



Review

Ecosystem-based adaptation for smallholder farmers: Definitions, opportunities and constraints



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ABSTRACT

Despite the growing interest in Ecosystem-based Adaptation, there has been little discussion of how this approach could be used to help smallholder farmers adapt to climate change, while ensuring the continued provision of ecosystem services on which farming depends. Here we provide a framework for identifying which agricultural practices could be considered 'Ecosystem-based Adaptation' practices, and highlight the opportunities and constraints for using these practices to help smallholder farmers adapt to climate change. We argue that these practices are (a) based on the conservation, restoration or management of biodiversity, ecosystem processes or services, and (b) improve the ability of crops and livestock to maintain crop yields under climate change and/or by buffering biophysical impacts of extreme weather events or increased temperatures. To be appropriate for smallholder farmers, these practices must also help increase their food security, increase or diversify their sources of income generation, take advantage of local or traditional knowledge, be based on local inputs, and have low implementation and labor costs. To illustrate the application of this definition, we provide some examples from smallholders' coffee management practices in Mesoamerica. We also highlight three key obstacles that currently constrain the use of Ecosystem-based Adaptation practices (i) the need for greater understanding of their effectiveness and the factors that drive their adoption, (ii) the development supportive and integrated agriculture and climate change policies that specifically promote them as part of a broader agricultural adaptation program; and (iii) the establishment and maintaining strong and innovative extension programs for smallholder farmers. Our framework is an important starting point for identifying which Ecosystem-based Adaptation practices are appropriate for smallholder farmers and merit attention in international and national adaptation efforts.

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1. Introduction

Agriculture is the main source of livelihood for 1.3 billion smallholder farmers worldwide (WB, 2008) and is highly vulnerable to climate change, particularly in the Tropics (Salinger et al., 2005). While there is no universally-accepted definition of 'smallholder farmers' (Morton, 2007), most cultivate small areas of land (usually less than 10 ha, often less than 2 ha), use family labor, and depend on their farms as their main source of both food security and income generation (Cornish, 1998; Nagayets, 2005). It is estimated that smallholder farmers represent 85% of the world's farms (Nagayets, 2005) and provide more than 80% of the food consumed in the developing world (IFAD, 2013). They also occupy a significant portion of the world's farmland ranging from 62% in Africa to 85% in Asia (FAO, 2014). What happens to smallholder farmers in the future – as the climate changes – will therefore have significant social, economic and environmental consequences globally.

Across the world, smallholder farmers are considered to be disproportionately vulnerable to climate change because changes in temperature, rainfall and the frequency or intensity of extreme weather events directly affect their crop and animal productivity as well as their household's food security, income and well-being. While in some cases, climate change may increase the productivity of certain crops (e.g., Rosenzweig et al., 2002; Tubiello and Fischer, 2007; Fuhrer and Gregory, 2014; Schultz and Jones, 2010), a growing number of studies show that the productivity of many crops (e.g., maize, rice, sorghum, cassava) and livestock that smallholder farmers in developing countries raise are expected to be significantly reduced in the coming decades due to increased climate variability and climate change, among other factors (Godfray et al., 2010; van Noordwijk et al., 2011).

Most smallholder farmers, especially in developing countries, have limited capacity to adapt to climate change, given their low education levels, low income, limited land areas, and poor access to technical assistance, market and credits, and often chronic dependence on external support (Morton, 2007; Harvey et al., 2014). In addition, in many regions, smallholder farmers farm on marginal lands (e.g., steep hillside slopes, poor soils or areas prone to flooding or water scarcity) and are therefore highly vulnerable to the impacts of extreme weather events that can cause landslides, flooding, droughts or other problems. Moreover, many smallholders in developing countries live in highly remote areas with low-quality infrastructure that further hampers their access to markets, financial assistance, disaster relief, technical assistance or government support (Harvey et al., 2014). As a result, although many smallholder farmers have been facing adverse climatic events and, in most cases taking corresponding action (Altieri and Koohafkan, 2008), most are ill-prepared for the challenge of adapting to the increased frequency and/or intensity of extreme climate events that are expected with climate change.

