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Costs and benefits of climate-smart agriculture: The case of the Dry Corridor in Guatemala

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ABSTRACT

Central American countries, particularly Guatemala, are experiencing extreme climate events which are disproportionately affecting agriculture and subsequently rural livelihoods. Governments are taking action to address climatic threats, but they need tools to assess the impact of policies and interventions aiming to decrease the impacts of climate change on agriculture. This research, conducted with national policy makers and climate change and agriculture stakeholders in Guatemala, provides a comparative analysis of eight climate-smart agriculture (CSA) practices and technologies associated with the smallholder maize-beans production system in the Dry Corridor. The practices were identified as high-interest for investment by national stakeholders. CSA practices and technologies aim to improve food security, resilience, and low emissions development, where possible and appropriate. The paper assesses the cost-benefit profile of the introduction of CSA options into farm production systems. Indicators related to profitability and valuation of environmental and social externalities are used to assess options. Probabilistic cost-benefit analysis (CBA) is used to address field variability and high uncertainty around parameter values. All practices except one were profitable over their lifecycle, with some practices, expected to be ideal for drought prone areas, presenting a higher risk for adoption. The results were discussed with national stakeholders who established best-bet CSA investment portfolios. This paper argues that a thorough understanding of the costs and benefits of potential CSA options is needed to channel investments effectively and efficiently towards both short- and long-term interventions and should be coupled with broader assessment of tradeoffs between CSA outcomes.

1. Introduction

Climate-smart agriculture (CSA) encourages sustainable development of agricultural systems through practices and approaches that achieve improved food security, increased resilience, and low-emissions development where possible and appropriate in the face of climate change (FAO, 2010). In contrast to conventional agriculture management and planning, CSA is an effort to integrate climate change and agriculture development planning, specifically seeking out opportunities to link adaptation and mitigation efforts. The approach aims to ensure planning around climate change and agriculture is holistic, maximizing multiple outcomes and minimizing tradeoffs in management of food systems (Lipper et al., 2014). Decision-makers, planners, funders, and other agriculture and development stakeholders need tools and methods that clearly outline the impact of practices and services within specific agricultural systems in order to assess CSA related tradeoffs (Rannow et al., 2010; Schroth et al., 2015). Economic assessments are in high demand as a way to better understand the impact practices will have for specific users and timeframes, and subsequently the likelihood of a practice to be adopted, maintained, and provide livelihood opportunities for specific target groups (Daigneault et al., 2016; El Chami et al., 2015). Social and environmental impacts of these practices should not be undervalued and cost-benefit analysis (CBA) that takes into account the full private and public potential of intervention can be highly useful for investment prioritization across levels.

This paper analyzes CSA options in Guatemala, which was ranked 9th among countries most affected by extreme climate events in the past two decades (Kreft et al., 2015). Prolonged droughts led the Government of Guatemala to distribute food aid to over 290,000 affected families in 2014 (Government of Guatemala, 2014b) and programs were reinstated in 2015. Losses in agricultural production have affected availability and access to staple crops, primarily maize and beans, creating further vulnerabilities within a country where almost one third of the population (30.7%) is already food insecure (FAO, WFP and IFAD, 2012).

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The Government of Guatemala has developed various policies and interventions to diminish the impacts of climate change on agriculture and the environment, demonstrating a commitment to addressing vulnerabilities and risks to climate challenges (CCAFS, 2014). The Ministry of Agriculture, Livestock, and Food (MAGA) established its own climate change strategic plan in line with national policies, which includes a framework for the Climate Change Unit of MAGA (CCU-MAGA) and links with strategies to address family farming and commercial farming (MAGA, 2013). The program '*From Dry Corridor to Corridor of Opportunities*: *plan of attention for families affected by prolonged drought in 2014*' ('Corridor of Opportunities') was established to provide emergency support to food insecure families and promote interventions that minimize the impact of drought on maize and bean systems and build local capacity. The adoption of agricultural practices that promote soil and water conservation were incentivized through provision of conditional monthly food aid (45.3 kg of maize, 13.6 kg of beans, and 7.9 kg of fortified flour) for a period of six months (Government of Guatemala, 2014a). Fourteen specific agricultural practices were promoted by MAGA based on climate threats and existing documentation of practices in projects (Government of Guatemala, 2014a). The economic profitability and the social and environmental benefits of these practices though had yet to be evaluated for both the farmer and the society. A process was deemed necessary to evaluate the climate-smartness and costs and benefits of previously incentivized practices and for integration of results into future planning, which provided the demand for this study.

In the agricultural sector CBA has been widely used to assess the profitability of alternative soil and water conservation technologies in developing countries (Balana et al., 2012; Bizoza and De Graaff, 2012; Cocchi and Bravo-Ureta, 2007; Posthumus and De Graaff, 2005; Prabuddh and Suresh, 2014; Renaud, 1997; Sain and Buckles, 1998; Uri, 2000; Zhou et al., 2009). The challenge when assessing costs and benefits of CSA practices and technologies is how to include supposed social and environmental impact often excluded in conventional assessments.

