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Quantifying crop yield gaps across the Indo-Gangetic Plains from new perspectives – production, farmer profit and sustainability of water use

Overview

Quantifying food production capacity from current farmland in a consistent and transparent manner is vital for policy makers, researchers, and farmers. The traditional concept of a *crop yield gap,* i.e. the difference between what farmers are currently achieving and what is physiologically possible at that location, is considered to be useful in national food security planning and determining what food increases are possible with improved practices, varieties or technologies.

The scientific literature is dominated by research into this *physiological yield gap,* however in reality the concept may be of limited practical value. We propose there are other lesser-known or lesser-considered 'yield gap' definitions which may be more useful to farmers, extension efforts, and policy-makers than the physiological yield gap. This particularly applies to the Indo-Gangetic Plains (IGP), where socio-economic constraints often limit options and over-exploitation of regional water resources has caused problems in the recent past.

These other yield gap definitions include what we will call (i) the *economic yield gap* (the difference between farmers current yields and the yields which would generate the maximum farmer profit) and (ii) the *sustainable-water yield gap* (defined by the maximum regional crop yield possible, while keeping irrigation water extractions (surface and ground-water) sustainable.

ACIAR project number	
Start date and duration (years)	February 2019 (one year)
Location	Indo Gangetic Plains (India, Nepal, Bangladesh)
Budget	AU$242, 305

Project leader(s) and Commissioned Organisation

Dr Don Gaydon, CSIRO

Partner country project leaders and their institutions

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These three crop yield gaps (physiologic, economic, and sustainable water) may all correspond to different yield levels, and those differences may vary between geographical location, soil environment, and socio-economic setting. A detailed understanding of these different crop yield gaps and how they vary across the IGP is currently non-existent but highly desirable. This project will begin the process of determining these different crop yield gaps across the IGP, and understanding how they are influenced by geography, resource dynamics (climate and water), economic settings, and future climate outlooks.

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Research

The aim of this project is to quantify current yield gaps (physiological, economic, and sustainable-water) for major food crops at sentinel sites across the IGP, and make preliminary assessments on the effects of CASI, future climate scenarios, and some economic variables.

A combination of methods will be employed, including cropping systems modelling, economic analysis, farmer engagement, and data-sourcing. The primary focus will be on the Eastern Gangetic Plains to fit with the Sustainable Development Investment Portfolio aims, but to provide perspective and comparison will include the whole IGP (minus Pakistan, which will be done in a complementary project) in our analyses. Our proposed methodology will centre around 8-10 sentinel sites chosen across the IGP region, at which detailed analysis will be undertaken.

Activities to be undertaken include:

1. Meeting with project team and key stakeholders
2. Collecting site data
3. Parameterise, calibrate and validate APSIM at each sentinel site (Jul-Aug 2019)
4. Conduct scenario analyses (using APSIM) to define yield gaps (Sep-Oct 2019)
    - » Run APSIM to simulate grain production (and risk) over the historical climatic record, for a range of scenarios:
        - *current farmer practice*;
        - *potential grain yield* – with no limitations of soil nutrients and water, and only climatic limitations (to define *physiological yield gap*);
        - *maximum economic grain yield* – consisting of current famer practice with incrementally increased inputs of water and fertiliser, until farmer gross margins are maximised (to define *economic yield gap*); and
        - *maximum sustainable-water grain yield* – limit the available farmer irrigation water according to the identified sustainable water extraction levels (yields) for the district (to define sustainable-water yield gap).
    - » Analyse how the revealed yield gaps (physiological, economic, and sustainable-water) vary over the IGP.

Conduct sensitivity analysis to understand how these yield gaps are influenced by prevailing cost-price structures. For example, in different parts of the IGP, how is the economic yield gap effected by (i) labour costs; (ii) fuels costs; (iii) grain prices; etc.

Anticipated outcomes

If demonstrated to be successful and useful, the methodologies and protocols developed during this project will potentially facilitate a much broader analysis of the whole region in a subsequent project, bringing in the latest GIS, satellite and remote-sensing technologies, together with the latest economic and climate forecasts, to provide robust insights for regional policy-makers and other stakeholders. The results from this project can be of use to policy makers, who need to know not just what is possible in terms of crop production, but what is economically and environmentally sustainable.

This work will be synchronised with a major international initiative, the *Global Yield Gap Atlas* (GYGA; http://www.yieldgap.org/ - led by Wageningen University (WUR, The Netherlands) and University of Nebraska, Lincoln (UNL, US)), funded by Bill & Melinda Gates Foundation, USAid, The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), amongst others. Through this project, we are hopeful of influencing the agenda of the GYGA initiative – to broaden their scope to encompass the more practical yield gap aspects which we have detailed above.