protocol illustrates the contrast between pollinator-friendly versus unfriendly practices. By focusing on practices, this protocol is directly relevant to decision-making, as it can quantify the consequences of the application of different practices (i.e. decisions). Value is expressed in monetary and non-monetary terms, and both are integrated in this approach, which is applicable at the farm and the landscape level.

This protocol provides guidance for determining the socio-economic value of pollinator-friendly versus unfriendly practices that can be implemented at different spatial levels (for example, farms or landscapes). The scope is comprehensive, and includes small as well as large-scale farming systems. Indeed, the comparison between these systems may be of great interest. For example, the results of the application of this protocol may be useful to both producers and other decision-makers in answering the following questions: Are differences in the socio-economic assets of the producers associated with friendly or unfriendly practices? Conversely, can the number of pollinator-friendly practices applied by producers be predicted by a group of socio-economic variables? Which assets should be built to enhance the number of pollinator-friendly practices used? Are there trade-offs or synergies among different assets (for example, biodiversity and crop production)?

This protocol is structured to provide a framework for valuating pollinator-friendly and unfriendly practices (or landscapes). Conceptual aspects are presented first, followed by practical guidance supported by examples and tables.



SECTION 3
VALUATION FRAMEWORK

There are different ways to define and measure value, of which 'monetary' is only one. The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) notes that, “in keeping with the general anthropocentric notion of 'nature’s benefits to people', one might consider a benefit to be the ecosystem’s contribution to some aspect of people’s good quality of life, where a benefit is a perceived thing or experience of value” (IPBES, 2013). In the definition provided by the IPBES Conceptual Framework, 'value' is multi-dimensional and cannot be estimated properly by only one variable. This is one of the bases of the multi-dimensional aspect of the protocol for socio-economic valuation of pollination-friendly practices, presented here.

The one-dimension and the multi-dimension valuation complement each other, and each one has advantages and disadvantages. The one-dimension approach can be understood, for example, through the effects of an ‘environmentally-friendly’ practice on ecosystem services, in which different ecosystem services (crop yield, pollination, water purification, etc.) are valued in the same units, usually monetary terms. The multi-dimensional approach can integrate different variables in the same analysis, in both monetary and non-monetary terms. The one-dimension analysis is simpler to communicate but has higher error and assumptions because one needs to translate all the variables into monetary terms.

This protocol takes into account three theoretical frameworks:

1) **Sustainable livelihoods:** Accounts for the multi-dimensional socio-economic value of agricultural practices by considering livelihoods assets: natural, physical, financial, human and social assets (Ellis, 2000; Nelson *et al.*, 2009).

2) **Local development:** Proposes that local development is an endogenous process of wealth creation and improvement in a population's living conditions, the result of efforts and commitments of social actors in their territories (Alburquerque, 1999). Local development is embedded in a wider and more complex reality with which it interacts, and from which it is influenced by both positive and negative pressures (Buarque, 1999).

3) Ecological economics: Addresses the interactions and feedback between natural and human economic systems (van den Bergh, 2001). The economy is considered as a sub-system of a larger ecosystem and the preservation of natural assets is emphasized.

The **sustainable livelihoods framework** (SLF), also known as 'rural livelihoods' framework, has been employed for many years in rural areas (DFID, 1999; Nelson *et al.*, 2010) and accounts for the multi-dimensional socio-economic value of agricultural practices by considering the following livelihoods assets:

- **Human assets**: the skills, health (including mental health), nutrition and education of individuals that contribute to the productivity of labour and capacity to manage land (Nelson *et al.*, 2010).
- **Natural assets**: "refers to the natural world, with an emphasis on biodiversity and ecosystems. Nature has values related to the provision of benefit to people, and also intrinsic value, independent of human experience" (Díaz *et al.*, 2015). (For more discussion about natural assets see Dickie *et al.*, 2014).
- **Social assets**: reciprocal claims on others by virtue of social relationships, the close social bonds that facilitate cooperative action, and the social bridging and linking together through which ideas and resources are accessed (networks and connections, relations of trust and mutual support, formal and informal groups, common rules and sanctions, collective representation, mechanisms for participation in decision-making and leadership).
- **Physical assets**: infrastructure, transport, roads, vehicles, secure shelter and buildings, water supply and sanitation, energy, communications, tools and technology, tools and equipment for production, seed, fertilizer, pesticides and traditional technology.
- **Financial assets**: the stocks of financial resources to which households have access, including cash, income, access to other financial resources (credit and savings) and overall wealth that influences the ability to generate income.
- **Cultural and other assets** can be important for the study being undertaken. These dimensions can differ, depending on the specificity of the case study and can be easily incorporated into the questionnaire and analysis (see below).

Conciliating producers' needs and ecosystem services (synergies and trade-offs)

Socio-economic valuation of ecosystem services and biodiversity takes into account multiple dimensions and can quantify among them both trade-offs and/or synergies. For example, increasing the conservation area on a farm could reduce crop production, involving a trade-off between natural and financial assets in the short term (Garibaldi *et al.*, 2014). A larger conservation area could, however, also increase production, because conservation areas may favour resources for pollinators and crop pollination. Identifying and quantifying synergies and trade-offs can serve decision-makers, helping them to improve the assessment of the consequences of their interventions. For example, socio-economic valuation can lead to promoting investments and the development of activities that strengthen synergies and reduce trade-offs, resulting in more effective, efficient and supported decisions (Nelson *et al.*, 2009).

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SECTION 4
DESCRIPTION OF PRACTICE: PROTOCOL FOR SOCIO-ECONOMIC VALUATION OF POLLINATOR-FRIENDLY PRACTICES

This protocol uses pollination as a case study for the socio-economic valuation of ecosystem services. Pollination, which is the process of pollen transfer from the male flower part to the female flower part, mediated by biotic and abiotic vectors, is considered a regulatory service because ecosystem changes affect the distribution, abundance and effectiveness of pollinators (Millennium Ecosystem Assessment, 2005). Pollination services are important not only for natural ecosystems but also to agricultural ecosystems as 75 percent of the world's crops rely upon animal pollination (Klein *et al.*, 2007).

Threats to pollinator populations can directly affect an economy (Constanza *et al.*, 1997; Roubik, 2002; Gallai *et al.*, 2009), for example, by loss in production of fruits and seeds (Jennersten, 1988; Steffan-Dewenter and Tscharntke, 1999; Morandin and Winston, 2006), poor fruit formation (Calvete *et al.*, 2010) or lower germination rates (Cardoso, 2003). These losses cannot be replaced by alternatives that replicate the role of pollinators (e.g. the use of pollen dispersing machines (Chiasson *et al.*, 1995). Insect pollination has been shown to improve yields of fruits and vegetables, as well as oilseed and nut crops (Klein *et al.*, 2007). Despite the importance of pollinators, there is evidence of recent declines in both wild and managed pollinators, and parallel reductions in the plants that rely upon them (Goulson *et al.*, 2008; Allen-Wardell *et al.*, 2000; Biesmeijer *et al.*, 2006; Watanabe, 1994).

The valuation of pollination services has been undertaken from different perspectives and at different levels (local to global). The *Handbook for participatory socio-economic valuation of* *pollinator-friendly practices* (Grieg-Gran and Gemmill-Herren, 2012)[1] focuses on valuation at the local level; it is a guide to help farmers evaluate the benefits and costs of applying pollinator-friendly practices within their fields and farms. It looks not only at the economic, but also the social value of these practices. Synthesizing possible impacts at the country level, FAO's Tool for valuation of pollination services at national level, using producer price and crop production data, is supported by the *Guidelines for the economic valuation of pollination services at national scale*[2] (Gallai and Vaissière, 2009). Using this methodology, Gallai *et al*. (2009) made a worldwide estimate that, for 2005, the global economic value of pollination was US$215 billion or 9.5 percent of the value of global food production.

Clearly, a convincing argument exists for the monetary value of pollination services. However, such services need to be further understood and documented so that they actually enter into decision-making. Farmers regularly take stock of what they spend on external inputs and assess the benefits; but few have the means to do so because of the 'hidden' costs and benefits of ecosystem services such as pollination. Furthermore, many academic valuation estimates have focused on the benefits of pollination to crop production alone and do not include all the benefits that pollinators provide to the economy and to farmers' livelihoods. A region´s wealth includes the financial, physical, natural, human and social assets that enhance development and sustainable rural livelihoods. Therefore, comparing the influence of pollinator-friendly, versus unfriendly, practices (or landscapes) using all these assets would allow a more robust approach to the valuation of pollinator changes and allow quantification of the synergies and trade-offs that are associated with pollinator enhancement. This protocol focuses on practices, and this is important, because recommendations that have been derived from it are directly applicable to decision-making processes.

There are four basic steps to implementing this protocol

Summary of the steps for valuation of agricultural practices

1) Experimental design: define a contrast.
2) Multiple dimensions of socio-economic value: define several (at least three) variables per asset and the method (feasibility) of obtaining information for each variable (questionnaires, GIS, databases).
3) Statistical analyses.
4) Supporting decision-making.

