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Reducing risks to food security from climate change

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ABSTRACT

Climate change will have far-reaching impacts on crop, livestock and fisheries production, and will change the prevalence of crop pests. Many of these impacts are already measurable. Climate impact studies are dominated by those on crop yields despite the limitations of climate-crop modelling, with very little attention paid to more systems components of cropping, let alone other dimensions of food security. Given the serious threats to food security, attention should shift to an action-oriented research agenda, where we see four key challenges: (a) changing the culture of research; (b) deriving stakeholder-driven portfolios of options for farmers, communities and countries; (c) ensuring that adaptation actions are relevant to those most vulnerable to climate change; (d) combining adaptation and mitigation.

1. Introduction

Reducing risks to food security from climate change is one of the major challenges of the 21st century. The impacts of climate change on crop yield can already be detected in observed data (Lobell et al., 2011). Climate impact studies on crops predominate, but impacts on fisheries and livestock production are no less serious (Creighton et al., 2015; Herrero et al., 2015). Whereas slow changes, such as rising temperatures and sea level, will only have major impacts in the coming decades, farmers already have to deal with changing weather patterns and rising frequency and intensity of extreme weather events, making farming even more risky (IPCC, 2012). Adaptation actions to reduce risks are urgent.

In many applied disciplines, there is a gap between research and implementation, variously termed the research-implementation, research-practice, knowing-doing or science-policy gap (Knight et al., 2008). With climate change there is the additional problem of deep uncertainties – not knowing the exact shape of future climates or even the next season, and these uncertainties are unlikely to go away in the next decade (Heal and Millner, 2014). But decision-making in the face of uncertainty is by no means unique to the climate change challenge (Beven and Alcock, 2012). We must seek tools and processes whereby uncertain knowledge can drive action.

We posit that, given the limitations of doing yet more impact studies (in particular crop-focused studies – Section 2) and given the seriousness of climate change (Section 3), the research emphasis should shift to supporting implementation of solutions for food insecurity (Section 4). As Heal and Millner (2014) note, we have more than enough information about climate change and variability to understand that it is a serious problem that requires immediate attention.

2. Knowledge limitations about climate change risks to food security

2.1. Crop-climate models limiting for food production impact studies

Crop-climate modelling is central to the development of future agricultural outlooks that can inform policy processes and/or field-

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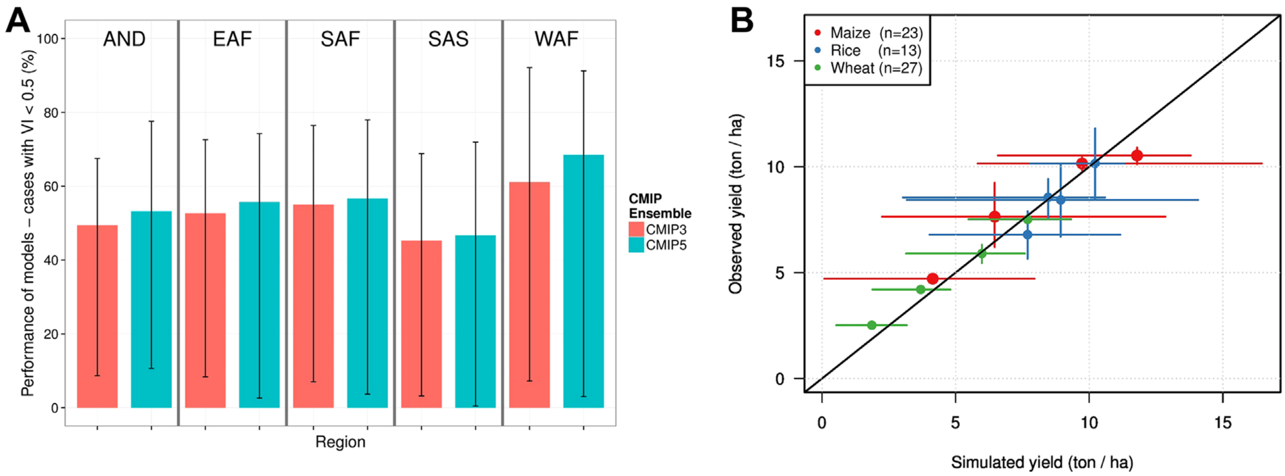

Fig. 1. Climate and crop model performance. (A) Improvement in CMIP climate model performance in representing interannual variability of temperature (from CMIP3 to CMIP5) across different regions (Ramirez-Villegas et al., 2013); (B) Summary of multi-crop-model evaluations for maize (Bassu et al., 2014), rice (Li et al., 2015), and wheat (Asseng et al., 2013). For A, model performance is measured as the number of country* season combinations with a variability index (VI) below VI=0.5, that denotes good model performance. Bars show the average of all GCMs and error lines span the range of variation of individual GCM simulations of each ensemble. AND: Andes, EAF: East Africa, SAF: Southern Africa, SAS: South Asia, WAF: West Africa. For B, each point shows the average of observations and median of simulations for 23 (maize), 13 (rice) and 27 (wheat) crop simulation models for a given site where model evaluations were carried out (4 sites for each crop). Horizontal error bars show maximum and minimum simulated yield in the ensemble of models, and vertical error bars show observational error.

