International Crop Production Forecasting Component of World Agricultural Supply and Demand Estimate (WASDE)

- United States Department of Agriculture (USDA)
- Foreign Agricultural Service (FAS)
- **International Production Assessment (IPA)**
United States Department of Agriculture (USDA)

- International crop production forecast process
- World Agricultural Supply and Demand Estimate report (WASDE)
- published by World Agricultural Outlook Board (WAOB)

WAOB Chaired Meetings: Cotton, Oilseeds, Rice, Grains

WAOB Arbitration: FAS, WAOB, ERS, JAWF

WASDE Report
FAS Lockup Commodities

Monthly review of available crop condition data. Crop estimates revised as needed. Production estimates are first step in S&D balance sheet. These estimates form basis of the WASDE report.

- **Food**
  - Wheat, Rice

- **Feed Grains**
  - Corn, Barley, Oats, Sorghum, Rye

- **Oilseeds**
  - Soybeans, Sunflower, Rapeseed, Peanuts, Palm

- **Cotton**
Mandate and Mission for Global Crop Production Analysis

Monthly International Production
Crop Monitoring Reports on Area, Yield and Production of Major Grains, Oilseeds and Cotton

1. FAS Strategic Plan 2010-2015 (page iv)
2. OMB Principle Federal Economic Indicator
3. Code of Federal Regulations - TITLE 7 AGRICULTURE - Under Secretary for Farm and Foreign Agricultural Services: “...Conduct studies of worldwide production...”

http://edocket.access.gpo.gov/cfr_2003/7cfr2.43.htm
Develop Country/Commodity Balance Sheets

SUPPLY = DEMAND

Beginning Stocks + Production + Imports = Exports + Domestic Use + Ending Stocks

- Private (On-farm)
- Private (Pipeline)
- Government (Security)

Area Yield

Commercial Concessional

Feed

Residual

Food, Seed, Industrial

WAOB Chaired Meetings: Cotton, Oilseeds, Rice, Grains

WAOB Arbitration: FAS, WAOB, ERS, JAWF

WASDE Report
FAS publishes updates on a monthly schedule of Area, Yield, and Production for foreign commodities.


FAS published OMB Principle Federal Economic Indicator

Schedule of release dates for principal Federal Economic indicators for 2013:
### Table 01 World Crop Production Summary
#### Million Metric Tons

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1/ Includes wheat, coarse grains, and rice (milled) shown above.
## Table 02 Wheat Area, Yield, and Production

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World Agricultural Supply and Demand Estimates

- USDA World Agricultural Outlook Board publishes updates on a monthly schedule.
- Supply (Production) and Demand for major world commodities.
- International AYP: FAS
Production is essential component of Output, Supply and Estimating World Trade forecasts.
FAS: “Production Supply Distribution” Database (PSD Online)

- AYP and Balance Sheet Data Input to the PSD system
- Public Facing Database
- Extraction for AYP and Trade Data
- Transparent USDA Market Information
Convergence of Evidence

IPADs final production estimate, produced by the 10th day of each month and cleared by the World Agricultural Outlook Board, is based on an all source convergence of evidence methodology.

USDA’s International Commodity Forecasts

The final production estimates are used in a variety of ways including:

- Official USDA statistics
- Principal federal economic indicators
- Crop conditions and early warning alerts
- Agricultural monitoring and food security
- Foreign aid assessments for food import needs
- Disaster monitoring and relief efforts related to food aid
- Commercial market trends and analysis
- Trade policy and exporter assistance
Input From Multiple Sources

Informational Inputs
- country, date, crop

Agribusiness
- Travel Reports
- World Weather Reports
- Wire Services

Government Reports
- Earth Observations
- Official Country Reports
- Attaché Reports

International Organizations
- Private Market Reports
- Private Commodity Reports

Analyst Processing

Crop Forecasts
Convergence of Evidence Inputs to USDA Monthly Forecasts

- Official Country Reports
- World Weather
- USDA’s International Commodity Forecasts
- Travel Reports
- Remote Sensing
- Economic and Trend Analysis

Mission: provide timely and informed estimates of world-wide crop production.
Global Data Sources for Estimating Crop Production
Production Estimates and Crop Assessment Division (PECAD)
USDA FAS-PECAD, USDA South Building, MS-1045, 1400 Independence Ave., SW, Washington DC, 20250
URL: http://www.fas.usda.gov/pecad/

- World Weather
- Satellite Imagery
- Crop Models
- Official Statistics Baseline Data
- Economic Data and Trends
- Attaché Reports
- Field Travel by Analyst
- International AYP Forecasts
Mission: provide timely and informed estimates of world-wide crop production.
Foreign Agricultural Service (FAS) of USDA

FAS Overseas staff collect data, statistics, crop progress, and agricultural market information.
Published GAIN Reports