1 http://www.fao.org/3/a-i2442e.pdf
2 http://www.fao.org/3/a-at523e.pdf

STEP 1.
EXPERIMENTAL DESIGN: DEFINE A CONTRAST

Based on satellite images and landscape features, characterization of the experimental plots helps in the identification and selection of contrasting study sites (Table 1, Figures 1 and 2). For example, these can be landscapes dominated by crop monocultures (pollinator unfriendly) versus those planted with several crop species (friendly), or low (unfriendly) versus high (friendly) habitat diversity (Garibaldi *et al.*, 2011; Kennedy *et al.*, 2013). An aspect to bear in mind is that areas providing resources for wild bees usually also provide them for managed pollinators (e.g. honey bees). In general, the following aspects define a pollinator-friendly site (i.e. higher species richness of flower-visitors (Garibaldi *et al.*, 2014):

- High complexity (diversity, heterogeneity) of habitats (different types of habitats).
- High habitat quality (not only natural).
- Low or no presence of pesticides.
- High within-field plant biodiversity (e.g. having abundant and diverse weedy plants)

Table 1

EXAMPLE OF GENERAL SITE CHARACTERIZATION IN ORDER TO SELECT CONTRASTING STUDY SITES.

STUDY SITE CHARACTERISTICS	
Main primary activity	I.e. Main crop grown.
General characteristics of the landscape	E.g. What other crops are grown? What is the typology of the natural habitat surrounding the landscape? Is livestock present? If so, which? Which are the primary pollinators (e.g. Africanized honey bees, stingless bees, midges)?
Scale	Describe the landscape and scale (e.g. each landscape is a drainage basin of approximately 5 x 5 km²).
Scope	Describe the scope, e.g. rural landscapes with more than 10 % of 'x' crop and less than 10 % of urban area.
Friendly vs. Unfriendly	Complexity of habitats, agricultural practices.

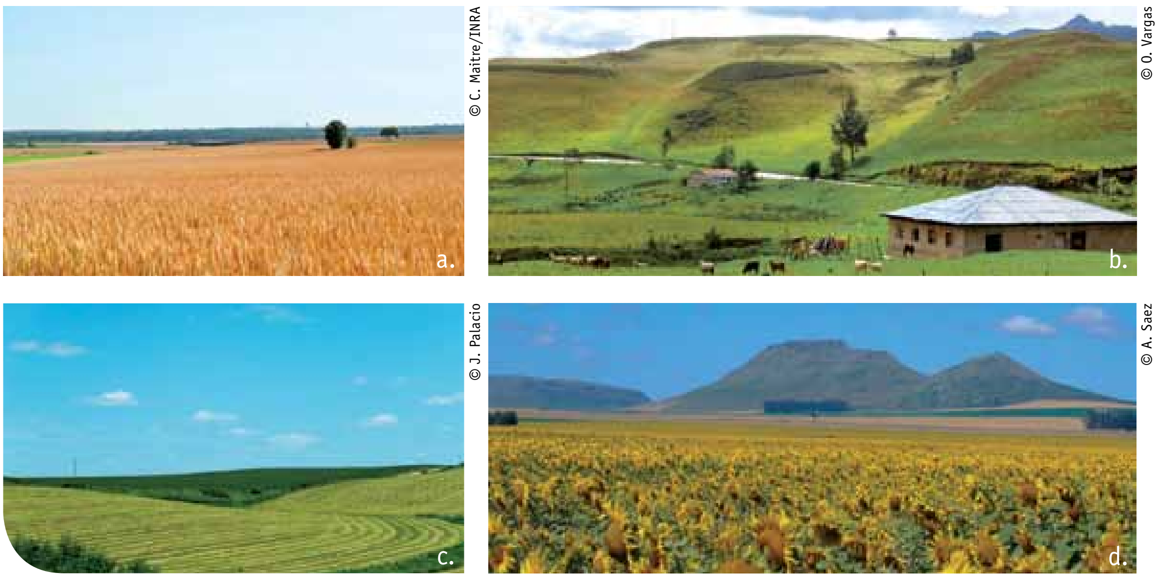
In statistical terms, there are at least two treatments (friendly *versus* unfriendly), each with several replicates. The number of replicates depends on the desired precision, selected confidence, and the variability among landscapes (Anderson *et al.*, 2008). Replicate numbers can be determined using standard statistical procedures (Anderson *et al.*, 2008). It is recommended that at least 10 replicates are done per treatment (thus an assessment should cover a minimum of at least 20 landscapes).

Figure 1

EXAMPLES OF POLLINATOR-FRIENDLY PRACTICES/LANDSCAPES: A) WEEDS CLOSE TO NATURAL FIELDS IN SWEDEN; B) GOATS WEEDING THE COFFEE FARM INSTEAD OF USING MACHINES IN BAHIA, BRAZIL; C) NATURAL AREAS CLOSE TO GUARANÁ PLANTATIONS IN AMAZONAS, BRAZIL; AND D) SMALL FARMS IN COLOMBIA.

Figure 2

EXAMPLES OF POLLINATOR-UNFRIENDLY PRACTICES/LANDSCAPES: A) MONOCULTURE FIELDS IN FRANCE; B) GRASS AREAS IN COLOMBIA WITH LOW DIVERSITY; C) MONOCULTURE OF A CORN FIELD IN NEBRASKA, UNITED STATES; AND D) SUNFLOWER MONOCULTURE IN ARGENTINA.



This section provides a framework to value different practices, and hence the user needs to choose the contrast that is most useful (relevant) to their specific objectives (e.g. assess landscapes providing resources for honey bees versus those that do not provide resources for honey bees, or compare fields where pesticides are applied without regard to pollinators versus pesticide-free cultivation). It may be of interest to contrast several practices that are pollinator-friendly, versus several practices that are not, if this answers a question around the value of different systems of farming.

The design implies an observational experiment, in contrast to manipulative experiments (Hulbert, 1984). In manipulative experiments, the treatments (pollinator-friendly versus unfriendly designs) are randomly assigned to the experimental units (for example, farms or landscapes). These experiments can establish causal relations (i.e. the effects of treatments on response variables); however, in many circumstances, they are not feasible (or ethical). Manipulative studies therefore are rarely employed in socio-economic valuations.

On the other hand, observational experiments can be set up in real-world rural landscapes, but evaluate statistical associations between treatment and response variables (not necessarily causal). Briefly, this design allows the user to evaluate if pollinator-friendly practices have a different socio-economic value than pollinator-unfriendly practices. The design, however, does not provide information on whether higher socio-economic value is a result of the agro-ecological design (e.g. pollinator-friendly practice), or vice versa (e.g. a higher socio-economic value determining a higher capacity to implement a pollinator-friendly design), or a win-win scenario (e.g. positive feedback between agro-ecological design and socio-economic value). The information provided by this protocol is of great importance for policy decisions. For example, the protocol will allow the user to detect if landscapes with more natural assets share fewer financial assets and, therefore, to correct for the financial deficit through payment for ecosystem services programmes (Zheng *et al.*, 2013).

The general idea is to choose farms (or landscapes) based on a priori knowledge and GIS information that differ greatly in the degree to which they support pollinator richness (Step 1). This information can be updated with field data and questionnaires (Step 2) to create a composite, quantitative index of the number of pollinator-friendly practices applied in each farm (or landscape). This index would provide robust information (Step 3) for guiding the decision-making processes (Step 4).

STEP 2.
MULTIPLE DIMENSIONS OF SOCIO-ECONOMIC VALUE

As described in Section 3 (Valuation framework), socio-economic values are considered to be multi-dimensional, including human, natural, social, physical and financial assets. The sustainable livelihoods framework provides a general structure that needs to be modified and adapted to ensure that it is appropriate for use with existing local circumstances and priorities (objectives).

Once the contrast has been defined, the relevant variables must be selected, data sources must be identified and instruments for the collection of data must be prepared and administered. Data gathered will comprise the database to be analysed (see Step 3: Statistical analyses).

a) Variables selection: adapt the framework to the specific conditions of your system

At least three variables per asset need to be selected. In particular, variables with a direct relation to pollinator-friendly practices (whether they are a result of the agro-ecological design or determinants of adoption of practices) should be looked for (see Step 1: Experimental design). Hypothesis and predictions should be clear before data sampling. For example, the idea that pollinator-friendly landscapes may increase health because of lower use of agrochemicals may justify human health measurements as part of the human assets (see below).

Different variables may be selected for different regions and socio-economic conditions. Researcher judgment and previous knowledge of the study context are important for selecting which variables are considered the most important within each asset and to determine how they should be measured. Below is a non-exhaustive list of variables and examples of elements for questions to ask for each of the assets described in the sustainable livelihoods framework. New variables should be added to that list and the unit of analysis should be adapted, as appropriate, to the individual assessment.

HUMAN ASSETS

Variable	Sample questions
Educational level	What is the highest level of education attained? Responses would be measured using an ordinal variable with the following values: (1) primary school completed or attended; (2) 1 – 4 years high school completed; (3) 5 – 6 years high school completed;(4) trade apprenticeship or technical qualification completed; and (5) university or other tertiary level of education completed (Tayyib *et al.*, 2007; Nelson *et al.*, 2010; Antwi-Agyei *et al.*, 2012). To measure this variable at the landscape level, one may calculate the percentage of each of the values or select the percentage of the value that is found to be more relevant (for example, the percentage of the producers that have attained levels 4 or 5). A similar procedure can be used for the other variables below.
Health status	Has any member of this household been ill (i.e. needing hospital treatment) in the last 6 months? Is there local (within the landscape) medical assistance? (Antwi-Agyei *et al.*, 2012). This may be measured directly by other methods, e.g. irritation, report of illness as a result of pesticide use.
Nutritional outcome	Yearly energetic value of primary and secondary production, per hectare or per kilogram.
Dietary diversity	Vitamins, antioxidants, minerals, essential amino acids and nutrients of primary and secondary production (e.g. using United States Department of Agriculture (USDA) data for nutritional composition of crops) (Eilers *et al.*, 2011).
Number of households	Number of households present on the site.
Labour status	Employed, unemployed and/or inactive inhabitants (Tayyib *et al.*, 2007).
Status in employment (A)	Self-employed, or employed.
Status in employment (B)	Full or part-time employment (Plagányi *et al.*, 2013).
Livelihood diversification	Number of livelihood activities that contribute to household income.
Pollination knowledge	E.g. knowledge of pollination: which insects visit the production area; of what a pollinator is; and the importance of pollinating insects for crops.
Beekeeping experience	Degree of experience they have with beekeeping (e.g. number of years of experience with beekeeping).

