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Farm-level adaptation to climate change in Western Bangladesh: An analysis of adaptation dynamics, profitability and risks

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ABSTRACT

Using long-term district-level climate data and a case study from a drought-prone village in western Bangladesh, this research explored trends in climate change, and analysed farmers' adaptation dynamics, profitability and risks. This is the first study of its kind for drought-prone areas in Bangladesh.

Farmers perceived climate changes included increases in temperature and decreases in rainfall which were as consistent with the trends of Chuadanga climate records. Farmers' adaptation measures included changes in cropping systems, cropping calendars, crop varieties, agronomic practices, crop diversification and improved animal husbandry. Reducing environmental stress, ensuring self-sufficiency in staple crops (mainly rice) and other crop production practices, and enhancing economic viability of farm enterprises have underpinned these adaptations. Off-farm and non-farm wage employment, temporary migration, self-employment and educating children, constituted the core non-farm adaptation strategies.

Emerging cropping systems like maize/cucumber and maize/stem amaranth/rice were economically more viable than the traditional rice/rice and rice/maize systems. Despite some uncertainties, farming was preferred to off-farm work, generating higher returns to labour for all cropping systems. Limited access to stress-tolerant varieties, extension services and affordable agricultural credit, combined with high production costs, variability in crop yields and output prices, are the main barriers to adaptation. Stronger agricultural research and support services, affordable credit, community-focussed farming education and training are critically important for effective adaptation to climate change.

1. Introduction

Bangladesh is one of the most vulnerable countries to climate risks because of its geophysical setting and variability, and projected future changes in climate (Yu et al., 2010; Ruane et al., 2013). Bangladesh is a highly densely populated low-lying agrarian country. Agriculture is the foundation of the economy, contributing – 17.22% to the Gross Domestic Product (GDP), 5.4% to the export earnings and the employment of 45.6% of the total workforce (BBS, 2014a). The mean cropping intensity for Bangladesh is 190%, with rice being the staple crop, covering about 79% of net-cultivated area and being grown in three seasons during the year (BBS, 2014b). However, potential risks from climate change to agriculture stand out as most critical production constraints among the long list of potential impacts (Yu et al., 2010; Ruane et al., 2013). The key vulnerabilities of Bangladesh and its agriculture include, rising temperatures, changing rainfall patterns and associated prolonged and frequent dry periods, floods, sea level rise, frequent coastal cyclones and storm surges, lack of irrigation water, and changes in groundwater aquifers and salinity levels (Yu et al., 2010; Ruane et al., 2013; WB, 2013). IPCC (2014) has predicted that the adverse impacts of climate change on agriculture in a country like Bangladesh are likely to be intense, uncertain and unprecedentedly devastating.

Overuse, degradation and changes in resource quality (e.g., soils) will intensify population pressure on an already declining area of arable land per capita and scarce water resources (Alauddin and Sharma, 2013; Yu et al., 2010). Drought is one of the extreme weather events that adversely affects agriculture and rural livelihoods in western and north-western Bangladesh (Shahid and Behrawan, 2008; Alamgir et al., 2015). Droughts result from a decrease in seasonal rainfall, delayed and premature ends to the wet-season, and regional extreme heat that exhausts water bodies and soil moisture through increased evaporation (WB, 2013). Increasing seasonal or year-round water scarcity is a potential

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threat to food security, environmental quality, and overall livelihoods in many parts of South Asia, including Bangladesh (Alauddin and Sharma, 2013). Climate change may further aggravate water scarcity (Vaidya et al., 2014). Adaptation to these risks is critically important to ensure food security, reduce poverty and sustain economic growth (Bandara and Cai, 2014; Ruane et al., 2013).

Although major countrywide droughts in Bangladesh usually occur about every 5 years, localised droughts occur more frequently. In the past, droughts have affected about 47% of the area and 53% of the population of Bangladesh (FAO, 2006). Severe droughts affect Bangladesh, on average, every three years. A severe drought in 1973 caused local famine conditions in 1974 (Habiba et al., 2010). Droughts in 1978 and 1979 affected about 42% of the total cropped area, reducing rice production by about 2 million tonnes, while a drought in 1997 caused a reduction of about one million tonnes in food-grain production (of which about 0.6 million tonnes was wet-season rice) (Baas and Ramasamy, 2008, p.1).

Bangladesh's vulnerability to climate change risk has increased national and international awareness (Ruane et al., 2013). Bangladesh has adopted some effective disaster response systems and strategies, including the development of flooding, drought and salinity tolerant crop varieties, cyclone shelters, embankments, early warnings and preparedness, and security of freshwater availability (Huq et al., 2004; Yu et al., 2010). However, mainstreaming climate change adaptation as a public policymaking processes is critically important (Alauddin and Sarker, 2014). Location and sector specific analysis of risks and vulnerabilities is a *sine qua non* for prioritising needs and appropriate adaptation options (IPCC, 2014). Therefore, understanding local perspectives, farm-level adaptation and risk management strategies, are critically important for supporting smallholder farmers in climate vulnerable countries (Burke and Lobell, 2010; Anderson et al., 2014; Wright et al., 2014).

