Agricultural Systems 150 (2017) 54–66

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Smallholder farmers managing climate risk in India: 1. Adapting to a variable climate

Zvi Hochman [a,*], Heidi Horan [a], D. Raji Reddy [b], Gade Sreenivas [b], Chiranjeevi Tallapragada [c], Ravindra Adusumilli [d], Don Gaydon [a], Kamalesh K. Singh [e], Christian H. Roth [f]

[a] CSIRO Agriculture, Queensland, Biosciences Precinct, 306 Carmody Road, St Lucia, QLD 4067, Australia
[b] PJTS Agricultural University, Rajendranagar, Hyderabad, India
[c] Livelihoods and Natural Resource Management Institute, Hyderabad, Telangana, India
[d] Watershed Support Services and Activities Network, 12-13-452, Street No. 1, Tarnaka, Secunderabad 500 017, Telangana, India
[e] Indian Meteorology Department, Lodi Road, New Delhi 110003, India
[f] CSIRO Land and Water, EcoSciences Precinct, 41 Boggo Rd, Dutton Park, QLD 4102, Australia

ARTICLE INFO

Article history:
Received 4 January 2016
Received in revised form 29 September 2016
Accepted 3 October 2016
Available online xxxx

Keywords:
Climate variability
Simulation
Participatory action research
Rice
Cotton
Maize

ABSTRACT

This paper describes an investigation of various adaptations of rice based cropping systems to climate variability in India's Telangana State. All adaptations were generated through participatory engagement and were field-tested with local smallholder households before being evaluated through cropping system simulation analysis. This approach contrasts with most research about adaptation of cropping systems to climate variability and climate change that is mostly based on simplifying assumptions about current farmer management practices and where the feasibility of implementing proposed adaptations is rarely tested. In this study, the investigation commenced with discussions about climate related issues in rice based farming systems between researchers, farmers and NGOs in three villages in three Mandals of the state of Telangana. Participatory intervention was used to identify new practices that could provide more adaptive and robust responses to climate variability. Suggested adaptations were implemented in on-farm experimentation. Fields demonstrating these adaptations were monitored and results were discussed with participating farmers at regular 'Climate Club' village meetings. Crop and soil data from these fields were used to locally parameterise the cropping systems simulator APSIM. Local adaptations that were trialled in the villages were simulated using local soil and long term historical weather data. In each of the case studies, a number of adaptations that were developed and implemented in the villages were shown through simulation to be successful in terms of agricultural production, stability of yields and resource use efficiency. Of the adaptations investigated, sowing rules to reduce the chance of crop failure due to early dry spells were most readily adopted and are also relatively easy to extend to other villages. Strategic irrigation of rainfed crops such as maize and cotton resulted in significant gains to profitability and stability of these crops but cannot be considered in isolation where access to water is limited. Reduced irrigation of rice resulted in over 60 mm/ha/yr. savings in water and some improvements in gross margins but this adaptation was not popular with farmers due to its burden on labour and added risks associated with unreliable supply of electricity for pumping at critical times. The reduced rice area for strategic irrigation of rainfed crops adaptation resulted in improved gross margins per hectare per year and higher net water productivity. This adaptation is most promising but will require institutional change around water use policy and more equitable allocation of limited water resources within villages. These results led us to the proposition that participatory action research with smallholder farmers, coupled with field-testing and simulation analysis can produce practical and productive adaptations to climate variability.

1. Introduction

The research described in this paper was conducted in the context of a broader integrated research program investigating adaptation to climate change in South and Southeast Asian smallholder rice based cropping systems (The Adaptation to Climate Change in Asia program – ACCA; Roth and Grünbühel, 2012). We recognise the broader context within which climate variability and climate change are just a part of many socially and economically important issues facing smallholder households. Issues such as economic and demographic change, gender inequality, urbanisation, labour dynamics, market access, competing demands for land and access to dwindling groundwater resources (Batchelor et al., 2003; De Koninck, 2004; Aggarwal et al., 2010) were

* Corresponding author.
E-mail address: zvi.hochman@csiro.au (Z. Hochman).

http://dx.doi.org/10.1016/j.agsy.2016.10.001

always present in our interactions. Other papers from this study are more focussed on these issues (Jakimow, 2013; Jakimow et al., 2013; Jakimow; 2014; Nidumolu et al., 2015; Williams et al., 2016; Brown et al., 2016). While the overall aim of this research was to investigate adaptations to climate change, it became clear in early discussions with farmers that they did not distinguish between climate variability and climate change. Farmers were well aware of climate variability and its impacts (Nidumolu et al., 2015) yet, they were generally unable to articulate how they adapted their management to cope with this variability (Brown et al., 2016). We decided to take a two staged approach in which we would first investigate adaptations to climate variability and then, to ensure that these are not maladaptations to climate change (Adger et al., 2005; Howden et al., 2007), examine the most promising adaptations against future climate change scenarios. This pragmatic approach is also supported in the literature for a range of reasons including: that adaptations to climate variability are likely to also be successful adaptation to climate change (Howden et al., 2007); that additionality over adaptation to climate variability is elusive (Hayman et al., 2012) and; that present action to address future change may be unjustified (Asseng and Pannell, 2013).