NATURAL ASSETS

Variable	Sample questions
Number of pollinator-Friendly practices	Compose an index that measures the number of pollinator friendly practices applied in the landscape. The index would have positive values for the pollinator friendly practices (e.g. holdings having beehives for pollination services in the productive area; having pollinator forage in the form of native bush or other crops or conservation areas; increasing pollinator accessibility to crops as, for example, the presence of water containers), and would have negative values (so, would be subtracted in the index) for practices that are detrimental to pollinators (e.g. use of chemical products; destroying wild pollinator colonies in the productive area; monoculture systems).
Landscape complexity	Several standard indices are available for land-use composition (richness, evenness and diversity of landscapes – e.g. those that quantify the composition of the map without reference to spatial attributes); and configuration (patch area and edge, patch shape complexity, core area, contrast, aggregation, subdivision, isolation – e.g. those that quantify the spatial configuration of the map, requiring spatial information for their calculation). Each category contains a variety of metrics for quantifying different aspects of the pattern. It is incumbent upon the investigator or manager to choose the appropriate metrics for the question under consideration (Mcgarigal, 2013; see also Kennedy *et al.*, 2013). The definition of the range in which the complexity is measured is important, because the effect of the variables is scale-dependent. For example, landscape complexity may be assessed on a farm, or it may be assessed in a circle around a farm with a radius of one kilometer.
Wildlife	As a proportion of natural (or semi-natural) habitats, as well as diversity of these habitats. Possibly highly correlated with complexity (depends on the index).
Crop biodiversity	Number of crops.
Ecosystem services	Services provided by agricultural landscapes not necessarily related to primary or secondary production (e.g. aquifer recharge, water quality improvement, carbon fixation, reduction of soil erosion). It is suggested that two 'key' ecosystem services should be chosen. There should be a relation between the chosen service and pollination provision.

TABLE FOLLOWS ON THE NEXT PAGE >>

FINANCIAL ASSETS

Variable	Sample questions
Profit per crop per hectare	Income versus costs: kg ha^{-1} produced per crop; kg ha^{-1} sold per crop (produced - sold = consumption); main costs (fertilizers, etc.); price at which sold (Grieg-Gran and Gemmill-Herren, 2012).
Access to credit	Access to credit for farmers' agricultural activities (Antwi-Agyeiet *et al.*, 2012).
Ownership of livestock	The types and numbers of livestock (including poultry) (Antwi-Agyeiet *et al.*, 2012).
Other income	Amount of income from sources other than the farming activity, received in the last year (remittances from family or friends; work abroad from the farm) (Antwi-Agyeiet *et al.*, 2012).
Income from tourism	Current or potential.

PHYSICAL ASSETS

Variable	Sample questions
Ownership of honey beehives	Holdings that own beehives, or number of honey-bee hives.
Irrigation facilities	Access to irrigation facilities.
Agricultural machinery	Use machinery in the productive cycle; annual expenditure on machinery.
Fertilizers	Expenditure on the use of fertilizers.
Pesticides	Expenditure on the use of pesticides (Tayyib *et al.*, 2007).
Economically active population	Number of people of working age on the farm, disaggregated by gender.
Workers	Number of working days per year and number of family/hired workers (Grieg-Gran and Gemmill-Herren, 2012).
Infrastructure	Availability of roads, ports.

SOCIAL ASSETS

Variable	Sample questions
Number of groups or associations present in the landscape (relative to the number of farms)	Membership in a group provides an indication of a linking form of social asset, the horizontal connections between socially similar groups through which ideas, resources and opportunities flow (Nelson et al., 2010; Antwi-Agyeiet *et al.*, 2012).
Tenure system	Type of arrangements for access to farming activities (e.g. owner, partner, occupant, employee).
Partners	Number of partners (non-family) running farm business. This variable provides an indicator of the bonding form of social assets, the kind of local social asset that provides support in times of hardship and enables individuals to take advantage of opportunities (Nelson et al., 2010).
Services from outside	Are services hired from outside the farm or landscape (e.g. for harvesting)? Cost of hiring services from outside the landscape.
Availability of extension service	Number of days per year that a professional from an extension service is available on the farm for technical assistance or other activities.
Access to Internet	Internet access availability. Access to the Internet is an indicator of the linking form of social asset – vertical or horizontal connections that provide access to ideas and resources between economically and socially differentiated groups (Nelson *et al.*, 2010).
Organization for production and commercialization	Is production/commercialization carried out collectively?

b) Data sources

Data can be obtained from *regular questionnaires* performed by governmental agencies, *GIS databases* and from *questionnaires specially prepared for this purpose*. Bear in mind that when preparing the questionnaire, questions will need to be formulated in an inquisitive, but polite, fashion. Responses with ranges, instead of detail of exact values, are recommended in order to reduce non-responses. In addition, a pilot sampling is very important so as to refine the questions before administering the questionnaire in heterogeneous sites (i.e. pollinator-friendly and unfriendly sites). It is good practice to ask more questions than those that will be analysed, so that the best variables can be selected later (but not too many). Administering the questionnaire should not take more than half an hour per farmer – remember human ethics.

c) Data collection

The sample of survey respondents should be selected randomly from GIS or other locational data. Thus, it may have been decided to compare a farming region with small and diverse farms that largely produce for an organic market against a nearby region of large monocultures. The data on which this comparison is based (average farm size, for example) should be collected and documented such that the two comparative sites can be described by aggregate statistics (mean, variance, skewness, equity, etc.).

Questionnaires should be applied preferably to the decision-maker or person with knowledge of how the farm operates. Here, the researchers may find different groups to compare within the community (e.g. beekeepers and farmers, gender comparisons). Face-to-face interviews are recommended in order to reduce non-responses. Trustfulness and empathy of the researcher are also important in collecting more reliable answers. In many places local governmental professionals advise farmers and already know them, so they should be involved to help when contacting the farmers. The information gathered can be useful for future programmes – for example, to pay the farmers for ecosystem service delivery – so farmers could be incentivized to respond to the questionnaires (Zheng *et al.*, 2013).

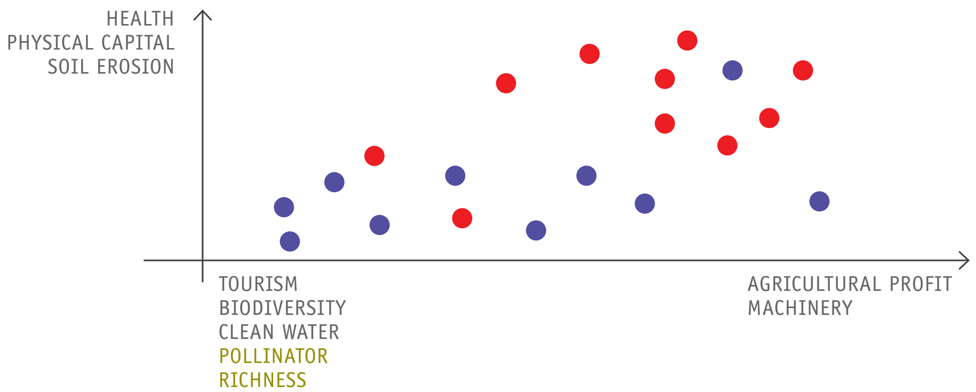
The survey should take as much as up to one month in total, considering the selection of variables that are conceptually relevant and the 20 sites as minimum (at least 10 replicates per treatment, as recommended in Step 1). Annex 3 suggests a data sheet format.

STEP 3.
STATISTICAL ANALYSES

Information gathered on the different variables (in Step 2) should be integrated and analysed using standard multivariate statistics. Examples include principal component analyses or correspondence analyses. Multivariate statistics are powerful, and provide useful information for socio-economic analyses, instead of having a general index. In this way the co-variation among different conceptually relevant variables is quantified (Figure 3) to understand synergies and trade-offs among livelihood assets (see Section 3: Valuation Framework). It is important to note that, for example, if one asset has very low values, this can limit sustainable livelihoods, despite the very high values of the other assets. Therefore, the balance among all assets is important.

Figure 3

EXAMPLE OF A POSSIBLE RESULT OF PRINCIPAL COMPONENT ANALYSIS.



Adapted from L. A. Garibaldi

STEP 4.
SUPPORTING DECISION-MAKING

Quantification of the socio-economic value of agricultural practices can make important contributions to decision-making processes and the design of subsequent interventions. In relation to the questions outlined in Section 2 (Objectives of this protocol), the protocol may provide some answers, for example, indicating which type of asset (human, social, physical, financial or natural) should be strengthened in order to enhance pollinator-friendly practices in a region. The protocol can also help to identify opportunities to enhance limiting factors.

Further, it could provide a solid argument for conservation, in cases where no negative relation is found between natural assets and economic revenue of the producers, since this suggests that it is possible to enhance pollinators without losing economic benefits (i.e. absence of trade-off between natural and financial assets). Moreover, pollination could even enhance the productivity of some crops (i.e. synergies may exist between natural and financial assets).