In light of both the observed and expected impacts of climate change on smallholder farmers, many governments, NGO's and multilateral organizations are now actively promoting initiatives to help smallholder farmers adapt to climate change (FAO, 2013). Most of those initiatives aim at strengthening and/or expanding four main types of activities that are deemed to improve

the capacity of smallholders to manage climate risks, namely: (i) developing new technologies, such as satellite-based early warning systems, (ii) facilitating government support (subsidies, insurance, technical assistance, etc.), (iii) assisting farmers in accessing credit, capital and risk-insurance, and/or (iv) adapting farm management practices (Smit and Skinner, 2002; Howden et al., 2007). While all of these activities are useful and necessary, the first three are often difficult to implement in the short-term due to time required for and external support needed to put in place the necessary enabling conditions such as appropriate policies, governance structures, economic incentives and infrastructure. An immediate and direct way to help smallholder farmers ensure their farm-based livelihoods in the face of the increasing stresses posed by climate variability is to focus on helping them use farm management practices based on agrobiodiversity and ecosystem services that provide adaptation benefits (van Noordwijk et al., 2011). There is a wide array of agricultural practices that could help farmers improve their farming systems and increase the resiliency of their systems to climate change (Wezel et al., 2014). Many smallholder farmers are already implementing practices that maintain complex agrobiodiversity and that result in a higher capacity of their production units to resist, cope with and/or recover from extreme climatic events (Lin, 2007; Altieri and Koohafkan, 2008).

Some of the most promising adaptation practices take advantage of existing ecological processes and biological diversity to provide adaptation benefits to agricultural producers and can be potentially incorporated in many of the increasing number of initiatives that are promoting ecosystem-based responses to climate change and variability. While several authors (Altieri and Koohafkan, 2008; Munang et al., 2013) and international organizations (SCBD, 2009; FAO, 2013; UNFCCC, 2013) have highlighted the general importance and benefits of ecosystem-based strategies for climate change adaptation, there have been no studies that have defined what 'Ecosystem-based Adaptation' (EbA) means in the context of agriculture and used this definition to identify which such practices are already in place. In addition, there have been no studies that have examined the associated benefits and costs of EbA practices for smallholders, or considered which processes are currently promoting or hampering the adoption of these practices.

The objective of this paper is to provide a framework for identifying which agricultural practices can be considered Ecosystem-based Adaptation and to explore which of these practices are suitable for smallholder farmers. We demonstrate the application of the framework using examples of practices used by smallholder coffee farmers in Central America. We also explore the opportunities and constraints for enhancing the use of EbA by smallholder farmers and provide recommendations for how EbA could be scaled up across smallholder farming systems globally. Identifying ecosystem-based practices which can both help farmers to adapt to climate change and also conserve the agroecosystems' capacity to provide both on- and off-site ecosystem services is important, not only because of the expected increase of negative impacts of climate change on smallholder farmers, but also because of the increasing pressure that will come from the rapidly growing human population on both provisioning (e.g., food, fiber) and non-provisioning (e.g., water and nutrient

cycles) services in agricultural landscapes (Tilman et al., 2002; Jackson et al., 2007).

2. What are EbA practices and which are potentially appropriate for smallholders' farming systems?

Ecosystem-based adaptation has generally been defined as the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (SCBD, 2009). While there is a rapidly growing interest in Ecosystem-based Adaptation for its potential social, environmental and economic benefits (e.g., Jones et al., 2012; Munang et al., 2013; Campos et al., 2014; Doswald et al., 2014), almost all of this literature has focused on the adaptation benefits that accrue from the conservation and/or restoration of natural habitats. We refer to Ecosystem-based Adaptation in agricultural systems as the implementation of agricultural management practices that use or take advantage of biodiversity, ecosystem services or ecological processes (either at the plot, farm or landscape level) to help increase the ability of crops or livestock to adapt to climate variability. In this respect, adaptation can be seen as a process to promote the maintenance or further adoption of ecologically-based management practices that can provide adaptation benefits. Under this definition, adaptation can be seen both as the process of using ecologically-based management practices that provide adaptation benefits, as well as a characteristic of diverse agroecosystems that are based on the use of biodiversity and ecosystem services and which are resilient to the impacts of climate change (Jackson et al., 2010).