Variability in rainfall is a principal source of fluctuations in food production, particularly in the semi-arid tropical countries such as India (Bantilan and Anupam, 2002; Meinke et al., 2006; Cooper et al., 2008; Aggarwal et al., 2010; Balaghi et al., 2010; Coe and Stern, 2011). Climatic uncertainty diminishes the capacity of farm households to plan for any given season. Unlike some other regions with variable climates much of the Indian subcontinent lacks a skilful climate forecasting system (Kar et al., 2012). Consequently, the challenge faced by farmers is to flexibly adjust their management practices and their level of investment in crop production inputs as the season develops in order to avoid either over-investing in crops with poor yield prospects or under-investing in crops with good yield prospects.

This paper is concerned with the role of simulation as a component of a broader participatory framework for developing and testing locally relevant adaptations for management of climate risk in smallholder rice based cropping systems. Dynamic, process-based crop and cropping system simulation models are commonly used in studies of climate risk management. Challinor et al. (2009) argued that the generation of knowledge for policy adaptation should be based on a more synergistic and holistic research framework that includes: (i) reliable quantification of uncertainty; (ii) techniques for combining diverse modelling approaches and observations that focus on fundamental processes; and (iii) judicious choice and calibration of models, including simulation at appropriate levels of complexity that accounts for the principal drivers of crop productivity, which may well include both biophysical and socio-economic factors. They argued that such a framework will lead to reliable methods for linking simulation to real-world adaptations. While such a framework does not currently exist, this study takes on board the need for simulations to be able to account for the principal drivers of crop productivity, to be locally calibrated, to be able to capture farmer decision making rules, to account for socio economic factors and to produce locally credible outputs.

Engaging stakeholders is an essential ingredient in the mobilisation of science to real world problems and a strong case has been made for stakeholder participation in the application of climate science and methods to integrate it into meaningful information that is embedded into the knowledge networks and the social and institutional processes through which farmers make decisions (Carberry et al., 2002; Cash et al., 2003; Sivakumar et al., 2005; Meinke et al., 2006; Meinke et al., 2009; Hochman et al., 2009; McCown et al., 2012; Mapfumo et al., 2013; Howden et al., 2014; Rurinda et al., 2014). Stakeholder engagement can take place at the policy and at the local (farming household, community) level. In developing locally credible management options that are adaptive to climate variability, local knowledge is important because it is specific to the geographical and cultural features of place and is expressed in terms that are better integrated with social experience (Lebel, 2012). In this study we test the concept that practical adaptations to climate variability can be developed by using participatory methods to elicit local ideas about adaptation, and by testing these ideas both through simulation analysis and with village farmers, to ensure that they can be adopted on the ground by smallholder farmers. To achieve this, the broader ACCA project harnessed a broad range of formal science skills including climatology, modelling, agronomy and social anthropology through to experiential and practical development knowledge embodied in NGOs and collaborating farmer groups. Some of the underpinning social research has already been published elsewhere as mentioned above.

2. Methods

2.1. Case study villages

This study was conducted from 2010 to 2013 in the State of Telangana (formerly part of Andhra Pradesh) in south India. We selected three case study villages located in three districts in Telangana, varying in rainfall and soils: Warangal, in the Central Telangana agro climatic zone and Nalgonda and Mahabubnagar in the Southern Telangana Zone (Fig. 1). Paddy rice, cotton, and to a lesser degree maize are the key kharif (monsoon) crops in these villages. Rabi (dry season) crops are mostly dependent on irrigation and include paddy rice, vegetables, turmeric and other high value crops. Paddy rice is grown under irrigated conditions mostly using groundwater pumped from bore-wells powered by electric motors. Cotton and maize are mostly rainfed. Farming households are diverse, ranging from many marginal and small farmers (<2 ha) with poor soil and limited or no access to irrigation (household types 2 and 3) or with access to irrigation (household type 4), to medium and large farmers with either no or limited access to irrigation (household type 5) or with good access to irrigation and good quality soil (household types 6 and 7; Williams et al., 2016). Livelihoods and adaptive capacity vary accordingly (Brown et al., 2016).

Fig. 1. Location of the 3 case study villages in Telangana, South India. Each circle represents a case study village.