SECTION 5 EXAMPLES OF SUCCESSFUL APPLICATION

This section provides examples from case studies in Brazil (coffee, cashew and cotton) and Kenya, where the socio-economic analysis was applied. Different variables (derived from the questions) were used according to the specificities of each locality.

EXAMPLE 1. BRAZIL (COFFEE, CASHEW, COTTON)

Coffee

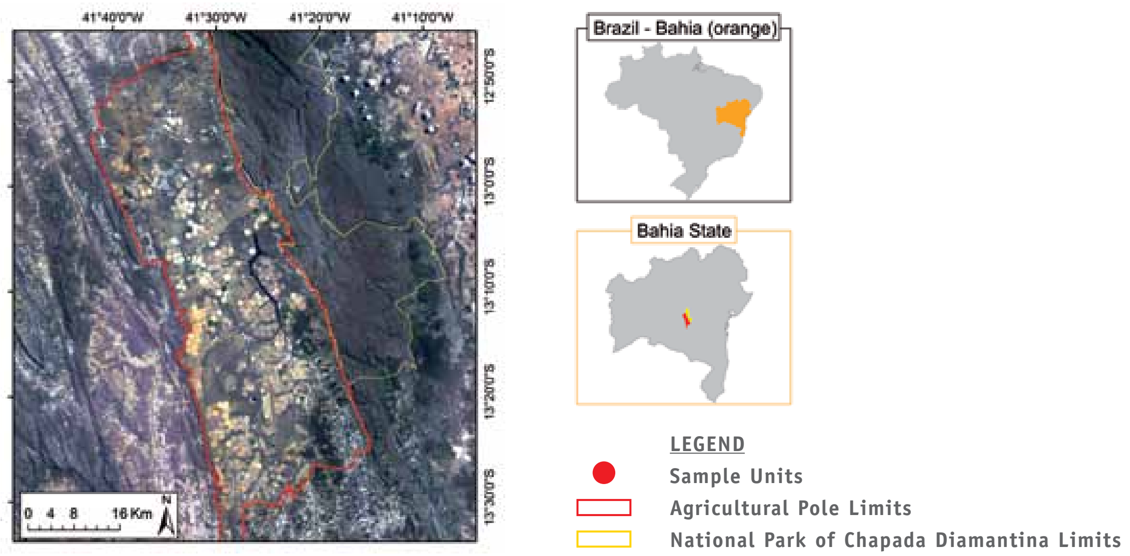
In 2014, this protocol was applied at the landscape scale on coffee farms in Bahia, Brazil. Sustainable livelihoods and human well-being depend on multiple anthropogenic and natural assets. However, the simultaneous impact of land-use decisions on these assets is often ignored. This example studies how the number of pollinator-friendly practices co-vary with natural (pollinator richness) and anthropogenic assets (human, physical, social, and financial) in order to quantify the multi-dimensional value of such management decisions, and to understand the synergies and trade-offs among relevant socio-economic variables on the coffee farms of Chapada Diamantina (Bahia, Brazil).

Step 1: Experimental design: define a contrast

Study sites included an area of intensive agriculture and high production (total area, productivity and quality) of coffee, potatoes, tomatoes and strawberry, among others, but also bordered one of the National Parks in Chapada Diamantina (Figure 4). The region is markedly dominated (80 %) by small (< 20 ha) coffee farms, but there are also medium (20 – 200 ha) and large farms (> 500 ha), corresponding to over 2 000 farmers (Seagri, 2002) on 11 250 ha of cultivated coffee (IBGE, 2013).

Figure 4

MAP OF THE AGRICULTURAL AREA OF CHAPADA DIAMANTINA IN BAHIA, BRAZIL. YELLOW AND RED LINES INDICATE THE BORDERS OF NATIONAL PARK OF CHAPADA DIAMANTINA (YELLOW) AND THE AGRICULTURAL REGION (RED).



Adapted from E. F. Moreira

Table 2

CHARACTERIZATION OF POLLINATOR-FRIENDLY AND UNFRIENDLY COFFEE LANDSCAPES IN CHAPADA DIAMANTINA, BAHIA, BRAZIL.

MAIN PRIMARY ACTIVITY	Coffee
GENERAL CHARACTERISTICS OF THE LANDSCAPE	Potato and coffee are the main crops in the region, although others can be found such as tomato and passion fruit. Presence of semi-natural habitats, many streams, some livestock, wild and Africanized honey bees, etc.
SCALE	Each landscape represents an area having a radius of approximately 200 m.
SCOPE	In each landscape coffee farms vary from 1 to 110 ha and natural (semi) natural areas range from 15 to 93 % of landscape areas.

CHARACTERISTICS THAT DEFINE LANDSCAPE	POLLINATOR FRIENDLY	POLLINATOR UNFRIENDLY
Beehives	Native or *Apis mellifera*	No
Pesticide use	No use or only when necessary (low use)	High
Weed control	Partial manual weeding	Total weeding
Organically certified	Yes	No
Hedges	Present	Absent
Crop richness	Presence of non-coffee crops (diversification)	Only coffee present (monoculture)

Step 2: Multiple dimensions of socio-economic valuation

Define several (at least three) variables per asset and the method (feasibility) of obtaining information for each variable (questionnaires, GIS, databases).

A standardized questionnaire was elaborated and tested in face-to-face meetings with twelve of the thirty farmers who ultimately responded to the final questionnaire (Annex 1). Some questions were excluded that were too general or inadequate. The final questionnaire included approximately five questions per asset. For statistical analyses, variables included not only those from questionnaires, but also variables obtained by GIS, such as the percentage of natural areas around the farm (Table 3). This allowed for more reliable data, as producers did not always have all the information per farm (when they possess more than one farm), or did not know the percentage of natural areas around the farm (small-scale farmers).

Table 3

SELECTED VARIABLES FOR COFFEE LANDSCAPES ANALYSIS.

VARIABLE	HOW?	WHY?
Human asset		
Education level	What is your highest educational level?	More formally educated farmers could practice more pollinator-friendly practices.
Management capacity	What are your functions on the land? Are they related to agronomic activities or administration activities?	Undoubtedly, this is a difficult variable to measure, but it should address the fact that farmers have different management capacities, some may be derived from other than formal education (as noted above), but it is important how their knowledge is applied; equally farmers with no formal education often have a higher capacity to manage and innovate on their farms.
Family structure	How many people in your family work on activities that are directly related to the farming activities?	Knowing the family structure and the number of people contributing to income may also reveal the number of women working the land, since not many are formally responsible for the farm.
Bee knowledge	Do you know if bees are important for coffee?	To observe if there is any pollination or management knowledge directly related to bees.
Natural asset		
Conservation	Percentage of natural area within 200 m around the farm.	This is a variable that has been shown to enhance pollination services and can be fairly easily gathered by GIS.
Forest Reserve	Do you implement the governmental requisite of forest reserve?*	To complement GIS information and analyse if forest reserves are close to the coffee area and can support ecosystem services (pollination).

TABLE FOLLOWS ON THE NEXT PAGE >>

Flower visitor richness	Richness of flower visitor species collected through net sampling on coffee farms (flowering period).	To understand if pollinator-friendly practices effectively enhance pollinator diversity.
Financial asset		
Production per crop per ha	How many crops per hectare? What is the amount of production per hectare?	Some caveats on determining this: This is related to area in coffee production, however the same number of plants are not always found in a given area (crop density), so both are important.
Other income	Is farming your main occupation? Do you have other employment, or receive any other form of income (e.g. government benefits, retirement, etc.)?	To analyse with other type of income not directly related to coffee management.
Area	What is the total farm area planted with coffee?	To measure production.
Physical asset		
Irrigation	Do you use any type of irrigation system?	To consider farm investments that could improve productivity.
Production system	Do you have any machinery? Which fertilizers and how much is used?	To consider farm investments that could improve productivity.
Improvements	What kinds of farm improvements have been made to increase coffee sales? (e.g. investment in post-harvest equipment such as for drying coffee, or for coffee selection)	To consider equipment that could lead to higher value of the final product.
Social asset		
Associations	Are you a member of any association?	To demonstrate potential social alliances.
Extension	Do you interact with professionals from extension services? If so, which extension services and how often?	The presence of extension services should lead to higher productivity and (or) sustainable management (benefits to the producer).
Sales	How do you sell your products? (Alone, with partner, etc.)	To demonstrate potential social alliances and their relationship to the product´s value. More alliances should lead to higher probability of selling the products (within the region or for exportation), especially to smallholders.

Step 3: Statistical analyses

Variables included were of different types: quantitative (continuous or discrete), such as the number of years of formal education; and categorical, such as the type of work related to land work or administration. The influences of socio-economic variables (predictor variables) on the number of pollinator-friendly practices (response variable) was analysed using a generalized linear model (glm function, R software).

* In Brazil such 'set asides' are mandatory. Called *Reserva Legal* (legal reserves), a portion of each property or settlement must have an established area for the conservation and rehabilitation of ecological processes and biodiversity, protection of the native fauna and flora, and sustainable use of natural resources (such as rubber extraction or Brazil nut harvesting in the Amazon forest). Thus, the *Reserva Legal* must be a natural area with indigenous species, managed in a sustainable way. The size of the *Reserva Legal* varies according to the biome in which it is found.

Results

Pollinator-friendly and unfriendly landscapes, as defined in Table 2 (Figure 5 and 6), were represented by a gradient of values, ranging from no application of pollinator-friendly practices (value = 0) to the application of many pollinator-friendly practices (value = 5). Importantly, flower-visitor species richness increased with the number of pollinator-friendly practices (Figure 7), indicating that such classification was effective.