These reports are in PDF format and you will need Adobe Reader in order to view or print these files. The download is free at [http://www.adobe.com/products/reader](http://www.adobe.com/products/reader)

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FAS Overseas staff, collect data, statistics, crop progress, and agricultural market information
Mission: provide timely and informed estimates of world-wide crop production.
Weather Data Sources

- World Meteorological Organization (WMO)
- US Air Force Weather Agency (AFWA)
- Experimental products from NASA
### World Meteorological Organization (WMO)

**Daily Data Loaded Next Day:**
- 24-hour precipitation
- Max Temp
- Min Temp
- Snow Coverage

**IPAD Updates Assessment Database:**
- Average Daily Temperature
- Cumulative precipitation
- Potential ET
- Soil Moisture
- Crop Calendar
- Corn Hazard (Alarm)
- Winterkill Model

---

>= **“Yesterday’s Weather Delivered Today”**

Daily weather data provided by approximately 7000 WMO ground stations
Air Force Weather Data (AFWA)

Daily AFWA Data Loaded Next Day:
- 24-hour precipitation
- Max Temp
- Min Temp
- Snow Coverage
- Actual and Potential ET
- Solar and IR Radiation

IPAD Updates Assessment Database:
- Average Daily Temperature
- Cumulative precipitation
- Potential ET
- Soil Moisture
- Crop Calendar
- Corn Hazard (Alarm)
- Relative Yield Reduction
- Winterkill Model

Spatial Coverage of AFWA Weather Data

Daily Modeled Weather Data for 85,000 Locations (Grid Cells)

11/29/2013

USDA/FAS/OGA/IPAD
Northeast Brazil

IPAD Database Resolution
Grid Cell Reference System

IGBP Landcover Class
- Evergreen Needleleaf Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Deciduous Broadleaf Forest
- Mixed Forest
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-Up
- Cropland/Natural Vegetation Mosaic
- Snow and Ice
- Barren or Sparsely Vegetated
- Water Bodies
- Missing Data
Northeast Brazil

IPAD Database Resolution
Grid Cell Reference System

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baseline geo-spatial data sets:

- Climate 30-year normals & NDVI multi-year averages
- Soils water holding capacity
- Average crop planting dates

Major Agricultural Regions

USDA/FAS/OGA/IPAD
Crop Assessment Database System

- **Automatic:** “Crop Explorer” products are displayed on the Internet every 10-days and for summer/winter growing seasons.

- **Interactive:** Arcview GIS extractions for any region and time period.
Explore by Region

North America
- United States
- Canada

Central America
- Mexico
- Central America and Caribbean

South America
- Brazil
- Northern South America
- Southern South America

Europe
- Europe

Middle East
- Iran, Iraq, Syria, and Turkey

Oceania
- Australia

Former Soviet Union
- Kazakhstan
- Russia, Azerbaijan, Armenia and Georgia
- Ukraine, Moldova, and Belarus

Africa
- North Africa
- Southern Africa
- East Africa
- West Africa

Asia
- Eastern China
- South Asia
- Southeast Asia
- Central Asia
- Korea
Crop Explorer: Eastern China

Two clicks: 10 day precipitation analysis over major growing regions. Two data sources. Actual and Percent Normal Results. Click once more for chart transformation.

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<th>Precipitation (Millimeters)</th>
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<th>AFWA 10-day Percent Normal</th>
<th>WMO 10-day Actual Amount</th>
<th>WMO 10-day Percent Normal</th>
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<tr>
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</table>

Decadal Percent of Normal (%)

| > 200                      | 150 - 200                  | 125 - 150                  | 100 - 125                  | 75 - 100                  |
| 50 - 75                    | <= 50                      | No Data                    | No Data                    | No Data                    |
Map shows AOI and charts depict rainfall events.
Explore by Region

North America
- United States
- Canada

Central America
- Mexico
- Central America and Caribbean

South America
- Brazil
- Northern South America
- Southern South America

Europe
- Europe

Middle East
- Iran, Iraq, Syria and Turkey

Former Soviet Union
- Kazakhstan
- Russia, Azerbaijan, Armenia and Georgia
- Ukraine, Moldova, and Belarus

Africa
- North Africa
- Southern Africa
- East Africa
- West Africa

Asia
- Eastern China
- South Asia
- Southeast Asia
- Central Asia
- Korea

Site Index
- UNITED STATES
End CE / RSGIS
Mission: provide timely and informed estimates of world-wide crop production.
Source of satellite data and imagery?

- It’s actually not from one particular satellite but from a several satellites of different capabilities
Radar satellite altimeters for monitoring reservoir and lake water levels.

Landsat for monitoring crop area changes.

MODIS sensor for monitoring relative crop conditions and yields.