We argue, along with other authors (Altieri and Koohafkan, 2008; Harvey et al., 2013; Lavorel et al., 2015), that the use of ecosystem-based management practices in agricultural systems and landscapes can help smallholder farmers adapt to climate change by providing both on-site (e.g., farm level) and off-site (e.g., landscape level) benefits. Agriculture depends on ecosystem services (such as pollination, nutrient cycling, pest control, Swift et al., 2004; Barrios, 2007), but also serves as an important source of ecosystem services to people (Tscharntke et al., 2005; Swinton et al., 2007). Ecosystem-based management practices that focus on conservation, restoration and sustainable management of biodiversity and ecosystem services could therefore potentially help farmers adapt both to climate change in the long term (i.e., by ensuring the continued provision of on and off-site ecosystem services) as well as to climate variability in the short term (i.e., by improving the resilience of production units to the increasing impacts of extreme weather events; Howden et al., 2007; Altieri and Koohafkan, 2008). Many smallholders are already implementing ecosystem-based practices that are already helping them adapt

to climate extremes (e.g., Holt-Giménez, 2002; Lin, 2007), however there is a tendency for development-oriented initiatives to promote technological packages that simplify these smallholder farmers systems, making them more vulnerable to market and/or climate-variability stresses (Eakin, 2005). The promotion of practices that are ecosystem-based could help reverse this trend and promote farming systems that are more ecologically and socially sustainable, and resilient to climate change (van Noordwijk et al., 2011).

We define Ecosystem-based Adaptation in agricultural systems as agricultural management practices which use or take advantage of biodiversity or ecosystem services or processes (either at the plot, farm or landscape level) to help increase the ability of crops or livestock to adapt to climate change and variability.

Under this definition ecosystem-based agricultural practices must be based on the conservation, restoration or management of biodiversity (at the genetic, species or ecosystem level) and ecosystem processes and services (such as nutrient cycling, water regulation). Examples of agricultural practices that meet these criteria include practices that use both agro-biodiversity and ecosystem processes include the management of trees in agroforestry or silvopastoral systems, the use of mulching or local species as cover crops to help conserve soil structure, humidity and nutrients, or the conservation of riparian vegetation in farms to ensure water provision, among others. In contrast, practices that substitute the role of biodiversity in providing ecosystem functions and services for agricultural production such as inorganic fertilization, or application of fungicides are not ecosystem-based.

Second, EbA practices are practices which have been proven to improve the ability of crops and livestock to adapt to climate change and variability. These practices can be implemented at various scales-from plot to farm to landscape. For example, on-farm management of genetic biodiversity (e.g., diversification of crop varieties or inclusion of wild relatives) can ensure a broader source of crop resistance-capacity to uncertain occurrence and effects of extreme weather events (Lewis et al., 1997; Jackson et al., 2010; Ratnadass et al., 2012). Other farm-level practices include the use of integrated pest-management strategies (i.e. the integration of cultural, biological, and chemical control methods), or new cropping systems to reduce the impacts of pests and diseases (Way and van Emden, 2000; Lamichhane et al., 2015), the planting of windbreaks, agroforestry systems or cover crops to help reduce the evapotranspiration effect of extreme radiation and/or wind, or the energetic force of extreme rainfall and strong winds on soil structure (e.g., Lin, 2007; Altieri and Koohafkan, 2008), among others. At the landscape level, EbA practices can include those that use biodiversity and ecological processes to help regulate water and nutrient cycling (e.g., by ensuring tree cover or

Table 1
Summary of three key dimensions and underlying criteria that agricultural practices need to satisfy to be considered Ecosystem-based Adaptation practices that are appropriate for smallholder farmers. Practices that fulfill at least one criterion in the 'ecosystem-based' and 'adaptation benefits' dimensions can be considered 'Ecosystem-based Adaptation practices. Practices that also fulfill at least one criterion in the third dimension are EbA practices appropriate for smallholder farmers.

Dimension 1: ecosystem-basedness	Dimension 2: adaptation benefits	Dimension 3: livelihood security
<ul style="list-style-type: none"> • Is based on the conservation, restoration and sustainable management of biodiversity (e.g., genetic, species and ecosystem diversity) • Is based on the conservation, restoration and sustainable management of ecological functions and processes (such as nutrient cycling, soil formation, water infiltration, carbon sequestration, etc.) 	<ul style="list-style-type: none"> • Maintains or improves crop, animal or farm productivity in face of climate variability and climate change • Reduces the biophysical impacts of extreme weather events (heavy rainfall, extremely high temperatures, strong winds, etc.) and high temperatures on crops, animals or farming system • Reduces crop pest and disease hazards due to climate change 	<ul style="list-style-type: none"> • Increases food security of smallholder households • Increases or diversifies income generation of smallholder households • Takes advantage of local or traditional knowledge of smallholder farmers • Uses local, available and renewable inputs (e.g., using local materials from within the farm or landscape, rather than external inputs such as pesticides, inorganic fertilizers, etc.) • Requires implementation costs and labor affordable to smallholder farmers