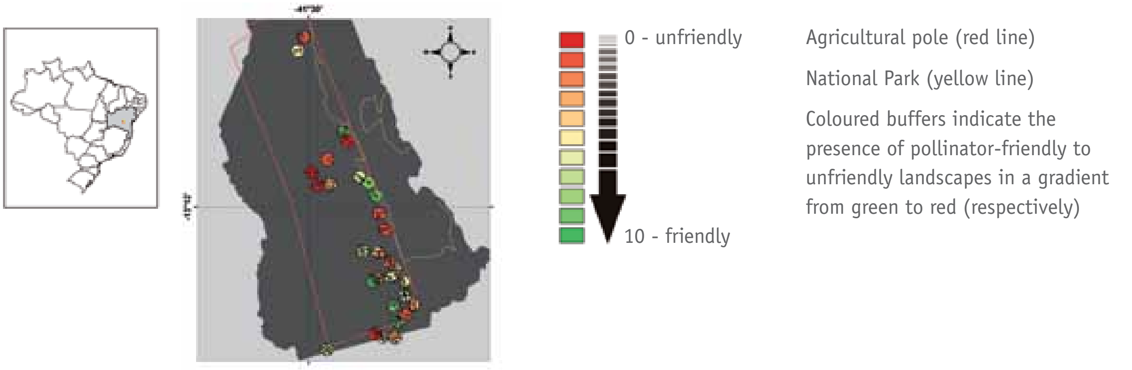
Figure 5

EXAMPLES OF POLLINATOR-FRIENDLY AND UNFRIENDLY PRACTICES USED BY COFFEE FARMERS IN CHAPADA DIAMANTINA, BAHIA, BRAZIL.

Pollinator-friendly practices (left): a) nest of *Melipona quinquefasciata* (Lepeletier); b) presence of flowers other than coffee (by partial weeding); and c) hedgerows: sources of food and nesting sites for pollinators. Pollinator-unfriendly (right): d) high pesticide use; e) total weeding and exposed soil; and f) coffee monoculture.

Figure 6

GENERAL OVERVIEW OF POLLINATOR-FRIENDLY AND UNFRIENDLY COFFEE LANDSCAPES AT THE AGRICULTURAL POLE AND CLOSE TO THE NATIONAL PARK OF CHAPADA DIAMANTINA IN BAHIA, BRAZIL.

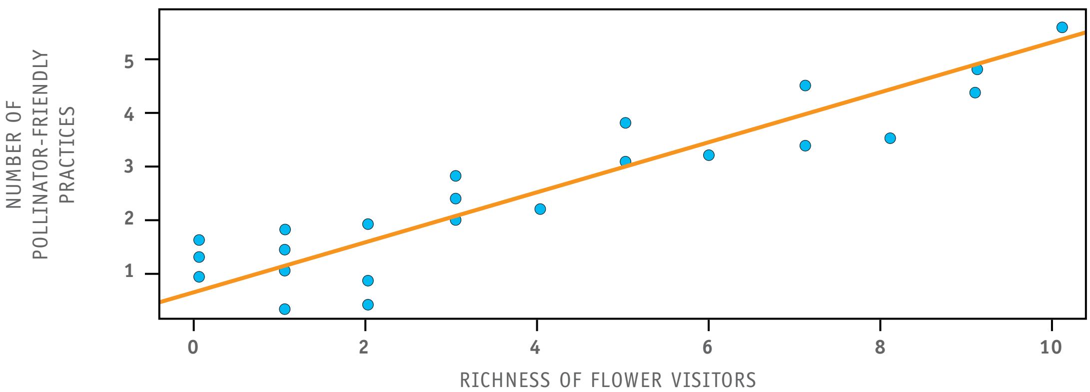


Adapted from J. Hipólito

Several socio-economic variables predicted the number of pollinator-friendly practices applied by coffee producers. A higher number of pollinator-friendly practices resulted in both enhanced flower-visitor richness (natural asset) and coffee yield (bags ha^{-1}) (financial asset). Farmers who dedicated the majority of the work force to land-use practices, compared to administrative work, engaged in more pollinator-friendly practices on their farms. The results highlight that land-use decisions oriented towards enhancing natural assets can also provide the highest levels of financial assets. Therefore, in general, these findings highlight the possibility of generating win-win scenarios between biodiversity and production and the producer's profitability.

Figure 7

FLOWER-VISITOR SPECIES RICHNESS INCREASES WITH THE NUMBER OF POLLINATOR-FRIENDLY PRACTICES IN COFFEE LANDSCAPES IN CHAPADA DIAMANTINA, BAHIA, BRAZIL (R2=0.3147, P<0.001).



Adapted from J. Hipólito

Step 4 – Supporting decision-making

Preliminary results of this work were first presented to stakeholders at a public hearing, held at the House of Councillors in the city of Mucugê, Bahia State, and later to decision-makers at a workshop in Brasília-DF (Figure 8). Sixty-one people attended the event in Mucugê, including representatives from governmental and non-governmental organizations, civil society and farmers, who discussed the development of a Participatory Action Plan for the management and conservation of pollinators in Chapada Diamantina. This public hearing was very important for exchanging information on the importance of pollinators in both environmental and economic terms, highlighting the social and economic value of pollination, and establishing the main guidelines for the Action Plan. Moreover, experiences were also shared on pollinator-friendly and unfriendly practices, which raised awareness of some best practices for sustainable agriculture. During the meeting in Brasilia, it became clear that the socio-economic analysis of pollination complements the specific studies on pollinators in agriculture. Therefore, implementation of a regional programme of incentives for farmers is feasible, to encourage them to adopt pollinator-friendly farming practices that favour pollinators and pollination, such as the enrichment of bee pasture and crop diversification, and to link conservation and food production in the region.

Figure 8

SUPPORTING DECISION-MAKING, BRAZIL: (A) PUBLIC HEARING IN MUCUGÊ, BAHIA STATE; AND (B) WORKSHOP FOR DECISION-MAKERS IN BRASILIA-DF.

Cashew

The protocol was applied to cashew in the States of Ceará, Piauí and Río Grande do Norte in Brazil. The survey targeted 162 producers and the sample stratified by the area allocated to cashew production (< 5 ha; 5 – 20 ha; 20 – 100 ha; >100 ha) **(Step 1)**.

The number of pollinator-friendly practices was a quantitative variable constructed on the basis of producer responses to the following questions: (a) Are there managed pollinators in the productive area? (b) Is there forage for pollinators available (in the form of native bush or other crops)? (c) Do you use chemical products on your farmland? (d) How do you manage beehives, and what do you do with the wild colonies in the productive area? and (e) Do you contribute to increasing pollinators' accessibility to crops (for example, through the presence of water containers in the productive area)? **(Step 2)**.

Findings highlight the positive socio-economic value of pollinator-friendly practices. Results show that the producers' experience in beekeeping is important to enhance the number of pollinator-friendly practices, emphasizing the benefits of promoting human assets among producers, especially knowledge of apiculture, which also contributes to diversification of the productive structure of landscapes **(Steps 3 and 4)**.

Cotton

In 2014, the protocol was applied to cotton farms in Brazil. The survey targeted 100 producers in three municipalities (Apodi, Janduís and Nova Descoberta, in the State of Río Grande do Norte) **(Step 1)**.

The number of pollinator-friendly practices was a quantitative discrete variable constructed on the basis of the producers' answers to the following questions: (a) Do you have conservation areas on your property?; (b) What do you do with wild plants in the productive area?; (c) Do you have beehives for pollinator services?; (d) Do you use chemicals? (In general and in particular during the flowering period); (e) Do you implement any alternative disease control method?; and (f) Is your production a monoculture? **(Step 2)**.

Findings highlight the positive socio-economic value of pollinator-friendly practices. Results show that landscapes with more pollinator-friendly practices are associated with higher natural, financial, physical and social assets. In addition, the number of pollinator-friendly practices increased when producers implemented an organic system of cultivation and had beehives for pollination services on their properties (both physical assets). Overall, for this crop, the pollinator friendly practices were related positively to four of the five assets. These results suggest that the conservation of natural asset is not related to lower financial outputs (i.e. agronomic yields and income can increase through sustainable pathways that do not destroy the natural asset) **(Steps 3 and 4)**.

