A Report on In-season Paddy Yield Forecasting (Summer 2015) using CRAFT in Nepal

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

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WFP World Food Programme wfp.org

Acknowledgment

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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.

This report relies on information provided through different agencies, including the International Centre for Integrated Mountain Development (ICIMOD), International Water Management Institute (IWMI), International Research Institute for Climate and Society, Columbia University, Nepal Agriculture Research Council (NARC), Department of Agriculture, MoAD and WFP. Hence, all contributing agencies and their staff are gratefully acknowledged for their support and cooperation.

The Nepal Food Security Monitoring System (NeKSAP) collects, analyzes and presents information on household food security, emerging crises, markets and nutrition from across Nepal. Initiated by WFP in 2002, NeKSAP is now jointly operated by the Ministry of Agricultural Development and WFP under the strategic guidance of the National Planning Commission.

http://www.neksap.org.np

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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 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 Crop Situation Update report twice a year, i.e., after the harvest of summer and winter crops. These reports 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 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 other agencies working on food security require estimates of food production in advance for various policy and programme decisions relating to pricing, marketing, export/import, distribution, and overall food security management. In this context, crop modeling tools can provide the Government of Nepal and other agencies with production estimates well in advance to support better food security planning and programme decisions.

A systematic 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, CCAFS has developed a crop yield forecasting tool customized for the South Asia Region, the CCAFS Regional Agriculture Forecasting Toolbox (CRAFT). The CGIAR Research Project on Climate Change, Agriculture and Food Security (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 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).

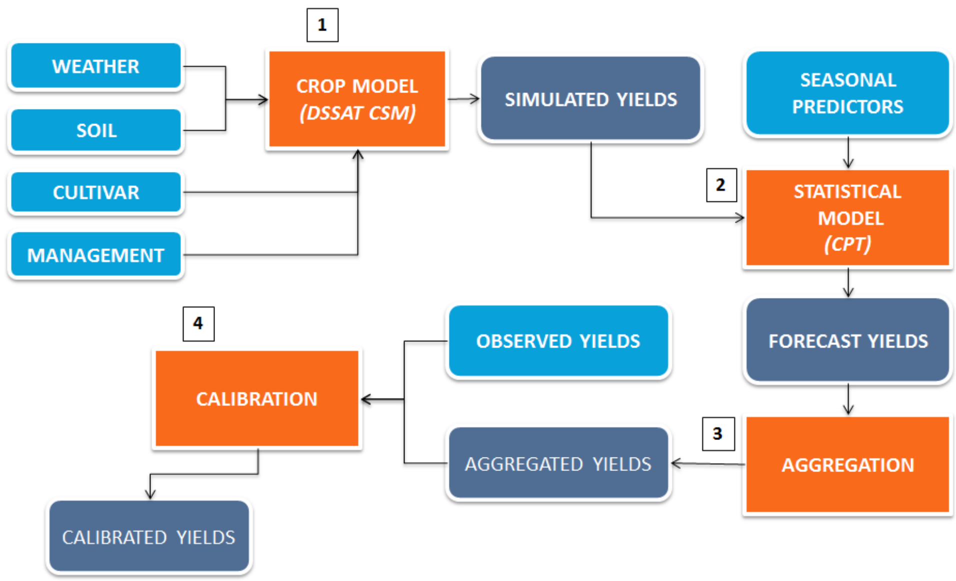

Figure 1: Flow diagram of CRAFT

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. Department of Hydrology and Meteorology (DHM) ground station data for precipitation and temperature for a time period of 1981 to 2009 were used in the model run. The precipitation data was taken from 163 stations and temperature from 45 stations across Nepal.[1] 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[2]. 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

[1] http://www.dhm.gov.np/hydrological-station and http://www.dhm.gov.np/meteorological-station/

[2] 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.

data (Love, 2002), which was accessed through the IRI/LDEO Climate Data Library.[3] Climatic data till August 20, 2015 were considered.

Paddy crop mask

The paddy mask was prepared for Nepal using the Ministry of Agricultural Development's national statistics on paddy grown area during different dates in the monsoon season for the year 2015. The final mask was based on the MoAD's estimated rice planted area of August 29. The reported area shows about 4.5 percent reduction as compared to the 2014 season. The ratio of paddy 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 rice 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 based on districts. It was assumed that the irrigated area remained the same in 2015.

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 of the United Nations (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

Jumli Marshy for the mountains, Khumal–4 for the hills and Mansuli for the Terai ecological belt were selected as the popular paddy cultivars. Calibrated genotypes obtained from the Nepal Agricultural Research Council (NARC) were used as the cultivar coefficients.

Crop management

The planting dates for the mountains, hills and Terai ecological belts were assumed to be 7, 10 and 11 July respectively. Similarly, it was also assumed that nitrogen fertilizer use was 80 kg/ha for both the hills and Terai. Total irrigation application was assumed to be 1000 mm for the hills and 1200 mm or the Terai. The assumptions 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 was used to forecast the paddy production for 2015 season. Prior to forecast, the model was run to simulate production for each year from 1991 to 2014 and the simulated values were compared against

[3] http://iridl.ldeo.columbia.edu/

the reported production from MoAD (See **Figure 2**). With a corresponding correlation coefficient of 0.71, the results suggest that the model run still has some ground for further improvement. Since paddy is highly sensitive to the climatic inputs, the model results require further calibration (especially with climate parameters) to establish a very sound validity for model application for paddy.

