CropWatch and application

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Issues for Food Security

- Food security is still a challenge issue over the world, in particular in Africa, south & southeast Asia. COVID-19, Desert Locust, drought, flooding, etc. further threaten food security.
- The paucity of adequate capacity in obtaining and accessing up-to-date staple crop production information pose the danger of taking decisions based on delayed and on not easily verifiable information.
Requirement of a Crop Monitor System

- Components
  - Agro-climatic analyses,
  - Crop-condition and stress monitoring, and
  - Crop production predictions, and
  - Early warning of likely food insecurities

- Operational, efficient and long-term services for stakeholders

- Cost effective, timely, location specific
  - Data stream from raw Earth Observation (EO) data as inputs to produce targeted information that is understandable by common users as outputs.
  - Software processes that synthesizes climate and EO data and converts these data into valuable information to support stakeholders.
  - Archived product for time series analysis and comparison
  - Baseline datasets
Constraints

- Initiative input and operational cost as well as adequate technical skills constrain many countries to set-up, operate, and maintain crop monitoring system, which make
  - most countries in the world do not have an operational crop monitoring system

- Combining of crops, phenology, location makes crop monitoring data streams very complex
  - Existing global systems have limited functions, mainly crop condition assessment
  - Most existing algorithms and methods are not implemented as operational activities
Outlines

- Overview of CropWatch
- Monitoring cropland to specific crops
- Conclusion remarks
CropWatch is a satellite-based hierarchical method of crop monitoring, with indicators of agro-climatic, agronomics, area, yield and production, earlier warning

Release Quarterly and annually bulletins on global crop monitoring, covering 173 countries and regions down to provincial scales, with special focus on 47 key agricultural countries
Auto data fetching and preprocessing

**Automatic fetching**
- Data from cloud
- Automatic chain
- Data storage on cloud
- Database
- Chart
- Image
- Table
- Map
- Advanced products
- Customize
- User

**Auto preprocessing**
- Models: IDL, IDL, python, arcgis
- Tables
- Figures
- Map services

**Data processing**
- USGS
- GSOD
- ECWMF
- ESA
- Other
- Auto download
- Batch
- http
- ftp
- python
- Processing
- Resample
- Composite
- Departure
- Database

**Data from cloud**
- Customize
- Advanced products

**Customize Advanced products**
- Chart
- Image
- Table
- Map

**Interactive component**
- Clustering
- Crop condition
- Crop mapping
- Crop yield
- …

**Data processing**
- Standard algorithm:
  - Temperature
  - Rainfall
  - PAR
  - PAR
  - Sunshine hour
  - Aerosol
  - PET
  - Other global products
- Advance algorithm:
  - Agro-climatic risk
  - CALF
  - VCI
  - VHI
  - Cropping intensity
  - From other sources
CropWatch Components

- **CropWatch-Pro**: to produce crop indicators at any time and anywhere
- **CropWatch-Explorer**: to explore and download crop information
- **CropWatch-Analysis**: to analyze crop information jointly or individually
- **CropWatch-Bulletins**: a web page for release bulletins, and methods

cloud.cropwatch.com.cn
CropWatch Processing offers an auto-processing chain from pre-processing of raw data to production outlook.

CropWatch generates 32 agro-climatic, agronomic, early warning indicators, and crop production (area, yield) and early warning,
- Drought indices are included, spi, spei, vci, tci and vhi, cdwi,

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NDVI Anomaly

- Crop Condition based on NDVI anomaly
- Model selection → Parameter Setting → Submit task → Task finished → Thematic Product

Parameter Setting

Queue in task list

Task status updating/finished

Preview thematic product and output to database
- adopting NDVI adjustments characterizing crop rotations or interannual phenological shifts, and this omission results in misleading information.
CropWatch integrates crop area estimation with geo-statistics & crop mapping

- The CPTP method in complex agricultural landscapes (66%)
- Transfer learning methods are integrated to reduce the reliance on in situ data (34%) for large field and simple cropping pattern
Yield models

- Yield prediction component is the weakest component in crop monitoring
  - VI saturation leads to poor performance when predicting yields, especially in dense or irrigated crop regions.
  - VIs have not precisely captured crop yield determinants, especially under extreme climatic conditions.
  - The uncertainty of current crop growth models makes it difficult to scale up to facilitate operational yield predictions.