EXAMPLE 2. KENYA

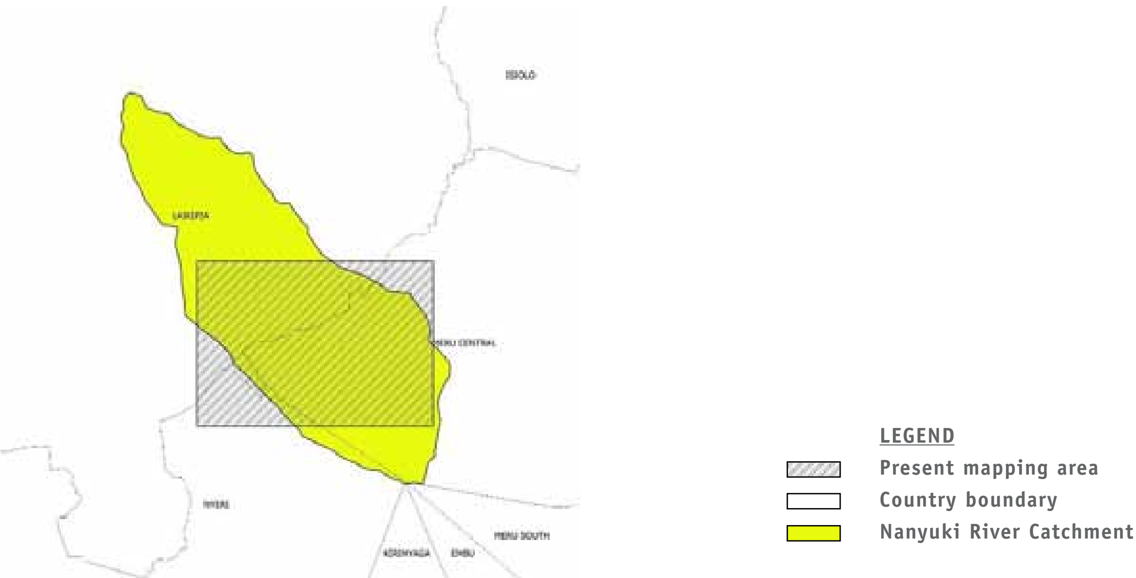
STEP 1: Experimental design: define a contrast

In 2015, the protocol was applied in Kenya. The study was carried out in a large catchment area, northwest Mount Kenya forest across two counties: Meru (near the forest edge) and Laikipia (further from the forest edge) (Figure 9). The area chosen hosted one of the Study, Training, Evaluation and Promotion (STEP) sites for the GEF/UNEP/FAO Global Pollination Project in Kenya. The area comprises small-scale farms growing a mixture of crops – both annuals and perennials – and large-scale farms of wheat and horticultural establishment. Within the catchment, twenty landscapes were identified – ten each, representing pollinator-friendly and unfriendly landscapes, respectively.

The choice of the landscape was based on the assessment of satellite data using imagery information, using 14 classifications (Figure 10). These were verified in the field and adjusted accordingly to reflect the description of pollinator-friendly landscapes. Open grassland, cropped area (dry) and barren land were categorized as unfriendly. Verification was carried out to ensure those classified as pollinator-friendly showed high habitat complexity.

Figure 9

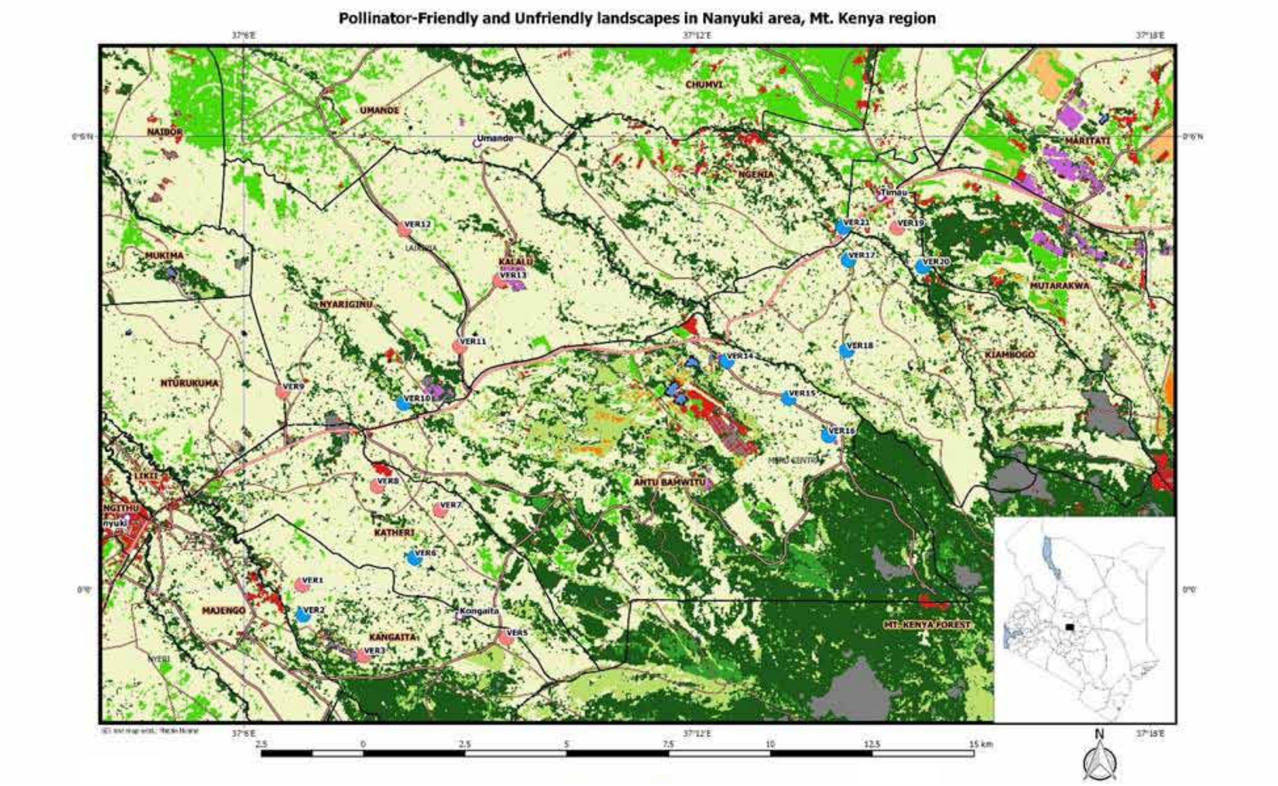
MAPPING AREA FOR THE LANDSCAPE STUDY, KENYA.



Adapted from M. Nyamai

Figure 10

SELECTED SAMPLING SITES FOR FIELD DATA COLLECTION AT NORTHWEST MOUNT KENYA FARMLAND, KENYA.



	LEGEND				KEY
■	Closed natural forest	■	Cropland (other)	●	Friendly landscape
■	Closed planted forset	■	Bare land	●	Unfriendly landscape
■	Closed trees	■	Water body	○	Town/market
■	Closed shrubs	□	Cloud	- - -	Administrative boundry
■	Open grassland	■	Cloud shadow	—	Trunk road
■	Cropland (planted)	■	Grassland	—	All weather road
■	Cropland (dry crop or harvested)	■	Built-up area	—	Other road

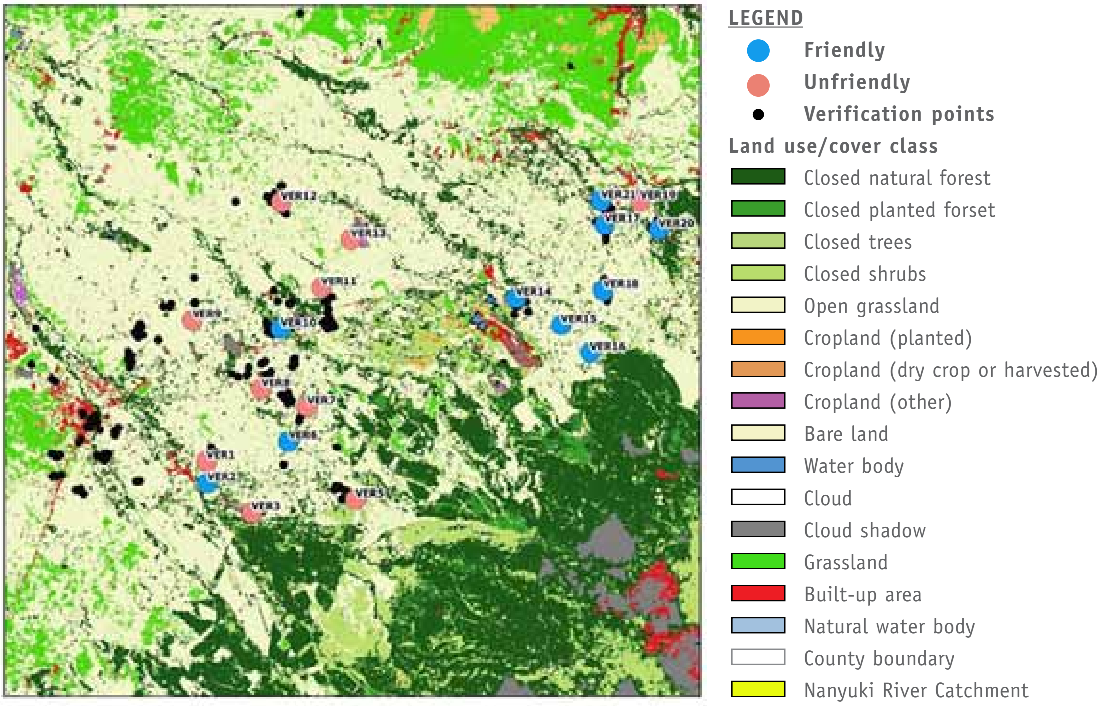
Adapted from M. Nyamai

STEP 2: Multiple dimensions of socio-economic value

After verification of the sites, a household survey was carried out that targeted 12 households per landscape (Figure 11). The household survey (see Annex 2), which incorporated all the five livelihood assets, covered 240 households in 20 landscapes. One questionnaire was lost, giving a total of 239 households. Farmers were requested to provide information about their human, social, natural, financial and physical assets in a face-to-face interview.

Figure 11

SELECTED SAMPLING SITES FOR FIELD DATA COLLECTION AT NORTHWEST MOUNT KENYA FARMLAND, KENYA.



Adapted from M. Nyamai

Table 4

SELECTED VARIABLES FOR SOCIO-ECONOMIC ASSETS IN KENYA.

