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The use of Ecosystem-based Adaptation practices by smallholder farmers in Central America

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ABSTRACT

There is growing interest in promoting the use of Ecosystem-based Adaptation (EbA) practices to help smallholder farmers adapt to climate change, however there is limited information on how commonly these practices are used by smallholder farmers and what factors influence their use. Using participatory mapping and field surveys, we examined the prevalence and characteristics of EbA practices on 300 smallholder coffee and maize farmers in six landscapes in Central America and explored the socioeconomic and biophysical factors associated with their use. The prevalence of individual EbA practices varied across smallholder farms. Common EbA practices included live fences, home gardens, shade trees in coffee plantations, and dispersed trees in maize fields. We found a mean of 3.8 EbA practices per farm. Factors that were correlated with the total number of EbA practices on farms included the mean area of coffee plantations, farmer age, farmer experience, the farm type and the landscape in which farms were located. Factors associated with the presence or characteristics of individual EbA practices included the size of coffee plantations, farmer experience, farmer education, land tenure, landscape and farm type. Our analysis suggests that many smallholder farmers in Central America are already using certain EbA practices, but there is still scope for greater implementation. Policy makers, donors and technicians can encourage the broader use of EbA by smallholder farmers by facilitating farmer-to-farmer exchanges to share knowledge on EbA implementation, assessing the effectiveness of EbA practices in delivering adaptation benefits, and tailoring EbA policies and programs for smallholder farmers in different socioeconomic and biophysical contexts.

1. Introduction

Smallholder farmers are highly vulnerable to climate change due to their dependence on rain-fed agriculture, their small landholdings, their location in often remote and marginal lands, and their restricted access to technical expertise, credit and institutional support, which limits their ability to adapt to changing conditions (Morton, 2007; Vermeulen, 2014). Governments, policy makers, donors and practitioners have recognized the urgent need to help smallholder farmers build resilience to climate change and are actively developing strategies to make that happen (Dinesh et al., 2016; Vermeulen, 2014). Agriculture is also assuming greater prominence in both national and international policy discussions around climate adaptation and becoming a priority sector for action. For example, as of May 2016, 127 countries had highlighted the importance of adaptation in agriculture in their intended nationally determined contributions (INDCs) under the Paris Agreement of the UNFCCC (Richards et al., 2016), and policy discussions on how to prioritize agriculture as a sector for adaptation and mitigation under the UNFCCC are ongoing (Dinesh et al., 2016).

One approach which could help farmers adapt to climate change is the promotion of Ecosystem-based Adaptation (EbA). EbA refers to the use of ecosystem services and biodiversity as part of an overall

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adaptation strategy to help people adapt to the negative impacts of climate change (Doswald et al., 2014; Munang et al., 2013). In the context of agriculture, EbA can include a variety of different practices that are based on the management of ecosystems, ecosystem services and biodiversity (Vignola et al., 2015). Common examples of EbA at the plot or farm scale include the use of agroforestry systems to buffer the impacts of high temperatures, heavy rains or other climate impacts on crops or livestock (e.g., Lin, 2007; Siles et al., 2010; Verchot et al., 2007), the establishment of windbreaks to reduce impacts of extremely strong winds (e.g., Easterling et al., 1997; Rosenberg, 1992), the use of soil conservation practices (e.g., use of cover crops, terracing) to prevent soil erosion and maintain soil fertility under heavy rainfall (Dabney, 1998; Erenstein, 2003), the establishment of live fences to prevent soil erosion and provide fodder to cattle during the dry season (Harvey et al., 2005), and the diversification of crops, cultivar types or animal breeds to minimize the risk of production losses due to changing climatic conditions or climate-driven pest or disease outbreaks (Burnham and Ma, 2015; Lin, 2011), among others. At the landscape scale, examples of EbA include the conservation or restoration of riparian forests to maintain stream flow under changing rainfall conditions (e.g., Capon et al., 2013), and the conservation of forests in upland areas to help prevent erosion and landslides due to extreme weather events (Locatelli et al., 2011).

Ecosystem-based Adaptation has been proposed as a particularly important adaptation strategy for smallholder farmers who often lack the resources and capacity to access other adaptation options, such as the adoption of new technologies that require external inputs (e.g., improved seed varieties, irrigation systems or increased fertilizer and pesticide use) or participation in farm insurance (Vignola et al., 2015). However, despite growing interest in the potential role of EbA in helping smallholder farmers adapt to climate change, there is still limited information on the use of EbA by smallholder farmers. According to a recent global review of smallholder responses to climate change (Burnham and Ma, 2015), many smallholder farmers are adopting environmental management practices in response to climate change, but more systematic and detailed information is needed on the specific practices farmers adopt and why. Information is lacking on what EbA practices farmers are using, how the use of EbA practices varies across farms and landscapes and what factors influence EbA use. While there have been previous characterizations of individual agroecological practices, such as shade trees, live fences and dispersed trees (e.g., Harvey et al., 2005, 2011; Haggar et al., 2015; Hellin et al., 1999), that could help farmers improve the sustainability of their farms and improve farm resiliency to climate change, there have been no systematic studies that have considered the full range of EbA practices present on smallholder farms. In addition, while there have been studies examining the factors associated with the use of individual agricultural practices (e.g., Nkamleu and Manyong, 2005; Wall, 2007), there has been no efforts to understand which factors are correlated with the use of multiple EbA practices at the farm level.