- 4 types yield models are developed and integrated into CropWatch to reduce the uncertainty of yield prediction
  - Agro climate
  - VIs
  - Biomass-harvest
  - Machine learning
Early warning indicators

- Cropped arable land fraction (CALF) represents the total cropping proportion at early growing stage
- Agro-meteorological risk index (AMRI) considering meteorological suitability for crops at different growing stage is used for yield alarming
- Crop production index (CPI), integrating cropping area, condition, irrigation, intensity, productivity
CropWatch APIs

- CropWatch Cloud provides APIs access to all functions of indicators and thematic maps, including both data access APIs and data processing APIs.
Component 2: CropWatch Explore

CropWatch-Explore explore and visualize data products in vector, raster, global, country, districts, crops, indicators....
Component 3: CropWatch Analysis

- CropWatch Analysis is cloud based participatory platform for individuals or team from over the world analyzing CropWatch indicators for the global, a country or IOA to better use local knowledge.
- It provides create document, allocate and manage tasks, monitor schedule and publish the document online functions which let people over the world finish their documents together on the cloud platform.
Increasing level of detail, from agro-climatic to agronomic; from 25 km resolution to 5m

CropWatch Hierarchical approach

Global: homogeneous crop mapping and reporting units
Using CropWatch Agroclimatic Indicators (CWAI) for rainfall, air temperature, photosynthetically active radiation, and potential biomass

Regional: Major production zones
In addition to CWAI, Vegetation health index, uncropped arable land, cropping intensity, and maximum vegetation condition index

National
In addition to previous indicators, crop cultivated area, time profile clustering

Sub-national for large countries
Crop type proportion (some countries)

173 countries and 110 zones
6 MPZ
47 and 225 agro-ecological zones
9 big countries
## Author assignment

### Executive summary

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### Global agroclimatic patterns

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### Crop and environmental conditions in major production zones

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### Main producing and exporting countries

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During this monitoring period, maize and sorghum (spring to summer) were still growing, while rice (spring to summer) was being harvested. Overall, crop condition was average according to the crop condition development graph based on NDVI.

The CropWatch agroclimatic indicators show that rainfall and temperature separately dropped below average by 9% and 0.2°C while RADAR increased by 2%. Consequently, BIOMASS was below average by 6%. In contrast, CALF and cropping intensity increased respectively by 9% and 3%. The map of spatial patterns for maximum VCI shows that high values (larger than 0.5) of this indicator are widespread, while low values occur only in western Sinaloa, northern Chihuahua and Tamaulipas provinces. According to the graph for spatial NDVI patterns and NDVI profiles, crop condition was above average in 66.9% of planted areas, mainly in Veracruz, Tlaxcala, Oaxaca, Guanajuato, and Jalisco. On the contrary, crops in western Sinaloa, southwestern and northern Sonora, and northern Chihuahua and Tamaulipas (accounting for about 31% of all cropland), experienced below or close to average crop condition, a pattern also confirmed by maximum VCI.

Altogether, crop yields for this season in Mexico are expected to be above average.

Figure 3.20: Mexico crop condition, July-October 2016
February 2019 CropWatch Bulletin (Vol. 19, No. 1)

This bulletin provides the latest production outlook for the major growing areas in the southern Hemisphere and some relevant northern Hemisphere countries where crop development is sufficiently advanced. Focusing on the months of October 2018 to January 2019, chapters cover global variety and region-specific conditions and the number of crops that were growing in February during this time. For China, the bulletin presents crop conditions for each major key agricultural area. The focus sectors reported are wheat, maize, sorghum, and tobacco with a tabular on production, the possibility of an El Niño event.

Key messages from the report:
- Agricultural patterns over agricultural areas: global trends were above average (0%); Ireland was below average (0%); and Argentina was 0% above average. Overall, below average crops area with below-average harvest has 0% increase in global patterns.
- Agricultural patterns: favorable conditions were observed in Australia (Fig. 1), but favorable crops area with below-average harvest has 0% increase in global patterns.
- China, agro-climatic conditions were generally below average with deficits of rainfall (0%) and sunshine (0%). Temperature was average for the national 0% average of the previous year.

FEBRUARY 2019 CROPWATCH BULLETIN

South and Southeast Asia crop and environmental conditions in major production zones

Satisfactory crop conditions provided over the South and Southeast Asian MRZ during the reporting period with the maximum (February) crop output of 95% being 95% of the crop output potential. MRZ has 0% lower than the average year. The fraction of improved area was 95% vs the average. Most unimproved and area, and small area is below average (0%) but the other regions and products also showed production above average (0%) and above average (0%).

Some selected RSUS values had significant positive anomalies for the season in the Philippines (+3%) and Cambodia (+1%). Other countries reported positive values (but close to average) (0%) with Indonesia and Vietnam, and Thailand were both slightly weaker (+1% to +3%) than the seasonal average. The largest anomalies were noted at the beginning of the season in Vietnam and Madeyno, but at mid-March to +2% anomalies in East and South of Thailand. Close to average temperature recorded throughout the monitoring period from eastern Vietnam across Bangladesh to most of southern India.