VARIABLE	HOW?	WHY?
Human asset		
Education level	Highest level of education of a family member/total years of education per household.	More formally educated farmers have a higher probability of practicing pollinator-friendly practices.
Ability of household to support employment	Number of people employed by the household.	Knowing the family structure, and the number of people contributing to income, may also reveal the number of women working the land, since not many are formally responsible for the farm.
Health	Number of persons with poor health/ distance (m) to the nearest health facility.	Better health contributes to the productivity of labour and capacity to manage land.

TABLE FOLLOWS ON THE NEXT PAGE >>

Experience	Number of years of experience in various farming enterprises.	Farmers have different capacities to manage and innovate on their farms, some of which may be derived not only from their formal education (as noted above) but how it is applied and their experience.
Specialized skills	Number of specialized skills per household.	To observe if there are any pollination or management skills related to bees, agronomic or administration activities that could increase capacity to manage land.
Natural asset		
Wildlife	Diversity of wildlife during interviews.	Records of higher wildlife activity within the homestead (where the interview occurred) is an indicator of either species richness in the area, or lack of safer sites for wildlife on the farmland.
Diversity of crops	Number of crops (and area) grown on the farm.	Mixed crop types increase pollinator richness, because plant species provide complementary resources over time and space, and insect species use different resource combinations.
Conservation	Percentage non-cropped/distance to neighbouring natural ecosystem.	To analyse if natural areas are close to the crop area and can support ecosystem services (pollination).
Financial asset		
Farming Income	Gross income from crop farming, livestock, beekeeping and remittances.	To know the financial resources related to farming activities to which households have access.
Sources of income	Contribution of farming to income.	To analyse if the farmer depends only on farming-derived income or counts on other types of income that is not related directly to farm management.
Physical asset		
Irrigation	Dependence on water source.	To consider farm investments that could improve productivity.
Production system	Number of pesticides used/diversity of other pest control products/methods.	Applications of chemicals or other pest control methods that could affect pollination.
Expenditure production process	Money spent in a season for activities and inputs.	To consider expenditure of hiring labour and buying inputs that could improve production.
Availability of specialized labour	Number of beekeepers.	To observe if the availability of specialized beekeepers increases productivity or production.
Pollinator hives	Number of honey beehives (colonized).	Having beehives could enhance pollinator services in the area.
Diversity of farm Implements	Type and quantity of farm implements.	To consider equipment that could lead to a higher value of the final product.
Social asset		
Associations	Are you a member of any group or association?	To demonstrate potential social alliances.
Land tenure system	Portion of land under various tenure systems.	Households that own their land are able to invest in it, including aspects that are friendly to pollinators.

STEPS 3 and 4: Statistical analyses and supporting decision-making

An Analysis of Variance (ANOVA) was performed, to analyse the differences in the responses among friendly and unfriendly-landscapes. Results indicate that there are differences in some variables representing natural, human and physical assets. On the one hand, higher diversity of wildlife was recorded in unfriendly landscapes during the study period, possibly because limited habitat is available for these animals outside the homestead. Examples of wildlife observed include Carpenter bees, honey bees, birds, crickets, house flies, butterflies, lizards, beetles, locusts and wasps.

On the other hand, health facilities were located at greater distances from the households in the case of the friendly landscapes, which may increase family expenditure on health. Related to the physical assets, results showed that dependence on rainfall was higher in pollinator-friendly landscapes and that farmers located in pollinator-unfriendly landscapes depend more on farming to sustain their livelihoods compared with those located in pollinator-friendly landscapes. This indicates they are more vulnerable to declining pollinator populations, and it is advised that strategies are implemented that can increase the presence of pollinators in these landscapes.

Considering that the landscapes are intertwined in a community, the lack of clear differences in the two types of landscapes could be a result of shared community interests, including crop and livestock investment systems, and previous government interventions. For example in a catchment, both friendly and unfriendly landscapes are scattered with no particular pattern as to where they occur. It is common to have friendly and unfriendly landscape bordering each other) in a community. If no effort is made to prevent this, pollinator-friendly landscapes are likely to turn into pollinator-unfriendly landscapes. In addition, the GIS maps show a very high possibility of this happening, considering there are very few pollinator-friendly locations in the catchment area.

Previous studies in Kenya have shown that farmers and extension workers have limited knowledge about pollinators and they do not correlate pollination with food security or economic gains (e.g. Kasina *et al.*, 2009). Therefore, to benefit from pollinators, a clear extension message about pollinator management and conservation needs to be developed and implemented. This extension message can help counties that are currently the custodians of agricultural extension and development, based on the recent constitutional changes in Kenya. Such intervention should include pollinator-crop profiles and a pollinator management strategy, based on a catchment approach where pollinator conservation is not an individual household initiative but a community effort to stabilize their food and economic interests.

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ANNEXES

ANNEX 1.
QUESTIONNAIRE FOR SOCIO-ECONOMIC VALUATION OF POLLINATOR-FRIENDLY LANDSCAPES – COFFEE (BRAZIL)

Remember questions could be changed regarding your study sites and could include more or fewer questions per asset than presented here.

Code: ____________________

General Information

Name of respondent*:			
Date:		Data collector:	
Age:		Marital status:	
Property size:		Planted area:	
Crops:			
Main crop:			

*Any Information regarding a person´s identity should not be published without authorization; remember human ethics.

1. HUMAN ASSETS

1.1. What is your highest education level?

- ☐ None
- ☐ Elementary school
- ☐ High school
- ☐ College

1.2 Do any other family members help you on the farm? And what educational level do they have?

Educational level	Partner	Son/Daughter 1	Son/Daughter 2	Son/Daughter 3	Other:
None					
Elementary school					
High school					
College					

1.3. Do you know what insects visit your plantation?

- ☐ Yes
- ☐ No

Which one(s): ____

1.4. Do you know what a pollinator is?

- ☐ Yes
- ☐ No

1.5. Who takes farm decisions (main person)?

- ☐ Man
- ☐ Woman
- ☐ Sons/Daughters
- ☐ Joint decision

1.6. How many household/farm members and employees reported ill health last month?

Gender	Number
Male	
Female	

1.7. What is the distance (km) to the nearest health facility (dispensary, health care, etc.)?

2. NATURAL ASSETS

2.1. Do you have any beehives? How many?

Type	Number
Honey bees	
Stingless bees	

2.2. What are the most significant diseases on your crops?

2.3. Do you implement the governmental requisite of forest reserve?

- ☐ Yes
- ☐ No

2.4. Are there any wild animals on your property?

- ☐ Yes
- ☐ No

Which one(s): ____

2.5. Is there any natural ecosystem near the farm/household? (riverine, forset, grassland, public land with no building)

- ☐ Yes
- ☐ No

Which one(s): ____

2.6. What tupe(s) of soil do you have? (e.g. sandy, muddy, clay, red, black cootn, etc.)

3. FINANCIAL ASSETS

3.1. What profit is gained from each crop (on average)?

Crop	Area	Profit

3.2. Do you have access to credit, to finance rural activities?

- ☐ Yes
- ☐ No

Which one(s): ____

3.3. Is the rural activity your main function?

- ☐ Yes
- ☐ No

3.4. Do you have another job or income outside the farm?

- ☐ Yes
- ☐ No

Which one(s): ____

3.5. Do you have any type of certificate?

- ☐ Yes
- ☐ No

Which one(s): ____

4. PHYSICAL ASSETS

4.1. What type of water sources does your farm depend on?

Water source	Months in a year
Rainfall	
Irrigation	

4.2. If you enjoy irrigation facilities, which type?

Facility	Area covered or number
Drip	
Overhead	
Flooding	
Watering can	

4.3. What type and number of machinery do you have?

Machinery	Number
Tractor	
Oxen plough	
Disc plough	
Harrowing	
Hay-making machine	
Water pump	
Fodder shredder	
Knapsack sprayer	
Other:	

4.4. Is there any kind of transportation available for marketing your products?

- ☐ Yes
- ☐ No

Which one(s): ____

5. SOCIAL ASSETS

5.1. Are you a member of any association

- ☐ Yes
- ☐ No

5.2. How many days/year do you interact with professionals from extension services?

5.3. Do you have internet access? Is it helpful for your farm activities?

- ☐ Yes
- ☐ No

How: ____

5.4. How many households are there on the farm?

Households	Number
Male	
Female	

5.5. How many employees do you have?

Number of households	Male	Female
Permanent		
Temporary		

ANNEX 2.
QUESTIONNAIRE FOR SOCIO-ECONOMIC VALUATION OF POLLINATOR-FRIENDLY LANDSCAPES (KENYA)

Measuring value of pollination services through the landscape approach in Kenya.

These questions are meant to generate truthful information from farmers in Meru and Laikipia county where the Kenya Pollination Project has engaged farmers since 2010 and trained them on the usefulness of pollinators in their livelihoods. The results will be used to inform policy on how to enhance pollination service provision in the country. The report will not be based on individual responses and will not be individualized. Please provide us with truthful information.

