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CropWatch Cloud Empowers Developing Countries' Ability and Capacity to Explore Earth Observation for Addressing Food Security Issues

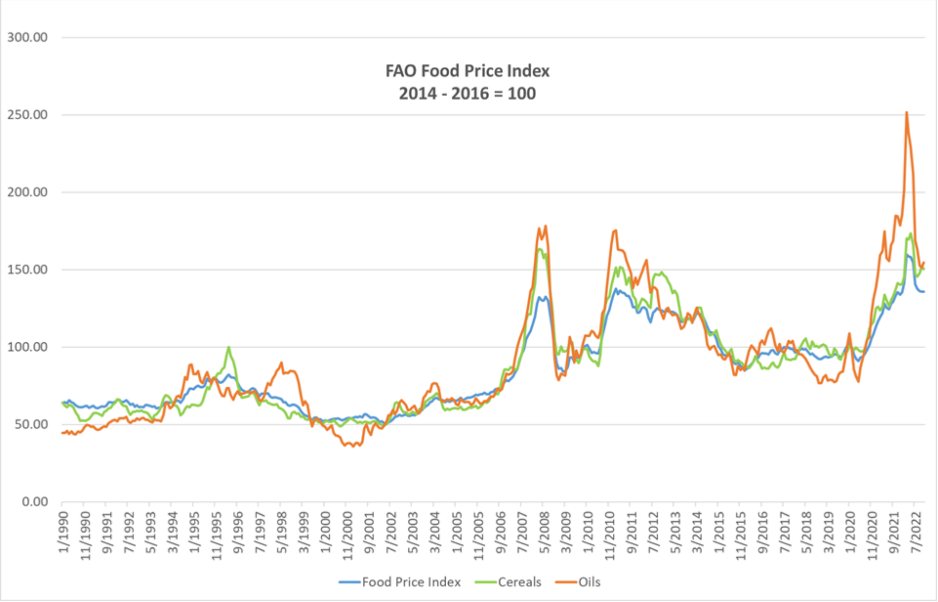
Wu Bingfang
wubf@aircas.ac.cn

Outline

- Background
- CropWatch programme
- Capacity building
- Outlook

Food Security

- Food security is still a challenge issue over the world, in particular in Africa, south & southeast Asia.
- Climate variability, especially extreme drought events are inducing yield depressions by more than 10%
- Pest and diseases overall impact to 10-20% of global crop harvest
- The paucity of adequate capacity in obtain and accessing up-to-date staple crop production information pose the danger of taking decisions based on delayed and on not easily verifiable information.



Crop Monitoring is essential

- for a country economic governance and securing food supply.
- Early production forecasts help policy makers to make evidence-based trade decisions
- In season warning (stress due to drought, pest & diseases) for better farm management
- Early warning information helps early response and actions on providing food aid to food shortage regions
- to improve food information availability and transparency
- Many countries want to develop crop monitoring system to derive near-real time crop information

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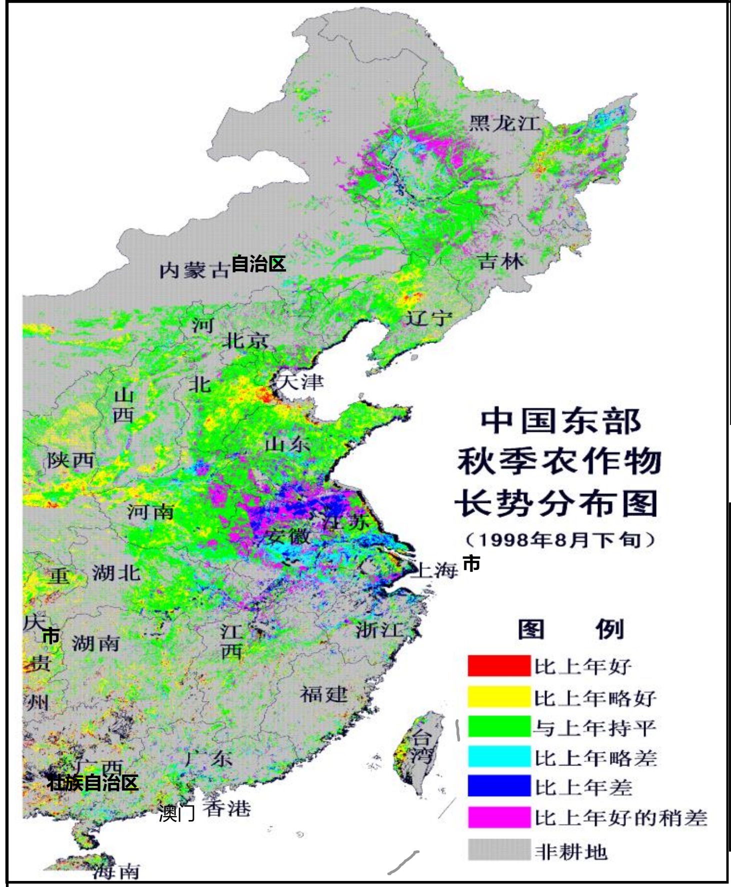
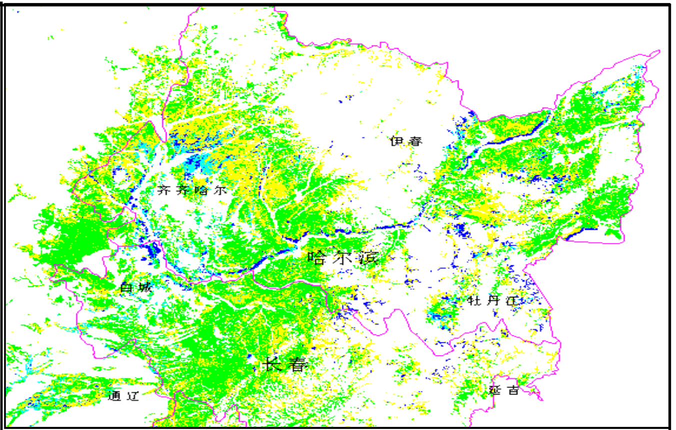
CropWatch Programme

