In-season Wheat Yield Forecast in Nepal (Winter 2015/2016) using CRAFT*

FINAL REPORT

*CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) Regional Agriculture Forecasting Toolbox (CRAFT)

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WFP World Food Programme wfp.org

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NeKSAP collects, analyzes and presents information on household food security, emerging crises, markets and nutrition from across Nepal. NeKSAP is implemented by MoAD with the strategic guidance of the National Planning Commission (NPC). WFP provides technical assistance for NeKSAP with funding from the European Union and UK aid from the UK government.

MoAD and WFP would like to acknowledge the recent collaboration with CCAFS South Asia to strengthen early warning for better food security planning in Nepal, especially under the present and anticipated changing climatic conditions. The results of this collaboration are presented in this report.

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Background

Crop yield forecasting refers to the prediction of crop yield or production prior to harvesting. Reliable, timely and accurate crop yield forecasts can provide crucial information for food security planning, particularly in the context of climate variability, change, and extremes. Crop yield forecasting uses meteorological data, cultivar specific genotype data, soil properties, and various management practice data to simulate plant-weather-soil interactions in quantitative terms and predict the crop yield over a given area, prior to the harvest. These models try to mimic fundamental mechanisms of plant growth and related processes in the soil-plant-atmospheric continuum to simulate specific outcomes. For any soil, cultivar and management conditions weather is a prime driver of inter-annual variations in the crop yield.

So far crop yield estimation in Nepal is based on traditional crop cuts, surveys and reports from the District Agricultural Development Offices (DADOs). Additionally, representatives from MoAD, WFP, FAO and other technical agencies undertake field verifications and consultations to collect additional information on crop performance and issues and challenges related to production and marketing of key cereals. Based on MoAD's preliminary estimates and field verification outcomes, MoAD, WFP and FAO issue the publication, Crop Situation Update, twice a year, i.e., after the summer crop harvest and winter crop harvest. These updates rely on sample crop-cutting, which is used to verify the yield for key cereal crops (paddy, wheat, maize, and millet).

Though this process has its own advantages, it is a time consuming and costly exercise and there can be delays in processing the results. The sample crop cut results can take from six months to over one year to provide a basis for the area and production estimates and the results only become available after the crops are actually harvested. On the other hand, the Government of Nepal and development partners working on food security require estimates of food production in advance for policy and programme decisions relating to pricing, marketing, export/import, distribution, and overall food security management. In this context, crop modeling tools can provide production estimates in advance of traditional practices, enabling better food security planning and programme decision making.

A systematic crop yield forecasting model is, however, not yet developed for Nepal. In the absence of a country specific model, a robust crop yield forecasting tool based on real-time climate information can serve the same purpose, providing accurate, precise, scientific estimates of crop yields for food security and early warning purposes. Once the simulation model is built, seasonal crop yields can be estimated by periodically updating climatic data and other information in the model.

Under its research theme on Climate Risk Management, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) has developed a crop yield forecasting tool, the CCAFS Regional Agriculture Forecasting Toolbox (CRAFT), customized for the South Asia Region. CCAFS is a strategic partnership of CGIAR and Future Earth, led by the International Center for Tropical Agriculture (CIAT), which conducts research to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security.

CRAFT (version 2.0) incorporates a crop simulation model (DSSAT), weather and seasonal forecast module (CPT) and a GIS mapping module (Map Win GIS). This tool provides the support for spatial input data, spatial crop simulations, integration of seasonal climate forecasts, spatial aggregation, probabilistic analysis of forecast uncertainty, and calibration of model predictions from historical agricultural statistics, analysis and

visualization. This tool helps to provide advance information to farmers and policy makers allowing them to manage within-season climate risks to agriculture. The model has been used in Nepal for a pilot study and is being currently used in Bangladesh, Sri Lanka and India as well. **Figure 1** presents the flow diagram of CRAFT with four major steps (e.g. crop model, statistical model, aggregation and calibration).