QUESTION	PART 1: GENERAL INFORMATION			
1.1	Date			
1.2	Enumerator			
1.3	Start time			
1.4	Landscape location			
1.5	County			
1.6	Sub county			
1.7	Ward			
1.8	Area/village			
1.9	Coordinates			
	PART 2: CHARACTERISTICS OF SOCIAL ASSETS			
2.1	Name of respondent			
2.2	Position in the household/farm (household head, spouse, child, other)			
2.3	Age of respondent (number of years)			
2.4	Number of households	Male:	Female:	
2.5	Number of employees	Male:	Female:	
2.6	Number of household members employed		**Male**	**Female**
		Permanent		
		Temporary		
2.7	Percentage of contribution of farming to income of household/farm	Up to 25 % [ ] Up to 50 % [ ] up to 75 % [ ] up to 100 % [ ]		
2.8	Other key contribution to household/farm economy (Rank in importance, high to lowest)			
2.9	Number of employees in the last 3 months		**Male**	**Female**
		Permanent		
		Temporary		

2.10	Number of people in the household belonging to groups or associations.	Male:	Female:
2.11	Highest number of groups and associations to which a person is a member.	Male:	Female:
2.12	Years of experience in farming *(Include more as respondent provides)*	**Enterprise**	**Years**
		Crop	
		Livestock	
		Beekeeping	
		Stingless beekeeping	
		Agro forestry	
		Shamba system (KFS)	
		Aquaculture	
	PART 3: CHARACTERISTICS OF NATURAL ASSETS		
3.1	List number of wildlife recorded during the period of household/farm question-answer period. *(Birds, reptiles, antelopes, rodents, flies, butterflies, bees etc.). Recording of the wildlife is done per household throughout the farmer-questioning period.*	**Name**	**Area grown/number**
3.2	Crops and area (acres)/number grown from the household/farm *(Use extra leaflet if this space is not enough; answer based on most recent cropping period).*	**Name**	**Area grown/number**
3.3	Number of honey beehives observed.	**Colonized**	**Empty**
3.4	Number of stingless beehives observed.	**Colonized**	**Empty**
3.5	Number of solitary bees observed. *(A transect from one household to the next noting time (min) from start of transect. Data collected only for the solitary bees).*	**Name**	

3.6	Type and number of livestock and pets owned by household/farm.	**Name**	
3.7	Type of manure used and quantity. *(Farm yard manure, compost, fertilizer [list]).*	**Manure/fertilizer**	
3.8	Form of tillage practices (tick).	Till [ ]; No (zero) till [ ]; conservation agriculture (CA) [ ]; minimum tillage [ ]; terracing [ ]; strip cropping [ ]	
3.9	List cover crops used in Conservation Agriculture.		
3.10	List three most important vertebrate pests and for which crops/livestock.		
3.11	List three most important invertebrate pests and for which crops/livestock		
3.12	List three most important diseases and for which crops/livestock		
3.14	Pesticides used for crops/livestock and amount spent last season *(Farm yard manure, compost, fertilizer [list]).*	**Pesticide**	**Amount (KES) spent**
3.15	List other pest control methods used and target pest/diseases/weeds. *(e.g. physical, cultural, biological etc.)*		
3.16	Percentage of farm area under agroforestry.		
3.17	Percentage of farm area under land set aside.		
3.18	Percentage of farm area covered by homestead/farm building.		

<table>
<tr><td rowspan="2">3.19</td><td rowspan="2">Percentage of farm area that becomes waterlogged and for how long?

(Answer is based on the area on the farm e.g. some areas stay waterlogged more than others on the same farm).</td><td colspan="6">Percentage of farm waterlogged</td><td colspan="6">Months waterlogged</td></tr>
<tr><td colspan="6"></td><td colspan="6"></td></tr>
<tr><td rowspan="2">3.20</td><td rowspan="2">Percentage of land under various soil types.

(e. g. sandy, muddy, clay, red, black cotton etc.).</td><td colspan="6">Soil type</td><td colspan="6">Percentage of land covered</td></tr>
<tr><td colspan="6"></td><td colspan="6"></td></tr>
<tr><td rowspan="2">3.21</td><td rowspan="2">Any natural ecosystem near the farm/household?

(Catchment, riverine, forest, grassland, public land with no building: Note distance from household/ farm).</td><td colspan="3">Name</td><td colspan="3">Number</td><td colspan="3">Average area</td><td colspan="3">Distance (m)</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td></td><td colspan="13">PART 4: CHARACTERISTICS OF FINANCIAL ASSETS</td></tr>
<tr><td rowspan="2">4.1</td><td rowspan="2">What profit is gained from each crop (on average)?</td><td colspan="4">Crop</td><td colspan="4">Area size (acres)</td><td colspan="4">Profit-KES</td></tr>
<tr><td colspan="4"></td><td colspan="4"></td><td colspan="4"></td></tr>
</table>

4.2	What was the overall gross income (KES) from livestock keeping in previous season?	**Livestock type**	**Number**	**Profit-KES**
4.3	What profit is earned from beekeeping? *(Both stingless bee and honey bees)*	**Beehive type**	**Number**	**Profit-KES**
4.4	How many household members have access to credit?	**Gender**	**Number**	**Name of lenders**
4.5	Who owns various crops?	**Gender**	**Number owned**	**Remarks**
4.6	Who owns various livestock?	**Gender**	**Number owned**	**Remarks**
4.7	Who owns honey and stingless beehives?	**Gender**	**Number owned**	**Remarks**

4.8	How much money do you get as monthly remittances?	**Source (Gender)**	**Amount – KES**	**Remarks**

4.9	Describe any other remittance you earned over the last three months.	**Source**	**Last month**	**Last 2 months**	**Last 3 months**

PART 5: CHARACTERISTICS OF PHYSICAL ASSETS

5.1	Dependence on water source.	**Water source**	**Months in a year**
		Rainfall	
		Irrigation	

5.2	Type of irrigation facilities employed by household/ farm. *(List all)*	**Facility**	**Area covered or number**
		Drip	
		Overhead	
		Flooding	
		Watering can	
		Basin	
		Bottle	

5.3	Type and number of farm machinery.	**Machinery**	**Number/Quantity**
		Tractor	
		Oxen plough	
		Disc plough	
		Harrowing	
		Hey making machine	
		Water pump	
		Fodder shredder	
		Knapsack sprayer	
		Hand sprays	

5.4	Light farm implements. *(List all)*	**Type**	**Quantity**
		Jembe Panga Fork jembe Slasher Spade Shovel File Rake Axe	
5.5	Portion of land under various tenure system.	**Type**	**Area (acres)**
		Own Leased Borrowed Overseeing Parents Inherited but not transferred	
5.6	Money spent paying for various activities. *(List all)*	**Activity**	**Season cost**
		Irrigation Land hire/lease Weeding labour Sowing labour Spraying labour Harvesting labour Seeds	
	PART 6: CHARACTERISTICS OF HUMAN ASSETS		
6.1	How many household/farm members and employees reported ill health last week?	**Number of male**	**Number of female**
6.2	What level of education do household members have? *(e.g. standard 8=8 years; form 4=12 years; teacher college = 14 years; 1st degree = 16 years.)*	**Years of education**	**Number of persons**

6.3	What is the level of education status of employees.	**Years of education**	**Number of persons**
6.4	Type of specialized skills by household members and employees. *(e.g. carpentry, knitting, masonry, event MC, DJ, saloon, tailor, puncture repair, shoe repair, singing, tent making, etc.)*	**Type of skill**	**Number of persons**
6.5	Distance (km) to the nearest health facility. *(dispensary, health care, etc.)*		
7.1	**End time of the interview.**		

NB: GO BACK TO 3.5 TO FILL AS YOU GO TO NEXT HOUSEHOLD

Acknowledgement

We thank all respondents for their truthful contribution to this questionnaire. The results will be used for the purposes of enhancing the provision of pollination services on farmland for the benefit of farmers and everyone at large.

ANNEX 3.
POSSIBLE DATA SHEET FORMAT

This example includes only two variables per asset. However, it is recommended that at least three variables per asset are selected (See Section 4- STEP 2).

Questionnaire	Landscape	Farm	NATURAL		HUMAN		FINANCIAL		PHYSICAL		SOCIAL	
			Friendly Practices	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
1	A	A	1	1	1	5	1100	1	8	385	1	1
2	A	B	4	2	2	2	4125	2	100	6000	3	0
3	A	C	4	4	2	2	1100	2	7	0	3	1
4	A	D	3	3	2	3	8250	1	17	1360	3	0
5	A	E	4	4	3	3	1100	2	12	1920	3	1
6	A	F	3	3	3	3	8250	1	147	0	3	0
7	A	G	3	3	2	8	8250	1	24	192	3	1
8	A	H	3	3	3	2	8250	1	70	2100	3	1
9	A	I	3	3	1	2	8250	1	60	4200	3	1
10	A	J	2	2	1	7	8250	1	40	1500	3	1
11	A	K	3	5	1	2	2200	1	25	750	3	1
12	B	L	2	5	1	2	275	1	4	480	5	1
13	B	M	1	3	1	2	550	1	3	360	5	1
14	B	N	3	3	1	2	1100	1	3	360	5	1
15	B	O	3	3	1	3	1100	1	6	500	5	0
16	B	P	4	3	1	1	550	1	4	480	5	1
17	B	Q	3	3	1	3	550	1	7	600	5	1
18	B	R	5	3	1	1	550	1	4	720	5	1
19	B	S	2	2	1	1	550	1	3	300	5	1
20	B	T	3	3	2	2	1100	1	5	600	5	1
21	B	U	5	3	1	2	550	1	6	330	5	1

This publication provides an approach for the socio-economic valuation of pollinator-friendly practices at a landscape/farm level. The text was prepared as part of the Global Environment Fund (GEF) supported project ‘Conservation and management of pollinators for sustainable agriculture, through an ecosystem approach’ implemented in seven countries – Brazil, Ghana, India, Kenya, Nepal, Pakistan and South Africa.

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GLOBAL ACTION ON **POLLINATION SERVICES**
FOR **SUSTAINABLE AGRICULTURE**

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