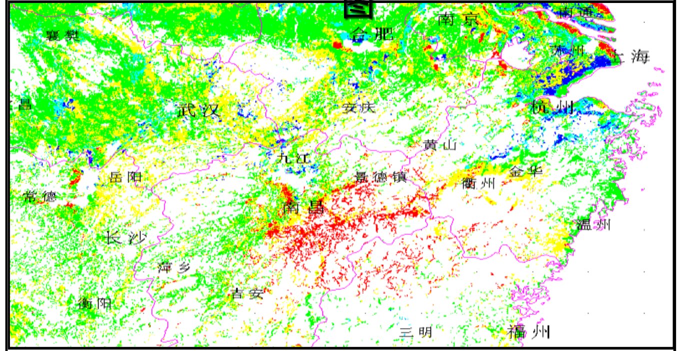
- Development over 1980s -1990s
- CropWatch bulletins since 1998
  - decade, month, quarter, annual
- Solid and accurate information
- Intensive field works and validation,
  - 1 million field data collection annually
  - Crop cutting on yield country wide
- Join the round table discussion
- Pressure on data modification
- Over 50 millions fundings from government



1998年8月下旬中国东部作物长势遥感监测图



1998年9月上旬松花江流域作物长势遥感监测图

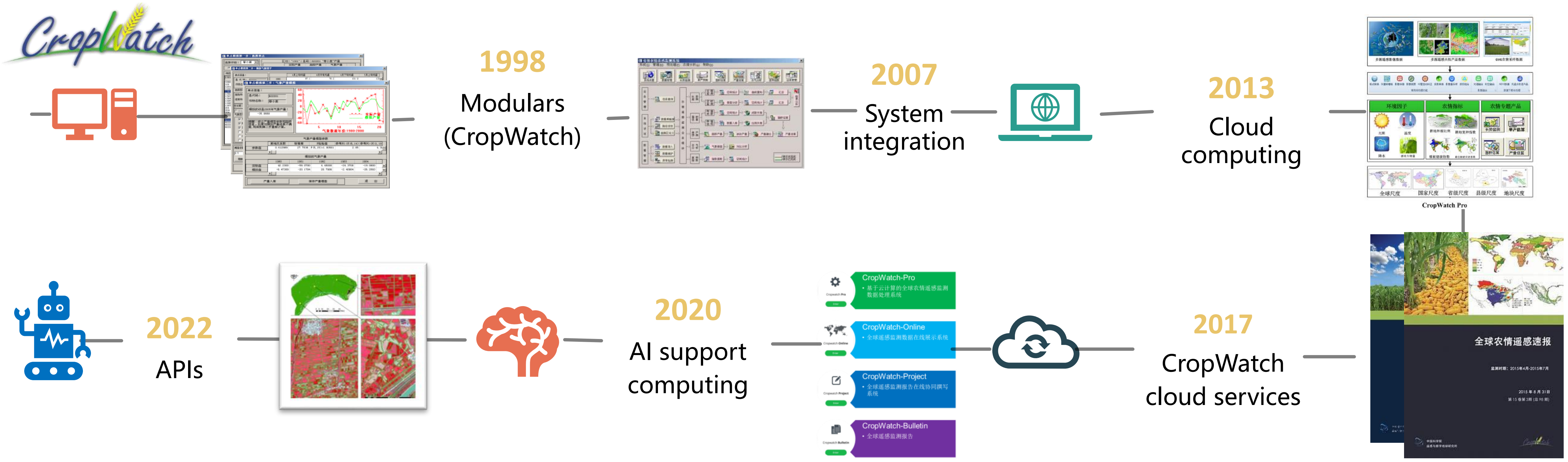


