BACKGROUND

1. Timely availability of reliable information on agricultural output and other related aspects is of great significance for planning and policy making particularly, in the management of concerns in areas such as food security, price stability, international trade etc. The information is extremely useful in identifying problem areas and the nature of required intervention in terms of spatial, temporal and qualitative inferences. However, the existing system of agricultural statistics, in spite of established procedures and wide coverage, has inherent limitations in the matter of providing an objective assessment of crops at the pre-harvesting stages with the desired spatial details.

2. In order to enhance the capabilities of the existing system of crop forecasts and crop estimation, Ministry considered the introduction of technological advancements and the adoption of emerging methodologies such as Remote Sensing (RS), Geographic Information System (GIS) etc. Accordingly, in the year 1987, the Department of Agriculture & Cooperation (DAC) sponsored a project called “Crop Acreage and Production Estimates (CAPE)” with the objective of developing methodologies using Remote Sensing (RS) techniques for crop area and production forecasting. The project was implemented through the Space Application Centre (SAC), Ahmedabad and provided the platform for development and standardization of basic procedures, models, and software packages for crop area and production forecasting, using remote sensing and weather data. The project successfully demonstrated national level forecast of wheat and kharif rice, in addition to making district level pre-harvest production forecasting of cotton, rapeseed/mustard and rabi sorghum in their major growing regions, in the country.

3. Besides Remote Sensing, other important inputs such as weather data, land based observations and economic parameters influencing farmers’ decisions, also serve as complementary and supplementary information for making crop forecasts. While Crop forecasting with RS technique required using the data when crop has sufficiently grown, forecasting at sowing stage is attempted through econometric and agro-met models using previous years’ crop acreage and production data, market prices, current season weather data etc. Thus, an approach which integrates inputs from these diverse sources was needed to make forecasts of desired coverage, accuracy and timeliness and the concept of “Forecasting Agricultural output using Space, Agro-meteorology and Land based observations” or FASAL was devised. The scheme is in operation since Aug. 2006. The activities planned under the scheme are as under

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BROAD ACTIVITIES PLANNED UNDER THE SCHEME

4. The functions to be carried out during the operation of FASAL have been broadly grouped into five core activities as follows:

(i) **Agricultural Information Group (AIG)** - It would design the data base structure covering crop statistics, crop calendar, administrative and geographic statistics, input and management practices, weather parameters, episodic events, available remote sensors (data format, price, path/row coverage etc.) and collate real time data to assist all forecasting activities. The archival of FASAL data/information will be yet another responsibility for this Group.

(ii) **Statistical Analysis Group (SAG)** - It would design survey programme, evaluate it for continuous upgrading and develop & use statistical and econometric approaches for making crop forecasts closely working with the AIG.

(iii) **Ground Observation and Analysis Group (GOAG)** – It would coordinate with field survey teams for designing of ground data collection plan meeting the statistical needs of early assessment, support analysis of remotely sensed data and also undertake accuracy evaluation of RS analysis for generating inventory / forecasts.

(iv) **Image Analysis and Pattern Recognition Group (IAPRG)** - It would be entrusted with handling of large volume of Remote Sensing data, their screening, geo-referencing and analysis of data for deriving final results. It will also develop procedures and models for analysis of multi source data.

(v) **Crop Growth and Yield Modeling Group (CYMG)** – It would develop agro-meteorological models for regional monitory of crop status and quantitative yield productions, integrate remotely sensed information into the models to improve spatial representativeness and the robustness of the models and work to summarize and organize results from the crop growth simulation and ago-meteorological research into forecasts that provide regional level information.

FORECASTS ENVISAGED UNDER THE SCHEME

**Econometric Forecast**

5. This forecast is envisaged at the initial stages of crop growth. IEG has developed and standardized econometric models for crop acreage and production forecasts for different crops. IEG have furnished experimental area and production forecasts of Kharif crops 2008-09 for All-India and major States based on these models. First econometric forecast for specified rabi crops for major States and All-India has been received.
Agro-met forecast

6. This forecast is envisaged at the mid season of crop growth when information on weather and other agro-met variables becomes available. So far no work has been done on this aspect.

For taking up the work on agro-meteorology component, the matter was pursued with IMD to identify the nodal officer and other scientists to work on the FASAL scheme.

Remote Sensing Forecast

7. This forecast is envisaged at the mid season and pre-harvest stage of crop growth. So far RS methodology has been developed for 3 crops viz. wheat, rice (kharif) and potato (winter). Development of RS methodology for making national and State level acreage and production forecasts for remaining crops is in progress. This year, forecast for Rapeseed & Mustard has also been attempted.

OVERALL APPROACH IN ‘FASAL’

ECONOMETRIC METHODOLOGY

8. It is commonly recognized that production in agriculture is much more difficult to predict than in other sectors. The major factor behind this unpredictability is the fact that cultivation is
much more exposed to the elements of weather than other sectors where production is under greater control. Even the distribution of the weather parameters over the growing period can be of significance. The largely unpredictable weather therefore plays a major role in determining the agricultural performance. There are other human and natural factors that also make the task difficult as well as imprecise. Agricultural production is the sum total of the consequences of the decisions taken by millions of farmers operating across the country in diverse conditions. The prices they face in both product and input markets are uncertain and farmers’ planting decisions are based on their expectations only, so that forecasting inherently involves presumptions about what they anticipate. Besides, the crops vary in their responses to rainfall, temperature, management practices and in general on various subtle influences.

