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Adaptation to climate change in perennial cropping systems: Options, barriers and policy implications

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ABSTRACT

Plantation crops are likely to be highly vulnerable to climate change because of their long economic life span, their typically non-irrigated cropping pattern and the inability to easily switch crops due to high upfront capital costs. Hence the sector requires appropriately designed adaptation options to cope with on-going climate change. Studies on climate adaptation in perennial cropping systems are rare relative to those on annual crops. Based on a cross-sectional survey of 50 tea estate managers representing all tea growing areas in Sri Lanka, this study analyses factors affecting choice of preferred adaptation options, barriers to adaptation and associated policy implications for tea production as an example of a perennial tree crop system. Current adaptation options identified are crop diversification, soil conservation, and shade tree establishment and management. All of these options are adopted in some situations and locations. All estate managers interviewed believe that climate change is happening and almost all are experiencing the negative impacts of climate change on tea production. Results from a multinomial logit analysis show that information on climate change, company size, tea growing elevation, and increases in temperature and rainfall are key factors influencing the preferred choice of adaptation option. Furthermore, results reveal that barriers such as a lack capital, inadequate access to near-term and medium-term climate knowledge, and poor governmental and institutional support may prevent estate managers from experimenting with new adaptation options. Policies should, therefore, be aimed at promoting new adaptation options through information exchange between a wide range of stakeholders, and integrating climate change adaptation with Sri Lanka's sustainable developmental goals. Governmental and institutional support and involvement would be instrumental in facilitating adoption of adaptation options such as joint-production of tea with valuable timber crops.

1. Introduction

Adaptation can be considered to be the search for 'a better fit' to changed conditions (Arthur and Van Kooten, 1992; Smit et al., 2000), and can be either incremental ('tinkering around the edges' of current practices), or transformative (deeper, more structural changes) (Moser and Ekstrom, 2010). Effective adaptation to the particular stressors imposed by climate change is likely to require the latter approach (Rickards and Howden, 2012). Transformative change is particularly challenging for the perennial plantation sector. The establishment of plantation crops is a lengthy process requiring considerable capital investment, particularly in comparison to annual crops. This typically constrains options for climate change adaptation such as crop switching (Burton and Lim, 2005; Lobell et al., 2006; Lobell and Field, 2011). In addition, plantation crops such as tea, rubber and coconut are typically rain-fed (non-irrigated). The distinct differences between annual and perennial crop farming, and the important role which perennial cropping plays in developing world agriculture, suggest that it is important to understand the factors which affect farmers' choice of climate adaptation options in both annual and perennial crop farming.

Agrawal and Perrin (2009) argue that adaptation can happen from the top-down through changes in policies and institutions, and from the bottom-up via individual farm-level responses. Thus, agricultural adaptation can result from an intentional proactive or reactive response to any risk or change which modifies the business environment (Bryant et al., 2000). Many studies have analysed factors affecting farmers' choice of climate adaptation options in annual crop and livestock production systems in different parts of the world. Seo and Mendelsohn

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(2008) estimate a multinomial logit model (MNL) of crop choices using data collected from 949 farmers across seven South American countries. They find that variations in temperature and rainfall are key determinants of decisions to switch between crops such as vegetables, fruits and rice. Similarly, Deressa et al. (2009) employ a MNL to identify the determinants of farmers' choice of adaptation options under climate change in Ethiopia, based on a cross-sectional household survey of 1000 farmers. The authors find that education, gender, age, farm income, non-farm income, information on climate change, access to extension services, agro-ecological setting and temperature are significant determinants of adaptation choices. Based on a survey of 546 rice farmers, Alam (2015) explores factors affecting choice of adaptation options for water scarcity in a semi-arid region of Bangladesh. The author finds that more experience, better schooling, better access to electricity and institutional facilities, greater awareness of climate effects and secure tenure rights are key determinants of choice of alternative adaptation strategy. In a livestock farming context, Kabubo-Mariara (2008) investigate factors that affect choice of different livestock species under climate change in Kenya. The study finds that annual temperature, rainfall, age of head of household, household size and average education level of the household are the key drivers of livestock species choice.

To the best of our knowledge, no studies have yet empirically investigated the drivers of adaptation choice in perennial agriculture. Tea is an example of a perennial crop with an economic life span of about 30–50 years, and is a crop which provides a major source of revenue and employment in a number of developing countries (Alkan et al., 2009; Brouder et al., 2014). A number of studies have discussed the impact of climate change on tea production (Costa, 2010; Gunathilaka et al., 2017; Wijeratne, 1996), and whilst these studies mention potential adaptation options, they provide very little empirical analysis of the drivers of adaptation choice. To fill this knowledge gap, the present study analyses Sri Lankan tea estate managers' perceptions of climate change impacts, factors which affect their choice of current and potential future adaptation options, and barriers to the uptake of these options. The Intergovernmental Panel on Climate Change (IPCC) predicts increases in precipitation, temperature and extreme weather events for South Asia by 2060 (IPCC, 2013). The productivity of agricultural crops is predicted to decline, leading to increases in the vulnerability of rural communities who are dependent on agriculture for their livelihood. To the best of our knowledge, this is the first study to analyse factors affecting estate managers' choice of climate adaptation options for plantation crops in a developing country context.