1998年9月上旬长江流域中、下游作物长势遥感监测图

Crop condition at 1998 sever flooding period

CropWatch versions

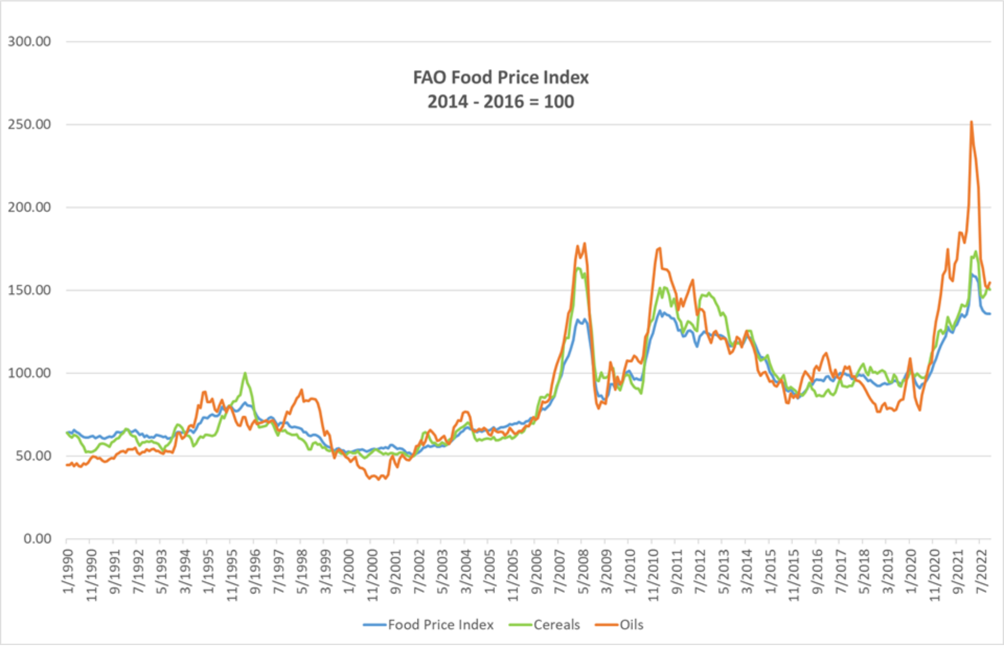
- 7 Versions of CropWatch: modulars (1998), systematization (2008), cloud computing (2013), cloud services (2017), AI based computing (2020), and APIs (2022)
- **APIs with edging computing**

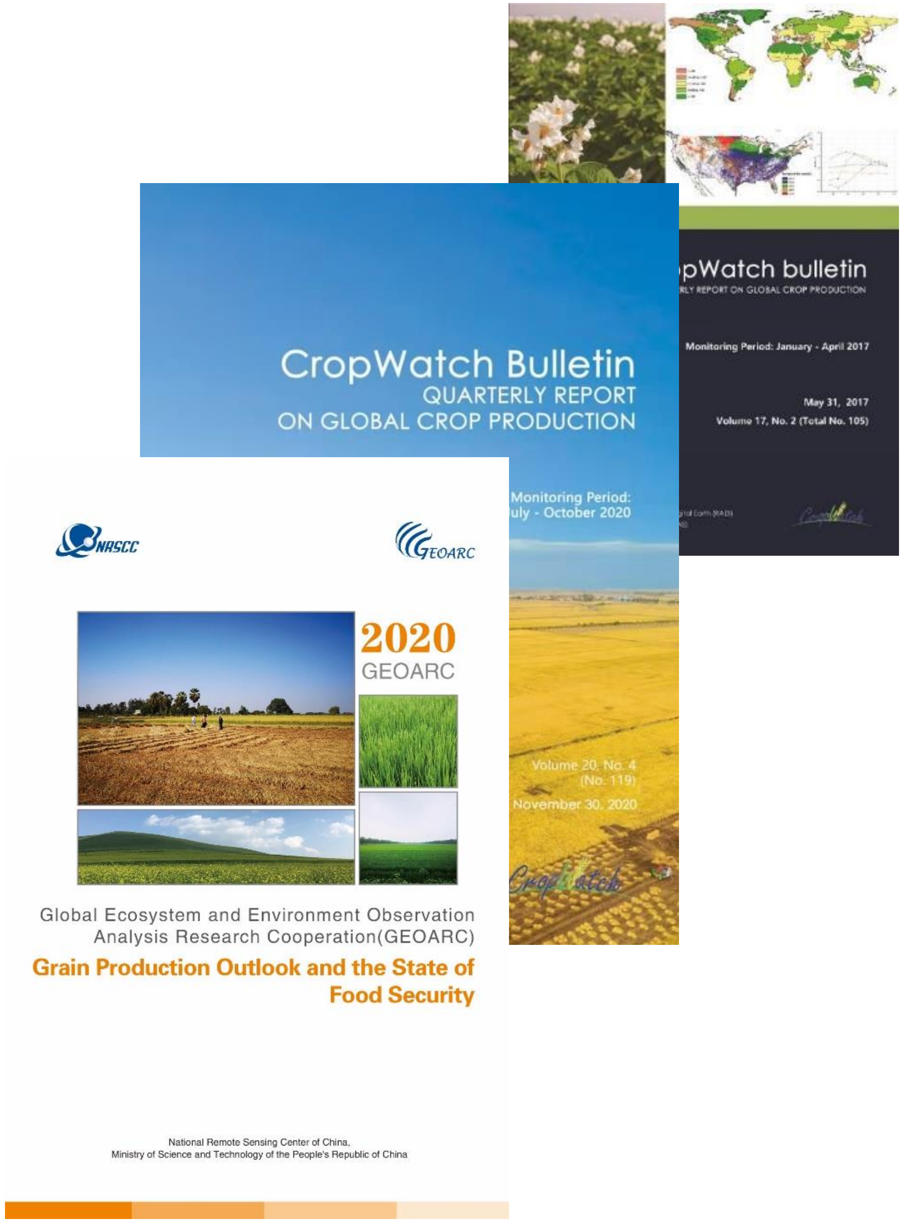


Wu B等， International Journal of Digital Earth; Wu B等， Remote Sensing, 2016; 吴炳方等， 遥感学报, 2019