natural vegetation in key hydrological hotspots), or to reduce the incidence or severity of crop pest and disease outbreaks related to extreme weather events (e.g., by enhancing the structural complexity of the agricultural landscapes through diverse cropping systems, or inclusion of natural vegetation and on-farm tree cover to promote pest regulation; Jackson et al., 2010; Juroszek and von Tiedemann, 2011; Pautasso et al., 2012; Jaramillo et al., 2013).

Practices that meet at least one of the criteria (see Table 1) in each of these two dimensions (i.e., those that are ecosystem-based, and those that provide adaptation benefits) can be considered to be Ecosystem-based Adaptation practices.

However, in order for an EbA practice to be considered appropriate or useful for smallholder farmers it must also help improve their livelihoods and take into account their socioeconomic realities. There is ample evidence that diverse agroforestry systems can increase the food security of smallholder farmers and households, and increase or diversify their sources of income generation (Sanchez, 2000; Altieri and Nicholls, 2008). Ecosystem-based Adaptation practices often take advantage of local or traditional knowledge, and can therefore be easily used by smallholder farmers. In addition, these practices typically are based on local, available and renewable inputs, such as using local materials from the farm or the landscape. Last, but not least, they should be practices that have low implementation costs and labor needs, which smallholder farmers can meet, and not increase farmer dependence on external production inputs (i.e., machinery, fertilizers, labor, etc.) (Munang et al., 2014).

In summary, in our proposed framework, if a given agricultural practice meets at least one criteria in each of the 'ecosystem-based' and the 'adaptation benefits' dimensions, it can be considered an Ecosystem-based Adaptation practice. If it meets at least one criterion in all three dimensions (ecosystem-based, adaptation, and livelihoods), it can be considered an Ecosystem-based Adaptation practice that is appropriate for smallholder farmers.

2.1. An application of this definition to practices used in smallholder coffee systems

To demonstrate the usefulness of our proposed framework for identifying EbA practices for smallholder farmers, we applied it to agricultural practices used in smallholder coffee production system, a common farming system in much of tropical America (Jha et al., 2014). Using information from a related extensive literature review ($n > 300$ papers) on practices used by small scale coffee combined with elicitation of expert opinion (Bautista-Solís et al., 2014), we identified the key practices used in smallholder coffee production and then evaluated each practice against the proposed criteria in Table 1 to identify which practices can be considered 'EbA' practices and which of these are suitable for smallholder farmers. In Annex 1 we provide the detailed information on the evidence that was used for evaluating each practice against the proposed criteria, including the full bibliography of the literature reviewed. Here, we present a higher-level summary of this information to illustrate how the different practices meet different criteria.

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Of the 16 coffee management practices evaluated, nine can be considered Ecosystem-based Adaptation practices, as they clearly are based on the conservation, restoration or management of biodiversity and ecosystem services, and confer adaptive benefits (Annex 1). On the other hand, some practices are clearly not ecosystem-based (e.g., irrigation systems, use of inorganic fertilizers and pesticides, genetically modified varieties, relocation of crops, drainage channels), while two (resistant varieties and

mulches) fall into a gray zone with their classification depending on exactly how these practices are implemented. Of the nine EbA practices identified, six can be considered to be appropriate for smallholder farmers, due to their ability to help improve family food security, diversity income generation, or their ease of adoption by smallholder farmers with limited resources. One EbA adaptation practice that stands out as particularly promising for smallholder farmers is the use of shade trees (i.e., producing coffee as an agroforestry system), as this practice can help ensure the continued provision of key ecosystem services (pollination, natural pest control, conservation of water and soils, etc.), buffers coffee from extreme temperatures and rainfall, ensures more stable production under climate-related stresses (Lin, 2007; Philpott et al., 2008), and provides clear socioeconomic benefits to smallholder farmers (Jha et al., 2014). However, this practice often results in lower yields in normal years (Lopez-Bravo et al., 2012), and has variable impacts on different pests and diseases (Avelino et al., 2011; Lopez-Bravo et al., 2012). It also requires significant knowledge, technical skills and labor for site-specific management of shade (Avelino et al., 2011; Ratnadass et al., 2012).