9. The forecasting of output is done by estimating separate functions for acreage and yield based on the time series data reported by the Ministry of Agriculture, Government of India. Expectations about future prices/revenues and other relevant explanatory variables are based on the past. Thus harvest season price of the previous year is taken as the proxy for expected price. The effect of change in administered price by revision of the minimum support price is also captured in the price variable. Previous year’s acreage is included in the area equation to accommodate partial adjustment. Exogenous variables as considered relevant are included and there is scope of developing the model by including policy and non-policy exogenous variables that are becoming important today. General form of the model is given as under:

$$A_t = f (A_{t-1}, p_{t-1}, p_{t-1}^s, I_t, PFert_t, X_{at}, RF_t^s, e_t)$$

$$Y_t = f (P_{t-1}, Fert_t, X_{yt}, RF_t, e_t)$$

Output_t = A_t * Y_t

Notations:

- $A_t$ = Area under crop at time $t$
- $Y_t$ = Yield of crop at time $t$
- $p_t$ = Price/revenue of crop at time $t$
- $p_{t}^s$ = Price/Revenue of substitute crop(s) at time $t$
- $I_t$ = Total availability of irrigated area in time period $t$.
- $PFert^t$ = Price of Fertilizer (sowing season)
- $Fert_t$ = Availability of Fertilizer in time period $t$ (Estimated/proxy may be used)
- $RF_t^s$ = Rainfall during sowing months at time $t$
- $RF_t$ = Rainfall during growing season at time $t$
- $X_{at}$ = Other relevant explanatory variables in area function
- $X_{yt}$ = Other relevant explanatory variables in yield function
- $e_t$ = Error term
AGRO-MET METHODOLOGY

10. India Meteorological Department (IMD) has developed crop yield forecasting models based on multiple correlation and regression technique. It is a linear combination of predictors (both meteorological parameters and technological parameters), which takes into account the influence of weather and technological advances on yield. Based on the above methodology, pre-harvest crop yield forecast models have been developed for *kharif* rice & *rabi* wheat for all the meteorological subdivisions where these crops are grown predominantly.

11. IMD would now develop Crop growth simulation models to estimate crop yield as a function of complex interaction of different physiological processes with the environment, biotic and abiotic factors. These models estimate biomass production using daily crop growth simulator. These models will be developed for major crops of the country to provide yield forecast.

12. Reasonably precise estimate of yield before the actual harvest of the crop is vital in policy planning. The relatively small cost and speed of assessment makes crop growth stimulation models promising for areas where significant daily weather data are readily available. In this approach, the model is run using actual weather data during the cropping season for the geographical region of interest. Weather data for typical years viz., normal, deficient, excess rainfall etc. are used to continue stimulation until harvest. For example crop growth simulation models, regional weather data bases and historical yield data are used to forecast rice yield for different regions of Japan. There is an urgent need to develop such model for early assessment of yield to help in strategic planning and decision-making. It is especially useful in countries where the economy depends on crop harvest.

13. Crop growth simulation requires good quality data and adequate representation of the key components and underlying processes involved. Data for simulation are in terms of process-related constants such as photosynthetic efficiency, data on partitioning of assimilates, and phenological development, and other external driving variables. Input data requirements such as agrometeorological data (radiation and temperature), soils data characterizing the hydraulic properties essential in soil-water balance, and data on crop parameters characterizing the physiological and morphological processes that determine crop growth are defined for a specific model. When these information requirements are not available, they may be estimated from existing databases and expert knowledge. But they may not result in accurate yield estimation.

14. Crop growth simulation modeling is useful tool to describe continuous crop growth and to estimate crop yield using environmental inputs, while remote sensing provides discrete observations during the crop growing season and indicates crop stage and state.

REMOTE SENSING METHODOLOGY

National wheat acreage and production

SAC, Ahmadabad has developed remote sensing based methodologies for selected crops as part of the FASAL project. Salient features of the wheat methodology iare given as under:
15. National wheat production forecasting involves analysis of multi-date AWiFS data during the wheat crop growth season for acreage and regression based wheat yield models between fortnightly temperatures and deviations of wheat yield from technology trend. This methodology developed by SAC, using WiFS / AWiFS data has been found to be satisfactory at nation level (<5% RD and <6% CV).

**Area Coverage:** Bihar, Haryana, MP, Punjab, Rajasthan and UP  
**Satellite Data:** Multi-date IRS-WiFS / AWiFS data

**Ancillary Data:** Historical crop area and production, ground truth data  
**Methodology:** Stratified random sampling approach with decision rule based classification to derive crop acreages  
**Deliverables:**  
- State and National wheat acreage estimates  
- Rabi cropped area by end of January  
- First estimate of wheat acreage by end of February  
- Final wheat acreage and production estimate by end of March  
- Multi-date registered AWiFS and classified image data

All the methodologies explained above are at various stages of development refinement in the development of models of forecast is an ongoing process.