Extreme events

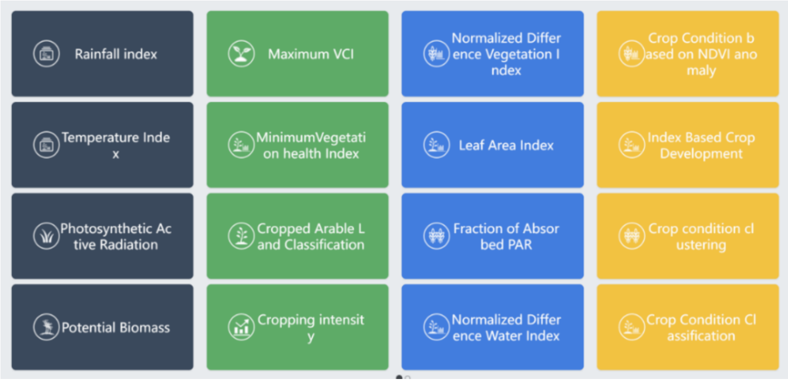
- News letter in response to drought, flood
- Extreme events: 1998 (flood), 2001 (drought), 2010 (world drought), 2020 (covid-19), 2022 (conflict)
- 2003-2004, soya bean crisis,
  - Because information from CropWatch is not used, 1.6 billion loses and many oil processing factories went to bankruptcy
- China food prices have been stable since 2004





CropWatch Cloud

- Satellite-based hierarchical method of crop monitoring,
  - Processing, explore, analysis and bulletin
  - 53 indicators addressing
    - agro-climatic,
    - agronomic,
    - production (area and yield),
    - extreme events and impacts,
    - early warning,
    - farming
- Release Quarterly and annually bulletins on global crop monitoring, covering 173 countries and regions down to provincial scales, with special focus on 43 key agricultural countries