Our framework appears to do a good job of identifying existing practices which can be considered 'Ecosystem-based Adaptation'. It also permits the identification of EbA practices for smallholder farmers, although the lack of readily available information about some of the socioeconomic impacts of these practices and the huge variability in smallholder farming contexts makes this dimension somewhat harder to quantify. Nonetheless, we propose that the framework is a useful starting point for identifying EbA options and could be applied to the wide variety of agricultural systems that exist globally, and could at least stimulate careful consideration of which of these practices are suitable for smallholder farmers.

3. Benefits and constraints of EbA practices for smallholders

Ecosystem-based Adaptation practices can potentially benefit smallholders in multiple ways beyond helping them adapt to climate change. The most obvious benefits of EbA practices are that they help ensure the continued provision of key ecosystem services (water provision, food provision, nutrient regulation, pest control, pollination) on which farming depends (Lavorel et al., 2015). This is in contrast to other (non-EbA) adaptation measures, such as the construction of dams for water irrigation or the increased use of agrochemicals, which also confer adaptation benefits but may negatively impact the provision of ecosystem services, while also having additional negative environmental off-site effects (e.g., loss of biodiversity or contamination of streams, Graymore et al., 2001; Battaglin et al., 2003; Carabias-Martinez et al., 2003) and socioeconomic impacts (such as negative impacts on health, Wesseling et al., 1997). In addition, the use of EbA practices can help diversify production systems and sources of income generation, providing more stability to smallholder farmers (Munang et al., 2014). For example, the use of agroforestry in coffee, cocoa or cattle production systems can diversify revenue by providing timber, fruits, fuelwood and building materials (e.g., Lagemann and Heuvelink, 1983; Somarriba et al., 2004; Herzog, 1994; Rice, 2008) that farmers can use for additional income, especially in years when income from the main cash crop is reduced (Jha et al., 2011). These additional products reduce farmer vulnerability to market changes (Jha et al., 2011) as well as their dependence on outside products (Toledo and Moguel, 2012), thus helping improve farmer food security directly and indirectly. The use of agroforestry practices can also make significant contributions to biodiversity conservation efforts (Harvey et al., 2008; Jha et al., 2014). In addition, many EbA practices can help mitigate climate change by either reducing the amount of GHG emitted from agricultural systems (e.g., by reducing the use of inorganic

fertilizers, agrochemicals, machinery and associated emissions), or by increasing the overall farm biomass (e.g., by increasing soil carbon stocks or above-ground biomass; [Doswald and Osti, 2011](#); [Harvey et al., 2014](#)). Overall, the co-benefits of EbA practices in terms of climate regulation, water purification, habitat creation, biodiversity conservation and landscape amenities are often significantly greater than those of engineering alternatives (e.g., flood defenses infrastructure, water treatment plants) ([Naumann et al., 2013](#)).

However, there are also some key limitations to EbA practices which can hamper their adoption by smallholder farmers, especially in developing countries. Some of these practices (e.g. using cover crops) can require farmers to make difficult trade-offs between the adaptation benefits they can provide in the longer term and the significant labor investment needed for their establishment (in the short term) or their maintenance ([Jha et al., 2014](#)). Another potential limitation is that some EbA practices (e.g., some IPM practices for Maize are based on external technical assistance; [Wyckhuys and O'Neil, 2007](#)) require information or knowledge that is not available to producers in marginal areas where technical assistance is limited or inexistent ([Anderson and Feder, 2004](#)). For example, practices that use complex pest management strategies such as the push-pull system (a system based on a combination of repellent and trap plants to eliminate insect pests) have been proven to improve harvests and control maize stem-borer in Eastern Africa using locally-available plant species but require significant technical assistance and multi-stakeholder engagement ([Khan et al., 2011](#)).

4. What is needed to scale up the use of EbA practices in smallholder farming systems?

In order for EbA to be scaled up, it is important to promote the adoption of EbA in appropriate farming systems and contexts, to encourage the continued use of these approaches in areas where farmers are already using EbA approaches, and also to reduce the on-going loss of biodiversity and ecological integrity within farming systems. We suggest three ways in which the use of EbA practices by smallholder farmers can be promoted and scaled up to help expand their adoption or, where they are already in place, stop on-going trends in simplifying biodiversity resources of smallholder farming systems.