level decisions (Porter et al., 2014). Despite robust outcomes in certain situations model-based assessments of future agricultural productivity are subject to uncertainty. Uncertainties can limit the predictability of the system being modelled, and hence preclude adaptation decisions (Weaver et al., 2013). Thus, understanding relevant predictability limits as well as reducing uncertainty remain critical topics of future research (Vermeulen et al., 2013). In climate modelling, improvements in parameterisation and increases in model complexity and spatial resolution have resulted in enhanced model performance (Delworth et al., 2012). However, progress remains slow considering the requirements of the agricultural community (Fig. 1(A)), thus limiting our ability to project future agricultural productivity and land-use changes. Crop model uncertainty also limits assessments of future food production (Challinor et al., 2014b). Differences in crop model ensemble size, precision, and accuracy across crops and sites mean that the quality and quantity of information available to stakeholders varies depending on the crop system and areas (Fig. 1(B)) (Challinor et al., 2014a). Additional limitations are evident in crop-climate impact studies. Most notably, model limitations have precluded the study of mixed systems and minor crops that are prevalent across the tropics, and of nutritional outcomes (Challinor et al., 2014b; Thornton and Herrero, 2015). Our understanding of climate variability and extreme impacts is also limited (Porter et al., 2014).

2.2. *Lack of attention to livestock, fisheries, pests and diseases, and interactions*

Rivera-Ferre et al. (unpublished) demonstrate how the IPCC analysis of food security in the Fifth Assessment Report (AR5) is largely crop-focussed, with minimal attention to livestock. And even in the cropping studies the focus is rather narrow – on crop yields, with little attention to crops as components of farming systems, value chains or landscapes. We extend their analysis to fisheries, and pests and diseases (Fig. 2(A)), which show similarly low levels of citation. More attention to these components is

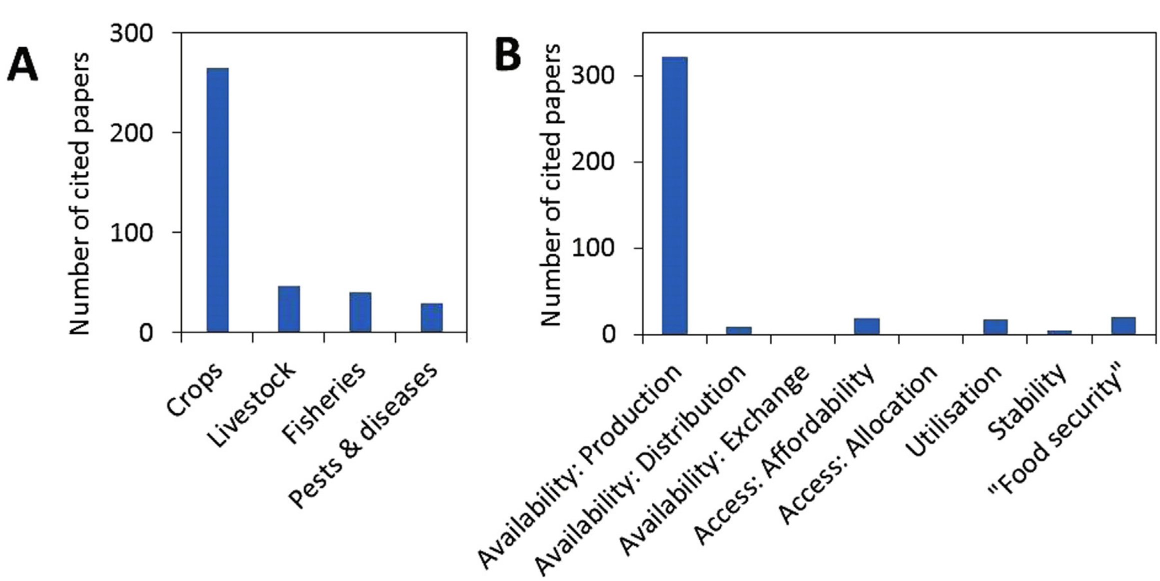

Fig. 2. Coverage in the food security chapter of AR5 of (A) sub-sectors, and pests and diseases; and (B) food security determinants. For (A) some citations are not mutually exclusive amongst categories (e.g. a few crop-livestock citations would be included in both sub-sectors). For (B) “Food security” covers food security in general terms.

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