Global Cropland at 30m

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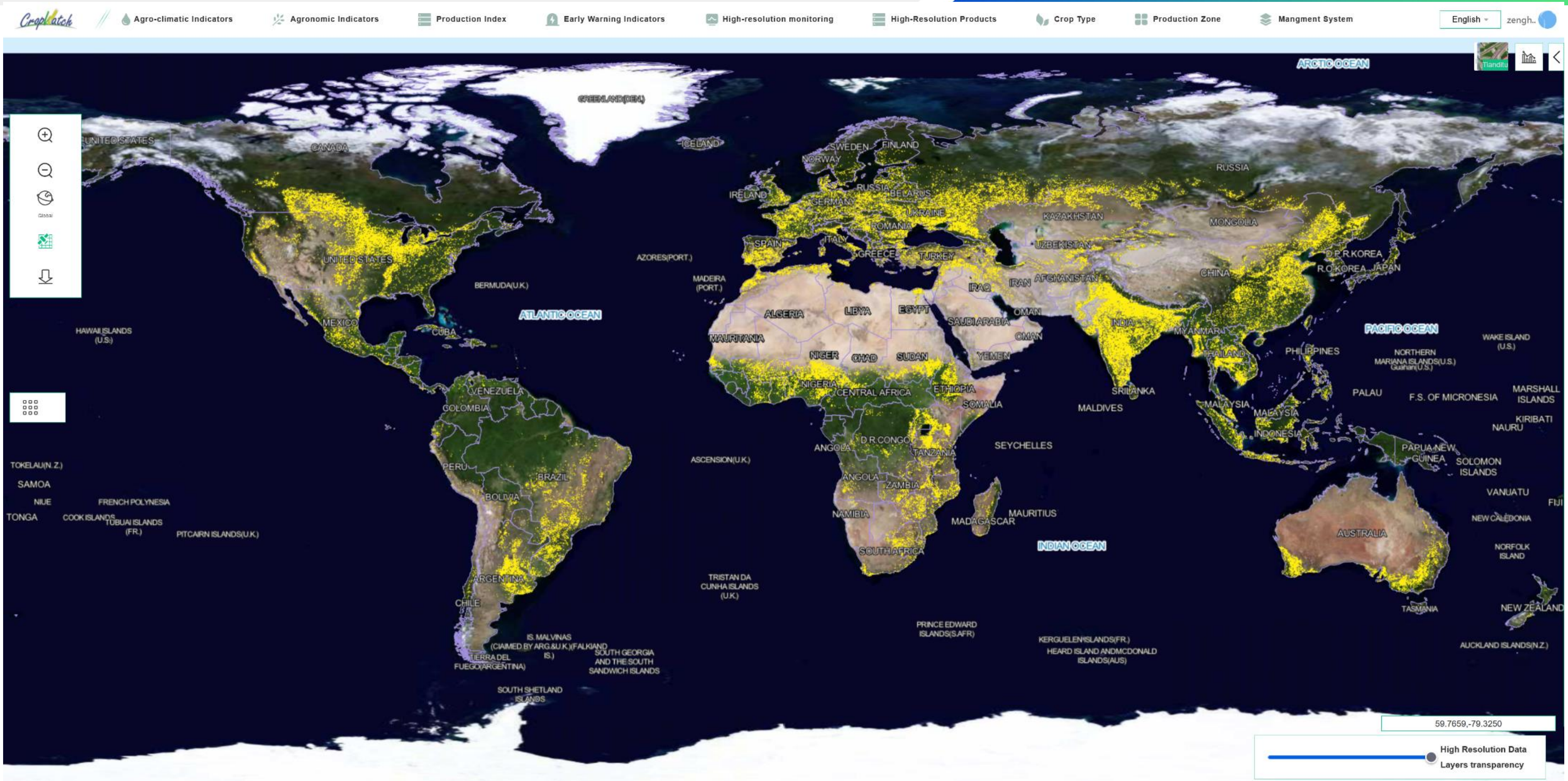
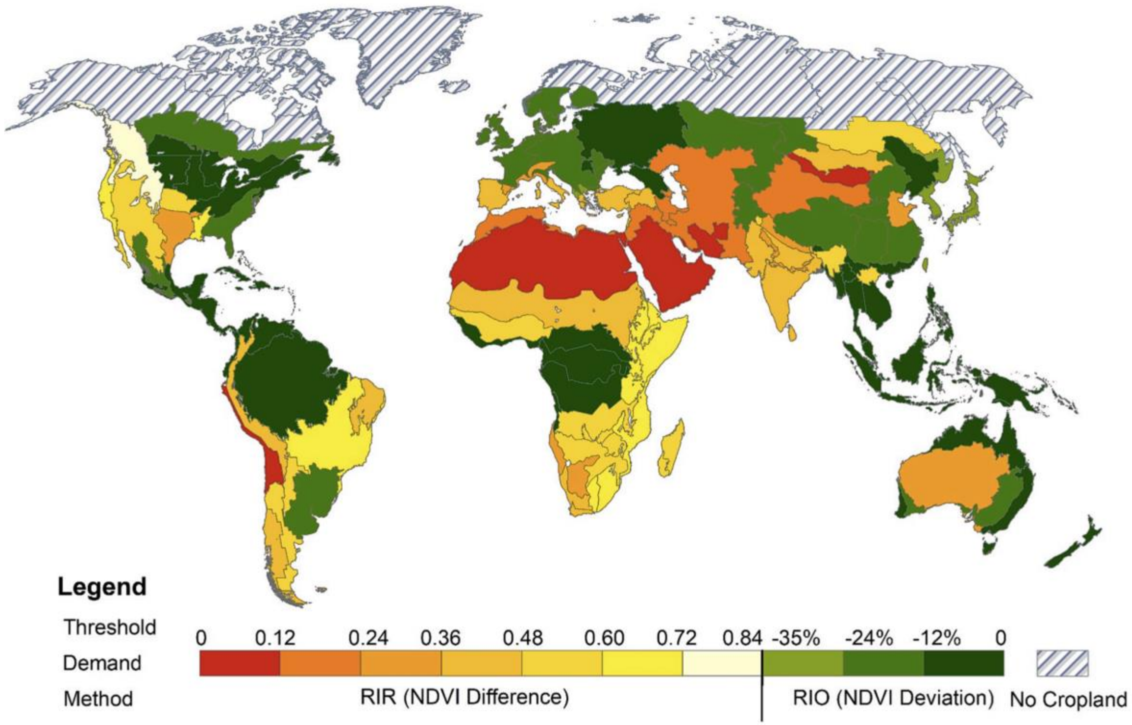
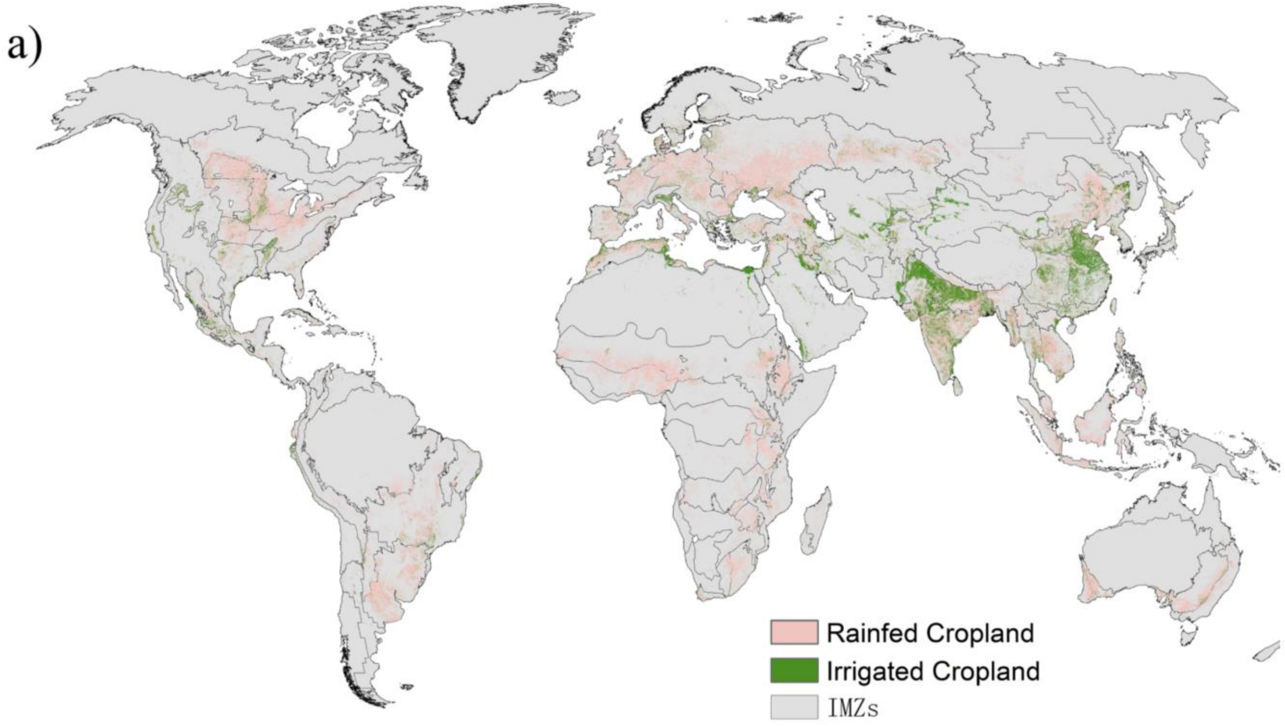