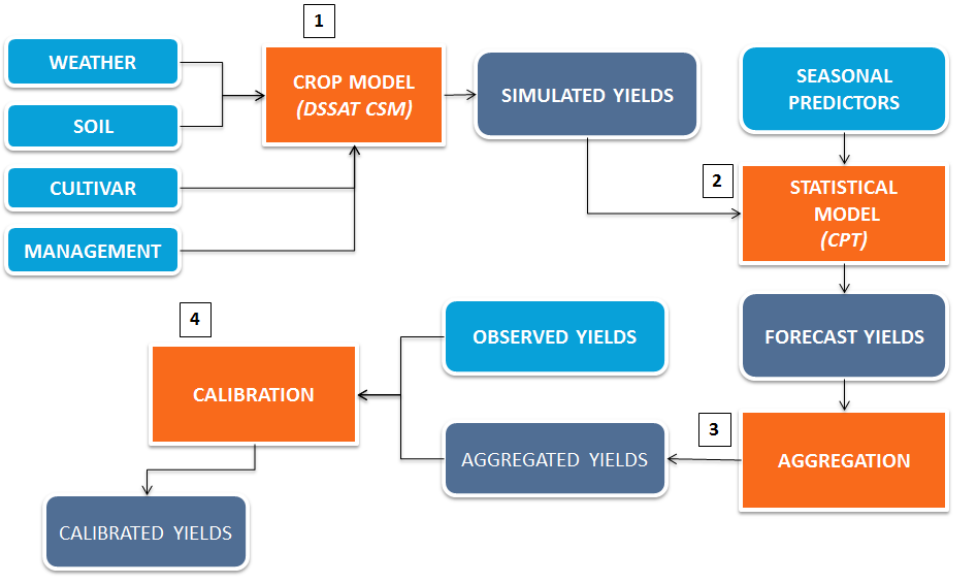

Figure 1: Flow diagram of CRAFT

Methods

Weather

Weather is the major driver of the CRAFT model, and the reliability of climatic parameters determine the reliability of model outcomes, i.e., the yield and production forecasts. Near-real time data is a prerequisite to get reliable yield forecasts. In the absence of the near real time data, ground measured station data were used in conjunction with the satellite based climatic estimates. The Department of Hydrology and Meteorology (DHM) ground station data for precipitation and temperature for the time period of 1981 to 2009 were used in the model run. The precipitation data was taken from 163 stations and temperature data was taken from 45 stations across Nepal.[1,2] The stations were selected based on the availability of the weather parameters. These data were interpolated in 5' x 5' schema grids using the nearest neighborhood method[3]. Beyond 2009, the weather data was supplemented using other satellite precipitation and temperature estimates. The supplementary precipitation data used was 0.1° RFE v 2.0 data (Love, 2002), which was accessed through the IRI/LDEO Climate Data Library.[4] Climatic data until 15 April 2016 were considered.

Wheat crop mask

The wheat mask was prepared for Nepal using the Ministry of Agricultural Development's national statistics on wheat grown area at two stages during the season: 15 February and 20 April. The final mask was based on

[1] http://www.dhm.gov.np/hydrological-station/
[2] http://www.dhm.gov.np/meteorological-station/
[3] The nearest neighborhood method calculates the distance and additional proximity information between the schema grids and the weather stations around it and picks the closest weather station for each grid.
[4] http://iridl.ldeo.columbia.edu/

MoAD's estimated wheat grown area of 20 April. The reported grown area is a 0.8 percent reduction compared to the 2014/15 season. The ratio of wheat grown area to the total area for each district was calculated and this proportion was uniformly distributed to each grid within a district to get a distributed wheat mask for Nepal.

Irrigated area mask

MoAD statistics on the ratio of irrigated area to the total cultivated area (2014/15) was used and distributed to grids within each district.

Soil data

The Soil and Terrain Database (SOTER) for Nepal was used as the soil source, and the respective properties, such as texture, depth, soil moisture content, bulk density, infiltration capacity, and organic matter content (Dijkshoorn and Huting, 2009), were added to the CRAFT database and used for modeling. The SOTER database, at a scale of 1:1 million, is supported by the Food and Agriculture Organization (FAO), ISRIC-World Soil Information and the United Nations Environmental Programme (UNEP) under the umbrella of the International Union of Soil Science (IUSS) to create a global soil and terrain cover.

Crop varieties

Wheat cultivars used in the model were as follows: RR-21 for the hills ecological belt and NL-297 varieties for the Terai ecological belt. Calibrated genotypes obtained from the Nepal Agricultural Research Council (NARC) were used as the cultivar coefficients.