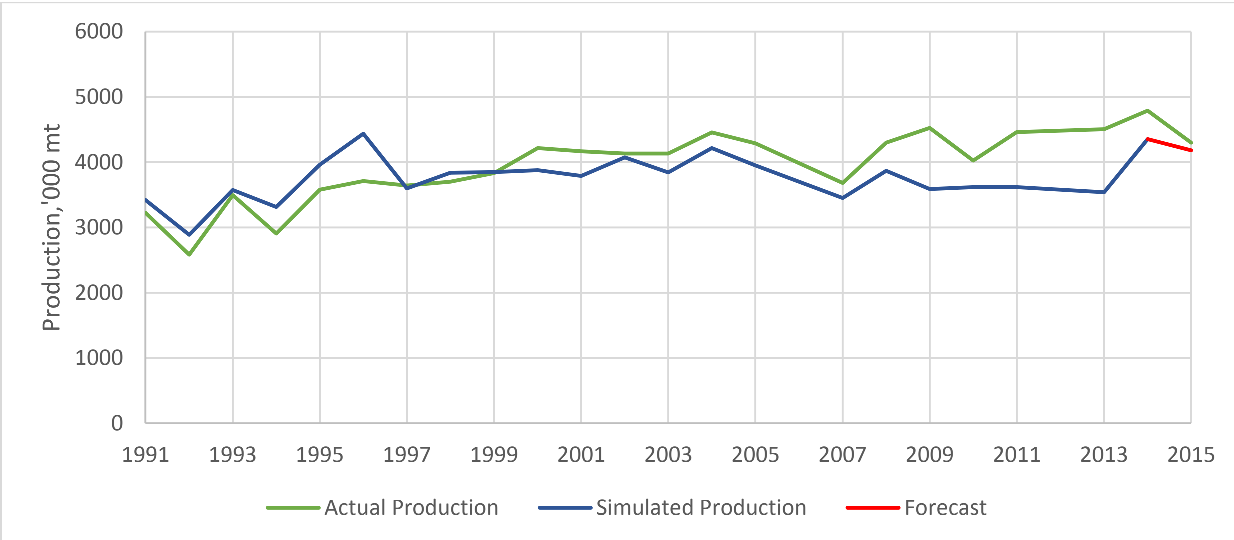

Figure 2: Observed, simulated and forecasted production, mt

*2015 production statistics are advanced estimates of MoAD
Model: DSSAT CSM in CRAFT framework

Preliminary paddy outlook 2015 season (with paddy mask as of 5 August 2015)

The preliminary model prediction run was based on the paddy crop area estimate as of 5 August 2015 and suggested an area of 1,046,928 ha (a reduction of 26 percent as compared to last season). The model forecasted a production level of 3,194,774 mt. The forecasted production shows reductions of 33.4 percent and 33 percent respectively as compared to 2014/15 production level and the preceding five-year average production level.

Preliminary paddy outlook 2015 season (with paddy mask as of 29 August 2015)

The aforementioned result was updated with updated crop area data obtained from MoAD which signaled the end of paddy plantation. Based on the updated area estimate of 29 August 2015, a production level of 4,181,298 mt was forecasted from a planted area of 1,370,212 ha (a 4.5 percent reduction from last year). The outlook is a 12.3 percent reduction as compared to the 2014/15 production level. Likewise, in comparison with the preceding five-year average, the forecasted production shows a 12.4 percent reduction. See **Table 1** for a summary of the production forecast, production observed and difference at the time of the prediction runs on 5 and 29 August.

Date of Forecast	Production forecast (mt)	Production observed (mt)	Difference (%)
5 August 2015	3,194,774	4,299,078	25.69
29 August 2015	4,181,298	4,299,078	2.64

Table 1: Comparison of statistics for production forecast and production observed on 5 and 29 August

Conclusion

Yield forecasting outcomes

The CCAFS Regional Agriculture Forecasting Toolbox (CRAFT) is being piloted as part of the Nepal Food Security Monitoring System (NeKSAP) and is a new initiative to incorporate crop yield forecasting in Nepal with technical support from CCAFS South Asia. CRAFT was used to estimate rice production in Nepal over the 2015 season. Once spatial inputs were included in the model, CRAFT was used to forecast the rice production. The latest outlook shows 4,181,298 mt predicted for the season, which is a 12.3 percent reduction in production. The forecasted yield closely matches the MoAD estimate of 4,299,078 mt with a prediction error of 2.7 percent. 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 CRAFT modeled outlook for rice production was published through the Nepal Food Security Bulletin (Issue 45)[4] and Crop Situation Update (2015/16 summer crops).[5] Furthermore, a dissemination meeting was held at the Ministry of Agricultural Development (MoAD) on 5 November 2015 to share the outputs of the 2014 wheat forecast and present the initial 2015 rice production estimates derived from CRAFT. The meeting brought together 25 participants from different stakeholders, including MoAD, Department of Agriculture (DoA), WFP, Nepal Agricultural Research Council (NARC), National Planning Commission (NPC), International Rice Research Institute (IRRI), International Maize and Wheat Improvement Centre (CIMMYT), and International Centre for Integrated Mountain Development (ICIMOD).

[4] http://neksap.org.np/food-security-bulletins
[5] http://neksap.org.np/crop-situation-update

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