This paper presents a model for conducting CBAs of CSA practices and technologies, which aims to answer the following questions:

(i) What are the main costs and benefits associated with implementing selected CSA practices?

(ii) How can environmental and social externalities be incorporated into estimates of economic profitability of CSA practices?

(iii) How can data gaps be addressed when carrying out CBAs that integrate economic, social, and environmental viewpoints?

This paper explores the economic assessment of eight CSA practices applicable to the Dry Corridor in Guatemala. These practices were prioritized through use of the CSA Prioritization Framework (CSA-PF), which explored a long-list of CSA practices applicable to the maize-bean system in the Dry Corridor, including the list in the existing policies as well as additional CSA options (Corner-Dolloff et al., 2014). The CCU-MAGA lead the implementation of the CSA-PF process, which assessed the practices for their potential impact related to productivity, adaptation, and mitigation to establish a short list of practices of highest interest, which were then evaluated using CBA. The CCU-MAGA then aimed to compare outcomes of the study with their promoted activities and revise the 'Corridor of Opportunities' plan.

The Methods section of this paper outlines the broader participatory research effort used to identify CSA investment priorities, the characteristics of the study site, and the main methodological choices made for the CBA. The results of the cost-benefit profiles of the prioritized practices are then presented. Discussion explores the findings from the case study and how the specific results can inform policy decisions. The paper argues that these types of economic analyses are necessary to provide policy- and decision-makers with evidence to determine best-bet CSA investment options, and to increase the likelihood of conducting targeted, context-relevant, and profitable interventions that achieve multiple desired outcomes.

2. Methods

2.1. CSA Prioritization Framework in Guatemala

The goal of the CSA-PF process was the participatory identification of CSA practices and investment portfolios for different users, taking into consideration economic profitability and overall benefits to determine (a) the feasibility of scaling out practices already implemented by farmers in the region and (b) new practices that can be incentivized in the Dry Corridor as part of MAGA's plan to mitigate drought impacts on agriculture in the region. CSA stakeholders, including governmental representatives (21), producers associations (7), research and academic institutions (9), and donor organizations (5), were engaged in the CSA-PF process.

The CSA-PF process included: (1) participatory identification of the study site, production systems of focus, and twenty-four CSA options relevant to the context; (2) evaluation of these practices using eleven indicators of the CSA goals (productivity, resilience, low emissions development) for use in prioritizing a short list of eight high-interest practices (Table 1); (3) CBAs on the eight practices; and (4) selection of CSA investment portfolios with stakeholders in a final workshop. This paper focuses on the results from phase three, outlining the detailed economic case for the eight short-listed practices.

The CCU-MAGA selected the Eastern Dry Corridor in Guatemala, which comprises five departments (Chiquimula, El Progreso, Jalapa, Jutiapa and Zacapa), for the focus of the assessment and validated this with 42 CSA stakeholders through surveys and a workshop. Practices that link with the maize and beans production system were targeted as this production system represents the staple foods and the most commonly cultivated crops in the selected region. Maize and beans are mainly grown on slopes on small-scale production farms (average 3.5 ha) for family consumption. The average productivity for 2007 was around 1.5 t/ha for maize and 0.7 t/ha for beans, which can be considered a low yield in the Central American context (IICA, 2009; Schmidt et al., 2012).

Table 1
List of CSA practices prioritized for economic evaluation.

Category	Practices	Specifications
Agroforestry	Live barriers with hedgerows	Introduction of *Gliricidia sepium* (Jacq.) hedgerows planted at a distance of 3 m between plants for 250 linear meters.
Agronomy	Conservation tillage with mulch	No-tillage and soil cover keeping the straw as mulch.
Agronomy	Contour ditches	Excavations of trapezoidal canals (0.5 m width, 2 to 3 m length, and 0.5 to 0.75 m deep) along a hillside following contour lines perpendicular to the slope for 75 linear meters.
Agronomy	Crop rotation (maize/bean)	Introduction of beans into previously monocropped maize-fallow system.
Agronomy	Heat and water stress-tolerant variety	Introduction of ICTA B-7, a local maize variety tolerant to limited water scarcity.
Agronomy	Pest- and disease-tolerant variety	Introduction of ICTA Ligero bean variety with tolerance to Bean Golden Mosaic Virus.
Agronomy	Stone barriers	Building a stone barrier along contour lines perpendicular to the slope for 200 linear meters.
Water Management	Water reservoirs/ponds + drip irrigation	These two activities are complementary practices: Water reservoir with a storage capacity of 30 m^3 and drip irrigation with plastic hoses and drippers distributed equidistant to planting distance.

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