TRMM for monitoring seasonal precipitation.
Low and Medium Resolution Sensors

- AVHRR (8 km)
- SPOT-Vegetation (1 km)
- MODIS (250 m)
- AWIFS (56 m)
- Landsat (30 m)
Remote Sensing Analysis Strategies:

Qualitative

Quantitative

Two examples of techniques employed to monitor crop conditions and ultimately make a monthly forecast update of crop production for each country.
Remote Sensing Strategies:

- Qualitative Analysis Satellite Imagery
- Quantitative Analysis Satellite Imagery

Pakistan Image Mosaic
Pakistan Satellite Imagery Mosaic
GIS and Statistical Data Identify Major Wheat Producing Areas

Pakistan District Boundaries
Identify High Production Zones: using GIS and statistical data

Pakistan District Boundaries

Pakistan District Statistical Data

11/29/2013
Identify High Production Zones: using GIS and statistical data

Pakistan District Map
Wheat Production

Wheat
High
Med
Low
Minor
Identify High Wheat Production Zones

Pakistan District Map
Wheat Production

Acquire Satellite Data

Satellite image at Critical Growing Period
Wheat Production Zones to Imagery Analysis and Qualitative Interpretation

Pakistan District Map
Wheat Production

11/29/2013
Visual Interpretation:
Landsat Satellite Imagery: Vegetation including field crops are displayed in red. Darker tones interspersed in predominantly red areas are fallow fields or non-vegetated areas.

Red: dense crop canopy

Agricultural Density
• Relative Crop Health
• Water Availability

Comparison of two seasons (same crop stage)

Full Scene: Current Season

Full Scene: Previous Season
Pakistan Winter crops, in particular wheat, are largely grown under irrigated conditions. In this scene the differences between river are apparent in capacity and flow rate.

**River Characteristics:**
- Width
- Volume
- Turbidity
- Rate of flow

Differences in water level and flow
Pakistan Winter crops, in particular wheat, are largely grown under irrigated conditions. In this scene the differences between river are apparent in capacity and flow rate.

**Irrigation Availability:**
- Water Storage behind dam
- Control Location
- Major Irrigation River

11/29/2013
Pakistan Wheat and Irrigation

Visual Comparison
Same week different years

This important wheat growing area is clearly showing a very large difference in conditions and vegetation health year-to-year. Given the river level at the irrigation headwork in the lower left of the scenes this lower crop health is mostly likely a result of a reduction in irrigation water availability.

11/29/2013
Remote Sensing Strategies:
• Qualitative Analysis Satellite Imagery
• Quantitative Analysis Satellite Imagery

Pakistan
Remote Sensing Strategies:
• Qualitative Analysis Satellite Imagery
• Quantitative Analysis Satellite Imagery

Australia
Quantification of Vegetation Conditions based on MODIS Satellite Imagery
Australia Wheat Production by Shire

Legend

- 0% - 0.1%
- 0.1% - 0.2%
- 0.2% - 0.4%
- 0.4% - 0.6%
- 0.6% - 0.8%
- 0.8% - 1%
- 1.0% - 2.5%

<table>
<thead>
<tr>
<th>Shire</th>
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<tr>
<td>WA</td>
<td>37%</td>
</tr>
<tr>
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</tr>
<tr>
<td>QLD</td>
<td>5%</td>
</tr>
<tr>
<td>NSW</td>
<td>30%</td>
</tr>
<tr>
<td>VIC</td>
<td>12%</td>
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Quantification of MODIS NDVI over Wheat Areas

- Max NDVI/Yield Correlated
- May – October
- Multi-season
- Wheat Belt
- Crop Mask, crop pixels
Vegetation Health and Satellite Imagery

\[
\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72 \\
\frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14
\]
The relationship between absorption of light energy by plants (specifically near infrared and red light) is the underlying principle in the use of satellite imagery to study vegetation.
The ratio of reflectance (and absorption) of Near Infrared and Red light is a measure of the photosynthetic activity or health of the plant. A commonly accepted ratio is the: Normalized Difference Vegetation Index (NDVI)
The NDVI is calculated from the reflectance values as follows:

\[
NDVI = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})}
\]

NASA Earth Observatory: http://earthobservatory.nasa.gov/Laboratory/ICE/tg_panama.html
On Average Victoria Produces 12% of Australia’s wheat

Country: Australia
State: Victoria
Bounding area: Cropping Area
Interior selection: Crop Pixels

Vegetation Index (Wheat Belt+Crop Mask) VICTORIA

Region: Australia, East
Date Range: 2009-Sep-30 to Oct-15
Shape: Australia Wheatbelt; Victoria
Detail Point: -34.05165 140.96654
Cropmask: Standard (MOD12)
Watermask: Standard (MOD12)
Greenness Threshold: 56.25
Source: USDA/NASA/UMD GLAM project
NDVI data MODIS Satellite Imagery

NDVI = \frac{(NIR - RED)}{(NIR + RED)}

NDVI Value Calculated from Red and Infrared Reflectance
MODIS Satellite NDVI: Victoria
MODIS NDVI: Extraction

Isolate areas (pixels) of crop land within the wheat belt of Victoria for a specific time period then calculate the NDVI Vegetation Index.