Irrigated Cropland

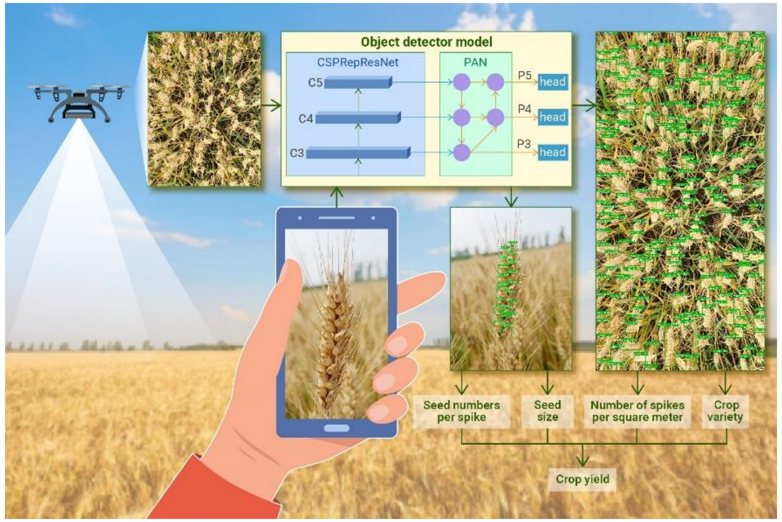
- Mapping the extent of irrigation with the NDVI differences between irrigated and non-irrigated croplands under water stress;
- The irrigation area at a 30-m resolution is 23.4 % of global cropland in the period 2010–2019, with an overall accuracy of 83.6 % globally
- Separating regular and intermittent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