First, we need to improve our understanding and scientific evidence of the long-term effectiveness of different EbA practices in enhancing the resilience of crops, livestock and farming systems in the face of climate change and extreme weather events, either individually or in combination with other practices ([FAO, 2013](#)). There are still limited studies that explicitly compare the relative performance and cost-effectiveness of EbA vs non-EbA options (an exception is [Jones et al., 2012](#)) under different climate-related stresses and agricultural systems. In addition, more information is needed on which EbA options are most appropriate for smallholder farmers living in different socioeconomic and agroecological contexts, as the relative merits and drawbacks of individual practices are likely to be highly context-dependent.

Second, we need better articulation of agricultural and climate change policies to promote incentives or actions that, while achieving production targets, also help maintain the ability of agroecosystems to provide on- and off-site ecosystem services and help improve farmer livelihoods in the face of climate change. Indeed, smallholder farmers are likely to maintain EbA practices (or adopt them if not already in place) if they perceive that these practices will help them achieve their production goals even under the impact of climate change, or if they receive direct incentives (e.g., payment for ecosystem services) for their implementation. More specifically, governments and development organizations

could promote greater use of EbA through a mix of policies, incentives, training, capacity-building, and technical support, so that smallholder farmers have both the necessary resources and the required knowledge to make informed decisions about how to adopt and effectively use EbA practices to enhance the overall resiliency of their farm. Recent efforts, such as those of the Colombian government whose Second Communication to UNFCCC explicitly includes EbA activities in agroecosystems ([Cabrera-Leal et al., 2010](#)) and the South African Expanded Public Works Programme ([Midgley et al., 2012](#)) that promotes the rehabilitation and restoration of ecosystems as a means of reducing environmental and social vulnerability of communities (including smallholder farmers) to climate change, are important steps in this direction. At the same time, governments should carefully revisit existing policies that, at the farm level, are currently undermining the maintenance or adoption of ecosystem-based approaches such as ongoing subsidies that promote the simplification of agro-ecosystems and the increased use of agrochemicals and fossil fuel ([Altieri and Koohafkan, 2008](#)). Similarly, governments should also revisit policies that, at the landscape level, downplay the role of agro-ecosystems to focus only on the use of hard infrastructure (e.g., dams, sea walls, roads) to reduce the impacts of extreme climatic events ([Pramova et al., 2012](#)).

Third, it is important that governments strengthen and provide ongoing support to agricultural extension programs, farmer field schools, agricultural technical programs and universities, and ensure that their curricula and outreach activities include the promotion of EbA practices. Globally, many countries have dismantled or significantly reduced their extension programs ([Chang, 2009](#)), yet the need for such support (especially for smallholder farmers facing the impacts of climate change) is greater than ever ([Porter et al., 2014](#)). Farmer field schools and effective extension programs are needed to foster information exchange on EbA practices from technical institutions to producers and viceversa as well as among smallholders ([Braun and Duveskog, 2011](#); [Vignola et al., 2010](#)). Greater investment in extension services is urgently needed to ensure that smallholder farmers have access to best available information on adaptation strategies and can make informed decisions about their farming systems and actually increase adoption rates of EbA practices ([Vignola et al., 2010](#)). In addition, innovative alliances (e.g., among farmers, NGOs, governments, scientists and the private sector) could play a valuable role in filling the extension services gaps and helping to promote appropriate EbA practices ([Munang et al., 2014](#)).

5. Conclusions

The use of Ecosystem-based Adaptation practices in agriculture offers an important opportunity to help smallholder farmers adapt to climate change, while providing important livelihood and environmental co-benefits. Our framework is designed to help identify which agricultural practices could be considered EbA and which of these practices may be appropriate for smallholder farming systems. Many of the practices that can be considered EbA (e.g., agroforestry practices, soil and water conservation practices, etc.) are already well known and have been proven to help smallholder farmers adapt to climate change, but current financial, political and technical constraints limit a more widespread adoption of these practices among smallholder farmers. For those challenges to be overcome, it is critical that policy makers at all levels (local, national and international) recognize and promote the use of EbA approaches in agricultural development, climate change and environmental strategies, and support their widespread adoption. Key strategies for promoting EbA include (i) improving our understanding on the effectiveness of different EbA practices and of what factors drive their adoption, (ii) developing

supportive and integrated agriculture and climate change policies that specifically promote EbA options as part of a broader adaptation program; and (iii) establishing and maintaining strong and innovative extension programs for smallholder farmers.

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