New South Wales

Wheat belt of Victoria

Non-wheat belt portion of Victoria
NDVI value calculated for each MODIS Satellite Image

Pixels color coded to NDVI legend on crop condition for specific area of interest, in this case Victoria and which crop statistical data is available.

This image is the compilation of NDVI values for controlled time period. In this case September 13, 2008 to September 28, 2008; a 16 day composite.

Cropland pixels of Victoria wheat belt

Each image date has a corresponding scene. The numerical NDVI values can then be graphed.
NDVI value calculated for each MODIS Satellite Image

Pixels color coded to NDVI legend on crop condition for specific area of interest, in this case Victoria and which crop statistical data is available.
This image is the compilation of NDVI values for controlled time period. In this case August 1, 2008 to August 16, 2008; a 16 day composite.

1 date = 1 NDVI value = 1 data point
NDVI data MODIS Satellite Imagery

Cropland pixels of Victoria wheat belt

Scenes from multiple time periods creates a time series. Each scenes NDVI value is plotted.
Cropland vegetation index Victoria wheat belt

Multiple MODIS satellite scenes from across the season creates a time series curve.

The NDVI value for each scene is plotted on graph.
The NDVI curve corresponds to crop stage, indicating the key stages in crop development:

- **Sowing**
- **Vegetative Growth**
- **Reproduction**
- **Senescence**
- **Harvest**
Additional NDVI curves from past seasons are added. A season to season comparison is a powerful tool for monitoring relative crop health yield.
Further analysis reveals statistically relevant relationship between NDVI curve and final yield.

- Max NDVI: 2.473, Current Season: 1.423, Wheat yields: 0.655

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<th>MODIS MaxVal</th>
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Excel Forecast Function using Yield-NDVI Relationship

\[ a = \overline{Y} - b \overline{X} \]

\[ b = \frac{n \sum xy - (\sum x)(\sum y)}{n \sum x^2 - (\sum x)^2} \]

### Table

<table>
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<th>( y )</th>
<th>( p )</th>
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### Calculations

- Using current VI value for latest date
- Use historical AVG VI increase date
- Use historical Max VI increase date
- To date

### Variables
- \( a \): Intercept
- \( b \): Slope
- \( \overline{Y} \): Average of \( y \) values
- \( \overline{X} \): Average of \( x \) values
- \( n \): Number of data points
- \( \sum xy \): Sum of products of \( x \) and \( y \) values
- \( \sum x \): Sum of \( x \) values
- \( \sum y \): Sum of \( y \) values
- \( \sum x^2 \): Sum of squared \( x \) values

### Correlation

- \( r \): Pearson product moment correlation coefficient
- \( r^2 \): Coefficient of determination

### Additional Notes

- Correlation function gives same result as Pearson function
- Returns the Pearson product moment correlation coefficient, \( r \), a dimensionless index that ranges from -1.0 to 1.0 inclusive and reflects the extent of a linear relationship between two data sets.
Australia Wheat Yield and MODIS NDVI

Australia Wheat: Yield vs. MODIS NDVI

Season

2001/02 2002/03 2003/04 2004/05 2005/06

Wheat Yield

70.0 72.0 74.0 76.0 78.0 80.0 82.0 84.0

Maximum NDVI

70.0 72.0 74.0 76.0 78.0 80.0 82.0 84.0 86.0

Wheat Yield
Vegetation Index (Wheat Belt+Crop Mask) VICTORIA

On Average Victoria Produces 12% of Australia’s wheat

Country: Australia
State: Victoria
Bounding area: Cropping Area
Interior selection: Crop Pixels

11/29/2013
Remote Sensing Strategies:
• Qualitative Analysis Satellite Imagery
• Quantitative Analysis Satellite Imagery

Australia
Remote Sensing Analysis Strategies:

Qualitative

Quantitative

Two techniques employed to monitor crop conditions and assist in making a monthly forecast update of crop production for each country.
Summary: Remote Sensing Analysis Strategies

- These analytical techniques provide exceptional value in representing data visually thereby enhancing the user and analyst experience.

- Enables analysts to more quickly and clearly discern trends, patterns and changes occurring in dynamic agricultural situations.
Contact

Jim Crutchfield
james.crutchfield@fas.usda.gov
202-690-0135
Foreign Agricultural Service (FAS)
Office of Global Analysis (OGA)
International Production Assessment Division (IPA)

• http://www.pecad.fas.usda.gov/cropexplorer/
• http://www.pecad.fas.usda.gov/ogamaps/