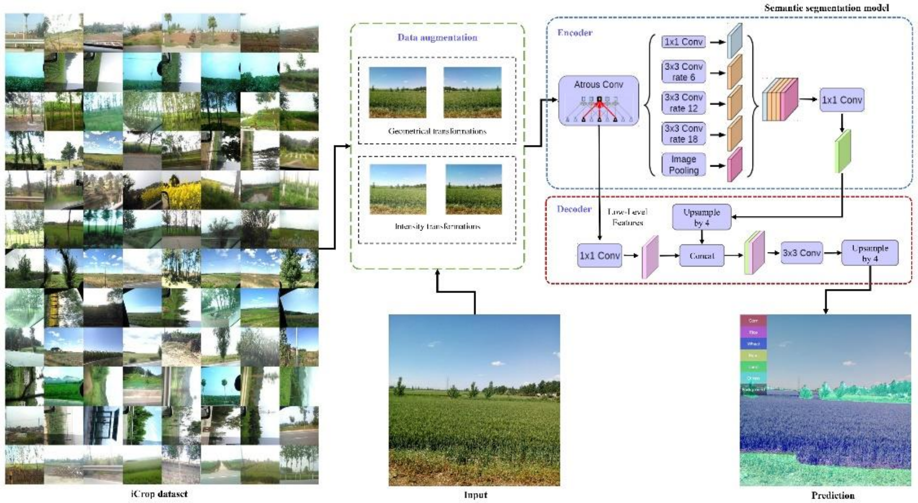


CropWatch tools

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



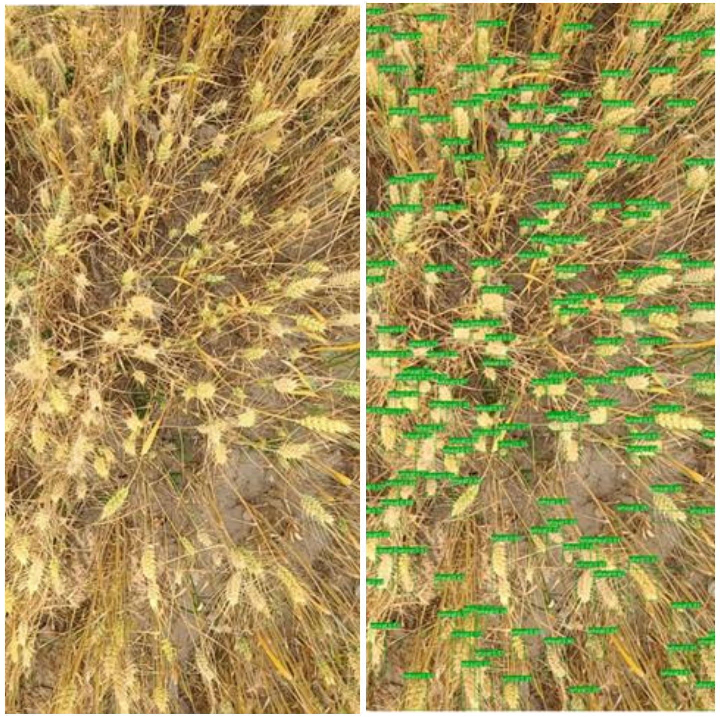
FieldWatch for yield data measurements

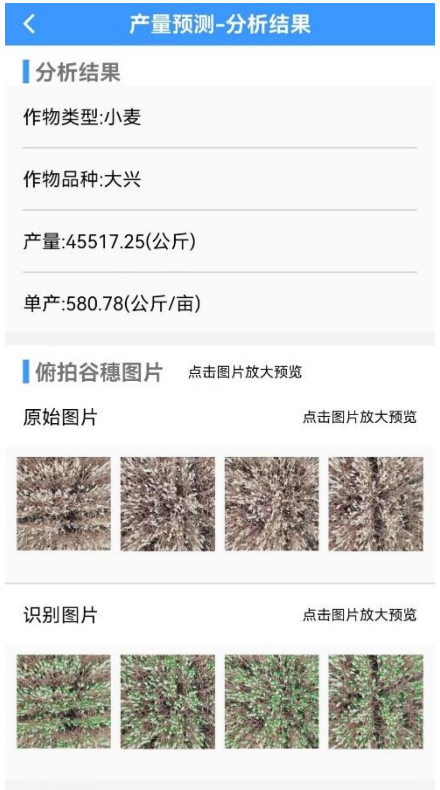


GVG Crop type identification from geo-tagged photos

Yield data collection

- With the support of the DL model, the number of ears/m2, and seed number per ear, size of seed are determined for crop yield estimation with accuracy of 92%
- FieldWatch supports disease identification, parcel crop condition and production





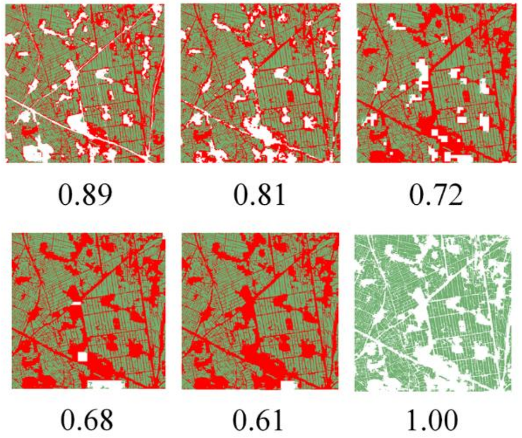
Crop type area estimation

LULC & cropland thematic maps

A_R : Pixel-counting area

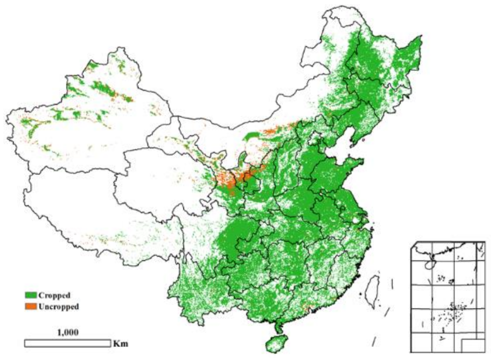
$$\text{UEC} \longrightarrow \forall = \frac{A_T}{A_R}$$