A significant body of literature has addressed climate change adaptation in drought-prone areas in Africa (Mertz et al., 2009; Stringer et al., 2009; Deressa et al., 2011; Fosu-Mensah et al., 2012; Gandure et al., 2013; Shackleton et al., 2015), Australia (Wheeler et al., 2013) and Canada (Bradshaw et al., 2004). Research on farm-level adaptation practices and constraints in Bangladesh has focused on the salinity prone south-western coastal region (Khan et al., 2014; Vivekananda et al., 2014) and drought prone areas in the north-western region (FAO, 2006; Ahmed and Chowdhury, 2006; Habiba et al., 2012; Alauddin and Sarker, 2014; Hassan et al., 2014; Alam, 2015). Using the discrete choice model, Deressa et al. (2011), Alauddin and Sarker (2014) and Alam (2015) have defined the factors that facilitate adaptation. Key findings of the studies included, the adoption of different stress tolerant crop varieties, crop management practices, livelihood diversification and migration. Human resources (education-level and family size), physical resources (land endowment), financial resources (credit and farm income) and social capital (markets and institutional support) mainly influence adaptation decisions. A lack of access to services, physical and financial capital, and adverse environmental conditions, impede adaptation.

Recent studies (Alauddin and Sarker, 2014; Alam, 2015) have underscored the critical importance of identifying adaptation strategies for informed policy formulation. The analysis of long-term climate trends and anomalies in the means and extremes in rainfall and temperatures that test farmers' perceptions of climatic change, have received inadequate attention. The existing literature also has paid inadequate attention, not only to the evolving process of farm-level adaptation in an historical context, but also to the rigorous analysis of risks and economic viability of existing cropping systems, despite the fact that profitability and risk-return trade-offs critically influence farming adaptation and production decisions (Dillon, 2003). In addition, different communities face different levels of vulnerability, which reflect adaptive capacity, physiographic features, and economic and socio-cultural constraints. These issues underscore the need to investigate location-specific adaptation options (IPCC, 2014).

Most previous studies have relied mainly on household surveys (Deressa et al., 2011; Habiba et al., 2012; Alauddin and Sarker, 2014; Alam, 2015) and focus group discussions (FGD) (FAO, 2006; Ahmed and Chowdhury, 2006; Baas and Ramasamy, 2008). In contrast, this study investigates contemporary phenomenon, including the complex relationships involving the biophysical environment and farming adaptation within a real-life context (Yin, 2009). Information collated from key informants in a drought-prone village (Durgapur) in Damurhuda Upazilla sub-district in Chuadanga district, western Bangladesh (Fig. 1), forms the empirical basis of this study. Using an anthropological approach, the study analysed farmers' adaptation dynamics, profitability and risks of cropping systems, and barriers to adaptation. It also explores trends in climate change based on long-term district-level climate data. Section 2 discusses the methodology of data collection and the analytical framework, while Section 3 presents empirical results based on the analysis of secondary data, farmers' adaptation strategies to climate and environmental changes, the drivers and constraints to adaptation, and an assessment of the economic viability of major cropping systems based on profitability and risk analysis. Section 4 presents the discussion, conclusions and implications of the study. This is the first study of its kind for drought-prone areas in western Bangladesh.[1]

2. Data and analytical framework

2.1. Secondary data

Long-term (1948–2013) daily climate data (maximum, minimum and mean temperature and mean rainfall) for the Chuadanga District Climate Station were made available by the Bangladesh Meteorological Department. The Statistical and Regional Dynamical Downscaling of Extremes (STARDEX) extremes indices software package (Haylock and Goodess, 2004) was applied to detect trends in both rainfall and temperature means and extremes. Trends and anomalies were analysed using the 1960–1990 base period, and to make comparisons of farmers' perceptions of recent changes in climatic conditions. Using Kendall's τ test, the study identified 118 temperature and rainfall trends across seasonal and annual timeframes: December to February (DJF), March to May (MAM), June to August (JJA) and September to November (SON).

2.2. Primary data collection, analysis and validation

The study village of Durgapur was selected, partly to allow a comparison with an earlier study that examined technology-environment-employment linkages of the village (Alauddin et al., 1995). While the arable area of the village is intensively used for rice and non-rice cropping systems, it is markedly affected by climatic (drought) and environmental stresses (a declining groundwater table as the aquifers are not being fully charged due to inadequate rainfall, even during the monsoon, and an increased incidence of pests) and market uncertainty. Alauddin and Sharma (2013) reported that an increasing dependence on groundwater for irrigation in north-west part of Bangladesh has led to a significant drop in the groundwater tables. In addition, the area lacks ready access to extension services due to its location (about

[1] Kabir et al. (2016) undertook a similar study in salinity prone areas in coastal Bangladesh.