Crop management

The agriculture sector, especially in the Terai, was significantly hampered by the earthquakes in the western and central regions in April-May 2015 and the disruptions to cross-border trade with India between September 2015 and January 2016. As a result of the severe shortage of fuel in the second half of 2015, the use of water pumps for irrigation was limited in many areas during the sowing and growing periods. Coupled with this, there was a weak monsoon in 2015 and significant decline in winter rains in 2015/2016, thereby reducing the amount of available soil moisture during the sowing and growing periods. Field visits during the joint crop assessment missions for summer crops (in November 2015) and winter crops (in April 2016) confirmed the late sowing of wheat due to insufficient soil moisture.

To simulate these unfavorable conditions in the model the irrigated area was reduced by 25 percent and the sowing dates were postponed by 10 days (compared to the normal sowing dates). The sowing dates for the hills ecological belt were assumed to be December 11 and for the Terai to be December 2. Nitrogen fertilizer use was estimated at 60 kg/ha for both the hills and the Terai. Total irrigation application was estimated to be 600 mm for the hills and 800 mm for the Terai. The assumptions on fertilizer and irrigation applications were based on the studies conducted by Gautam et al. (2011), Hobbs et al. (1996), Adhikari et al. (1999), and Amgain and Timsina (2005).

Results

Once the aforementioned spatial-temporal inputs were prepared and entered into the model, CRAFT forecasted the total wheat production for the 2015/2016 season. Since the model was already established for wheat during the 2014/15 wheat production forecast, the calibrated parameters were used to forecast the wheat production for this season.

Preliminary wheat outlook for the 2015/2016 season (with the wheat mask as of 15 February 2016)

The preliminary model prediction run was based on the MoAD estimated wheat crop area of 723,754 ha (as of 15 February), which was a 5 percent reduction compared to last season. The model forecasted a production level of 1,570,746 mt, which is 20.5 percent less than the 2014/15 production level and 16 percent less than the five-year average production level. See **Figure 2** below.

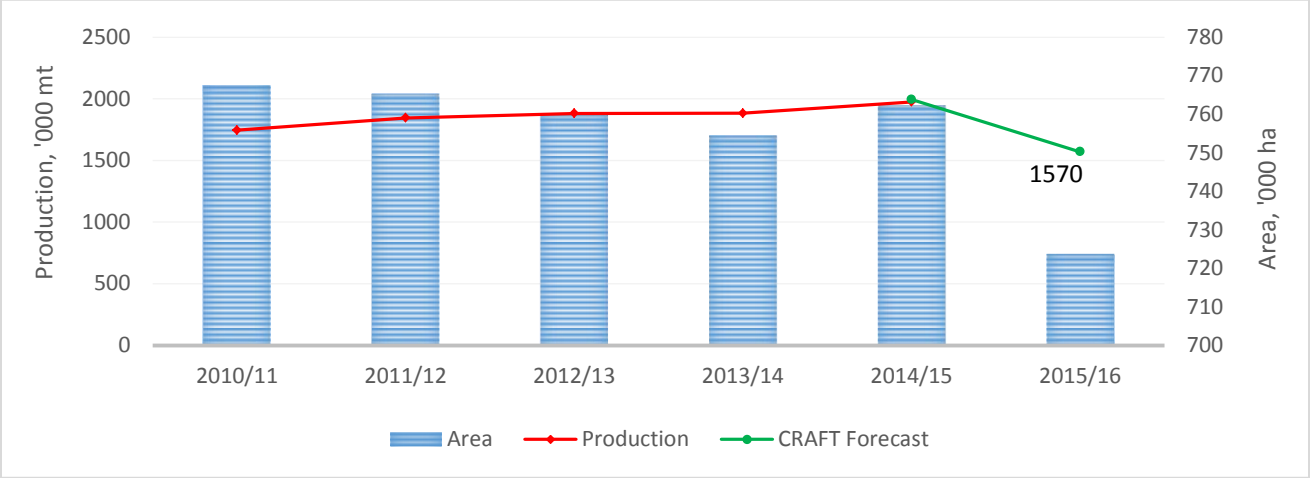

Figure 2: Crop area (in ha) and observed and forecasted production (in mt) as of 15 February 2016

Preliminary wheat outlook for the 2015/2016 season (with the wheat mask as of 20 April 2016)

The aforementioned result was revised with the updated MoAD estimated wheat crop area of 756,547 ha (as of 20 April, the end of wheat plantation), which was a 0.8 percent reduction from last season. The model forecasted a production level of 1,718,120 mt, which is 13 percent less than the 2014/2015 production level and 8 percent less than the five-year average production level. See **Figure 3** below.