Understanding the potential use of EbA by smallholder farmers is particularly relevant to Central America, a region with an estimated 2.3 million smallholder farmers (PRESANCA and FAO, 2011) who cultivate marginal, steep lands and depend on agriculture for both food security and income generation (Hellin and Schrader, 2003; Tucker et al., 2010). As in other regions, smallholder farmers in Central America are highly vulnerable to climate change and face a range of climatic threats, including higher temperatures, more variable rainfall, and more frequent and more intense extreme weather events (Baca et al., 2014; Hannah et al., 2017). Changes in climatic conditions are expected to lead to significant changes in water availability (Imbach et al., 2015), increased pest and disease outbreaks (Avelino et al., 2015), and reduced crop productivity of key smallholder crops, such as coffee, maize and beans (Baca et al., 2014; Jones and Thornton, 2003). Climate change also threatens food security and farmer wellbeing across the region (Bacon et al., 2017; Hannah et al., 2017). Adaptation strategies that can help build resiliency of smallholder farmers to climate change are urgently needed across Central America (Schroth et al., 2009), yet information on appropriate adaptation strategies (and the potential role for EbA) for smallholder farmers is scant and insufficient to guide adaptation policies and strategies (Donatti et al., 2017).

We explored the potential role of EbA in helping smallholder farmers adapt to climate change by conducting participatory mapping and field surveys of EbA practices in six different smallholder farming landscapes in Central America. The specific objectives of our work were: 1) to document the prevalence of EbA practices on smallholder farms and characterize how these practices are implemented, and 2) explore which biophysical and socioeconomic factors are correlated with the presence of individual EbA practices. Our study provides novel information on the use of EbA practices by smallholder farmers and provides important insights into the factors that are associated with EbA use and the potential for EbA systems to help smallholder farmers adapt to climate change. These issues are of international importance given the estimated more than 500 million smallholder farms worldwide, the importance of smallholder farmers for global food security, and their high vulnerability to climate change (Graeub et al., 2016; Morton, 2007).

2. Methods

We characterized EbA practices on smallholder farms in 6 Central American landscapes (Turrialba and Los Santos in Costa Rica, Choluteca and Yoro in Honduras, and Chiquimula and Acatenango in Guatemala, Fig. 1), that were typical of smallholder farmer landscapes in the region. We selected landscapes that a) were dominated by smallholder farming systems, b) had coffee and/or basic grain production (beans and maize) as the predominant agricultural land use, and c) had farming communities with low adaptive capacity to climate change. We focused our study on smallholder farmers who had either coffee or basic grain production as these are the two most common types of smallholder systems in the region (Baca et al., 2014). We characterized landscapes as having low adaptive capacity using expert mapping interviews, validation workshops and expert on-line surveys, in which experts from the region characterized landscapes on the basis of 20 variables (representing natural, human, social, physical and financial capital) that contributed to farmer adaptive capacity. Additional details on the methodology and analysis are provided in Holland et al. (2017). Of the six selected landscapes, the Turrialba and Los Santos landscapes are dominated by coffee production, Choluteca is dominated by basic grain production, while the remaining landscapes (Yoro, Acatenango and Chiquimula) include a mix of coffee and basic grain production. Key characteristics of each of the landscapes can be found in Table 1.

In each landscape, we had previously conducted an extensive household survey of randomly-chosen smallholder farms, using a rigorous sampling frame. In the Costa Rican landscapes, we selected farmers randomly from an existing list of coffee farms. In the Guatemalan and Honduran landscapes, we generated a sampling frame by using remote sensing imagery to detect household roofs and then randomly sampling households from this list of potential farms. In total, we sampled 860 randomly-selected farmers (115–155 farmers per landscape). The household survey included information on farm, farmer and household characteristics, and farmer-reported presence of EbA on farms, among other aspects. In each landscape, we used information on the number of EbA practices reported by farmers in the household survey to stratify the farmers in each landscape into two groups (a group with a relatively ‘high’ number of EbA practices, and a group with a relatively ‘low’ number of EbA practices) based on the frequency of the number of reported EbA practices per farm. We then randomly selected 25 farmers from both the ‘high’ and ‘low’ groups for field work (for a total of 50 farmers per landscape), to ensure that our field survey covered the diversity of farm types present in each landscape. Our total