For RSUS, the largest anomalies were noted in Bangladesh (+3%), India (+3%), and the Philippines (+3%) as well as Vietnam show excess population. The season assessment was noted at the same time as the heating period in October, the highest easterly in southern India, India, and the Phuket Delta area, and deficits in coastal Australia and global and seasonal average.

As a reflection of the agro-climatic conditions during the reporting period, the business assumptions potential fell below the reference of 0% this December. The largest RSUS departures were found in India (+3%), Philippines (+2%), Bangladesh (+3%), Myanmar (+2%), Thailand (+2%), and Malaysia (+2%).

Low values of the index were recorded mostly in India, Cambodia, Thailand, and Vietnam. Minimum VCI approximately 0% in India and Thailand.

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Service modes

- Customization of CropWatch and/or development of CMS for specific needs
- Data processing engine and download for local services
- Independent analysis for a country
Outlines

- Overview of CropWatch
- Monitoring cropland to specific crops
- Conclusion remarks
Hierarchy of crop-related terms

Cropland (areas)
- Permanent (areas), tree crops
- Arable land (areas), cereal crops
  - Rainfed/irrigated (areas)
    - Growing seasons (periods)
    - Cropping patterns (areas)
    - Crop specific (areas and yields)

These might be improved using Earth science data, especially in the era of large AI models
Landcover with cropland
Global Cropland Data at 30m
Irrigated Cropland Mapping

- Mapping the extent of irrigation with the NDVI differences between irrigated and non-irrigated croplands under water stress;
- The irrigation area at a 30-m resolution is 23.4% of global cropland in the period 2010–2019, with an overall accuracy of 83.6% globally;
- Separating regular and intermittent irrigation.
Central pivot irrigation
Cropland at different resolution

\[ \forall = \frac{A_T}{A_R} \]

\( \forall \) : Unbiased Estimated Coefficient (UEC)

\( A_T \) : Actual cropland area

\( A_R \) : Pixel-counting area
Global Cropping Intensity at 30m
Field-based high resolution crop type mapping

Field level crop map

- Maize
- Soys
- Rice
Crop type area

\[ A_R : \text{Pixel-counting area} \]

\[ A_T : \text{Actual parcel level cropland area} \]

\[ \forall \Rightarrow \frac{A_T}{A_R} \]

Cropland  \times  UEC  \times  CALF  \times  CPTP

Arable land

cropped and uncropped arable land, by pixel

Crop type ratio by GVG

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Cropped and uncropped identification

- NDVI threshold (< 0.3: uncropped; >0.6: cropped)
- Decreasing (maturity stage and will be determined as uncropped)
- Increasing (early growing stage for cropped field), Compare the peak value with historical value
Overall accuracy is 98% using multi-temporal 30m resolution Landsat, 16m resolution GF-1 and 10m Sentinel-2 data
Tools for ground truth data collection

- The field data collection prevents most systems have crop area and yield components
  - Cost, labor and time consuming
- Two tools developed for free use
  - GVG app for crop identification and FieldWatch for yield measurement with image recognition

FieldWatch for yield data measurements  GVG Crop type identification from geo-tagged photos
Estimated crop area for China and other countries

Crop area for different countries for different crops
Summary for crop area estimation

- From cropland to specific crops
- Estimating crop acreage
  - Geographic method
  - Provide statistical crop area information for each unit
  - Same approach for different regions with diverse agriculture systems
  - No need to consider mixture of different crop types within each pixel
- Major challenges
  - More labor and cost to field survey
  - Representative of samples collected during field survey
  - No detail map or crop type information at field level
Outlines

- Overview of CropWatch
- Monitoring cropland to specific crops
- Conclusion remarks
Conclusions and outlook

- CropWatch Cloud provides an open and customizable platform that stakeholders over the world can calibrate, localize, customize and automatically generate agro-climatic and agronomic indicators according to their own specific requirements in areas of their interest.

- CropWatch provides services through APIs and edging computation which enables CropWatch extensible including calculation and data storage in a cloud platform for users in agricultural sectors.

- It offers a unique opportunity for the country to monitor their agriculture without considering storage and computational resources.
Steps to implement CropWatch

- Requirements analysis, crops, levels,
- Formulation of work plans and baseline data preparation
- Trainings both in house and field, at national and subnational levels
- Stakeholder meeting for further requirement analysis
- Joint customization, independent models incorporated
- Analysis, reporting and services independently, technical support remotely
  - guarantee that CropWatch cloud is available, accessible, functionable, flexible
- Promoting ownership and no investment needed for infrastructure
CropWatch Vision

- Promoting ownership
  - Customized according to the specific demand for each country and work as a national/regional system
- Respecting data sovereignty
  - Countries will strengthen the agricultural monitoring capacity on their own
- Reducing constraints
  - Cloud based system assessable from internet everywhere without investment on computing infrastructure, storage, etc
Thank you!

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