Tea is the foremost agricultural crop in Sri Lanka. The tea industry generates about 15% of national foreign exchange earnings and provides employment for about 7% of the total workforce. Over 600,000 employees and their dependents rely on the tea sector for their livelihood (Ministry of Plantation Industries, 2013). The plantation crop sector in Sri Lanka has, however, been adversely affected by changes in climate over recent decades (Central Bank of Sri Lanka, 2014; Gunathilaka et al., 2017; Wijeratne and Chandrapala, 2014). Both the larger plantation estate sector and the smallholding sector face challenges from climate change, raising questions about their long-term viability. The quantity and quality of tea are greatly influenced by climatic parameters, particularly rainfall and temperature (Boehm et al., 2016; Wijeratne et al., 2007). Therefore, in Sri Lanka there is particular concern over the tea sector's vulnerability to climate change (Costa, 2010; Wijeratne, 1996).

Comprehensive knowledge of available adaptation options is of utmost importance if estate managers are to counteract production losses from climate change and maintain the competitiveness of Sri Lankan tea brands in the international market. This is also vital for efficient and effective channeling of available resources to address the consequences of climate change. Employing data derived from face-to-face interviews with 50 tea estate managers in Sri Lanka, this study focuses on the following research questions: (i) What are estate managers' perceptions of climate change? (ii) Which adaptation options are estate managers currently adopting? (iii) Which factors influence the choice of preferred adaptation options? And (iv) What are the policy implications of preferred adaptation options for long-term sustainability?

The paper is structured as follows: Section 2 describes the study area, data and survey sample characteristics. Section 3 reports managers' observations of the impacts of climate change on tea plantations. Section 4 describes a multinomial logit model of climate adaptation choice and presents multinomial logit results. Section 5 discusses constraints on the choice of adaptation options, and Section 6 concludes with policy implications.

2. Study area and data collection

2.1. Sri Lanka's tea sector: context and challenges

Historically, Sri Lanka's tea plantations were owned and developed by the British, and managed by British private companies (Loh et al., 2003). Between 1972 and 1975, however, all foreign and locally-owned estates larger than 20 ha were acquired by the government and vested under the Janatha Estate Development Board (JEDB) and the Sri Lanka State Plantations Corporation (SLSPC). JEDB and SLSPC managed 509 tea, rubber and coconut estates under the purview of the Ministry of Plantation Industries. Nationalised management through JEDB and SLSPC was not successful, and as a consequence between 1992 and 1993 the 509 estates were clustered into 23 Regional Plantation Companies (RPCs) with ownership of these companies retained by the government. Initially, management of RPCs was based on 99 year leases, with 5 year management agreements with private agents. This short term management agreement proved insufficient to motivate adequate investment, and financial performance continued to be poor. In 1995 Government divested ownership of all RPCs to the private sector, while retaining ownership of the land on a shortened lease agreement of 50 years (Kularatne and Takeya, 2003).

Currently, there are 306 tea estates scattered across three major growing regions of the country, owned and operated by 21 different RPCs.[1] Individual tea estates are managed centrally by a plantation company and usually possess their own processing facilities. This level of vertical integration constrains opportunities for crop switching as a climate adaptation strategy.

Further constraints on adaptation arise from the structure of the estate labour market. The estate sector operates with a large residential workforce who typically comprise Tamils originally brought from South India to Sri Lanka during British colonisation (Duncan, 2002). Labour operates under a centralized wage system, whereby plantation companies are required to increase the wages of plantation workers every three years (Sinnathamby, 1993). The number of workers and workdays in the estates are fixed for registered workers regardless of production, and worker productivity has not kept pace with wage increases; compared to other tea producing countries, Sri Lanka's plantation workers harvest approximately 18 kg/labour day, while workers in Kenya, South India and Assam harvest 48, 38, 26 kg/labour day, respectively. As a consequence, Sri Lankan tea estates tend to deploy labour only for essential management practices, such as tea plucking, and ignore capital-intensive sustainable management operations such as soil conservation and replanting.

Sri Lanka is part of the Indian sub-continent and has a tropical climate. Tea growing areas are located in Sri Lanka's wet zone (annual average rainfall − > 2500 mm) and intermediate zone (average annual rainfall − 1750–2500 mm). Plantation areas receive most rain during two major monsoons: the South-West Monsoon between May and September, and the North-East Monsoon between December and

[1] The remaining two RPCs only manage coconut plantations, not tea.

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