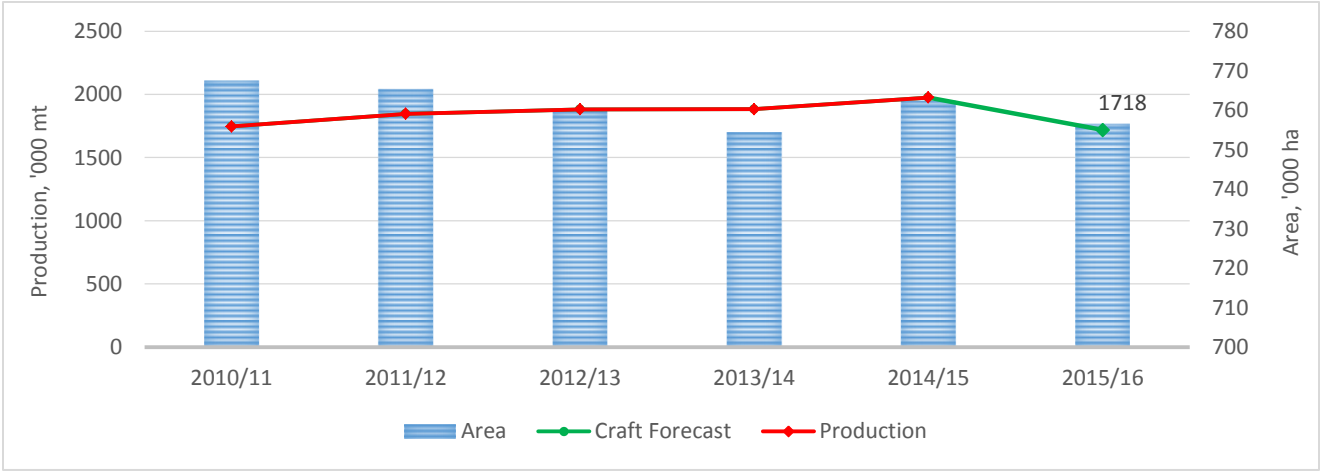

Figure 3: Crop area (in ha) and observed and forecasted production (in mt) as of 20 April 2016

Conclusion

Crop yield forecasting outcomes

Since 2014, the CCAFS Regional Agriculture Forecasting Toolbox (CRAFT) has been piloted as part of the Nepal Food Security Monitoring System (NeKSAP) and is a new initiative to incorporate crop yield forecasting in Nepal, with the technical support from CCAFS South Asia.

CRAFT was used to estimate the total wheat production level in Nepal over the 2015/2016 season. See **Table 1** for the forecasted wheat production results at different stages and MoAD's observed wheat production results after the harvest[5]. The latest crop yield forecast from 20 April is 1,718,120 mt, which is a 13 percent reduction in total wheat production compared to the 2014/2015 season. The forecasted amount closely matches the MoAD production estimate of 1,736,849 mt with a difference of 1.1 percent.

Date of forecast	Production forecast, mt	Production observed, mt	% difference
15 February 2016	1,570,746	1,736,849	10.04
20 April 2016	1,718,120	1,736,849	1.08

Table 1: Comparison of forecasted and observed wheat crop production results, 2015/2016 season

These results show that there is the potential for crop yield modeling to be incorporated in the crop yield estimation process in Nepal and can thus make a significant contribution to food security planning and early warning.

Dissemination of results

The initial results from CRAFT for wheat production were published through two advance estimates on 1 March 2016 and 20 April 2016[6]. Furthermore, MoAD and WFP held a dissemination meeting on 18 May 2016 to share the CRAFT results with stakeholders from key institutions, including various divisions in MoAD, Department of Agriculture (DoA), National Planning Commission, International Maize and Wheat Improvement Centre (CIMMYT), and International Centre for Integrated Mountain Development (ICIMOD).

[5] MoAD released the wheat production estimate on 22 June 2016
[6] www.neksap.org.np

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