A_T : Actual parcel level cropland area



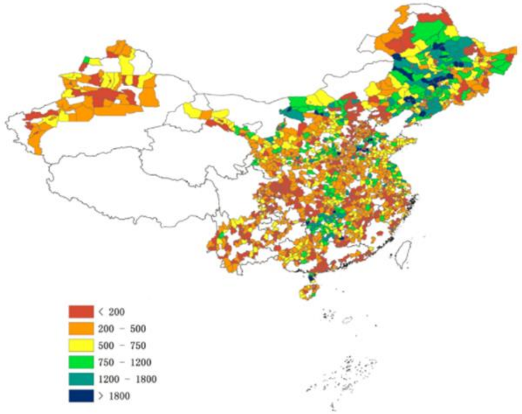
CALF

cropped and uncropped arable land, by pixel



Crop type ratio

Crop type ratio by GVG



Cropland × UEC × CALF × CPTP

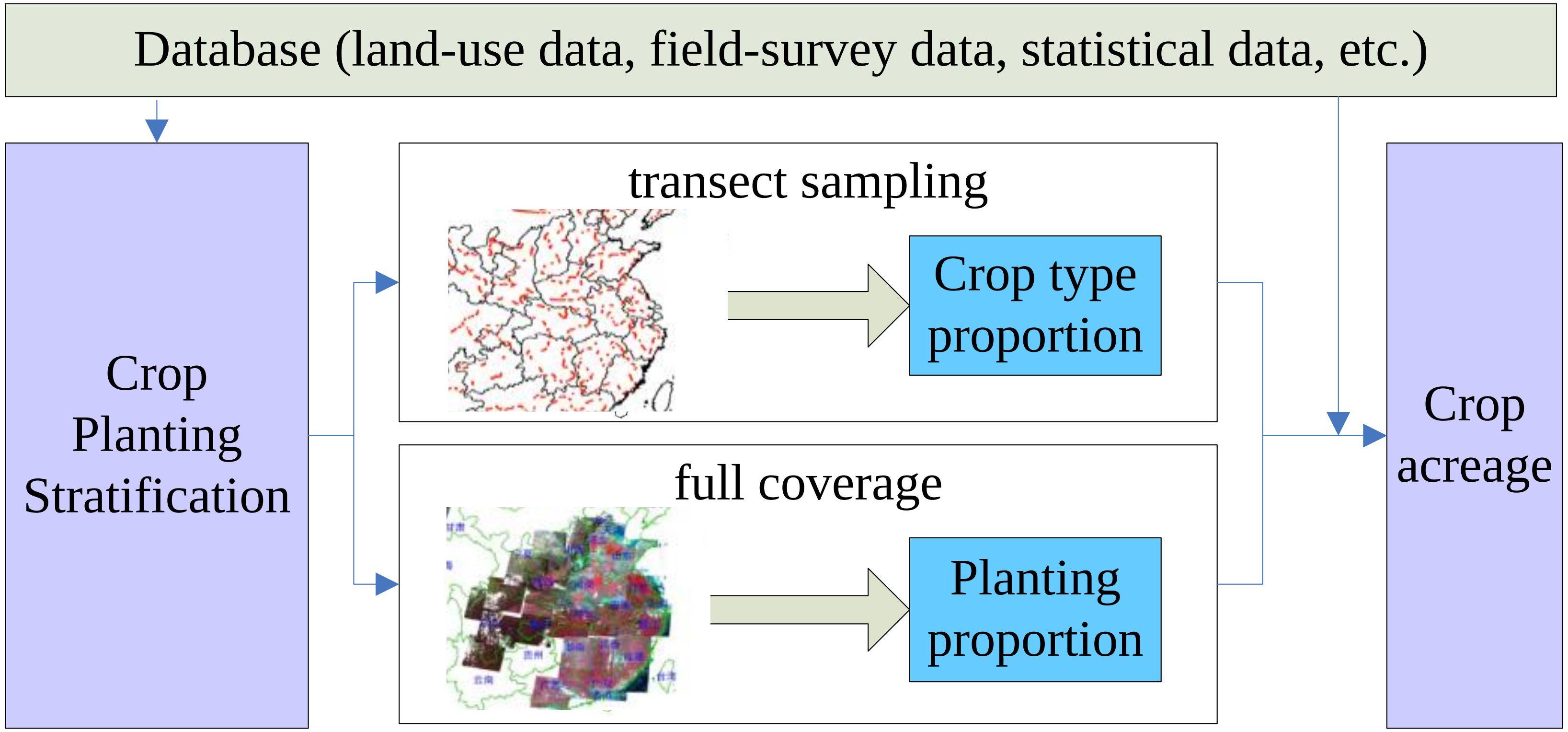
UEC → Arable land

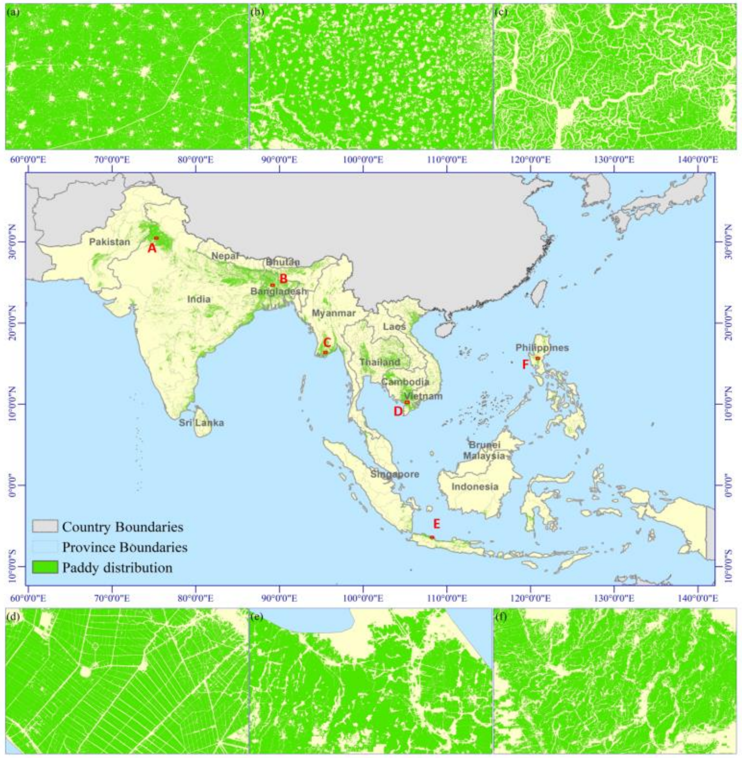
CALF → Farming land

CPTP → Crop type

Crop Areas

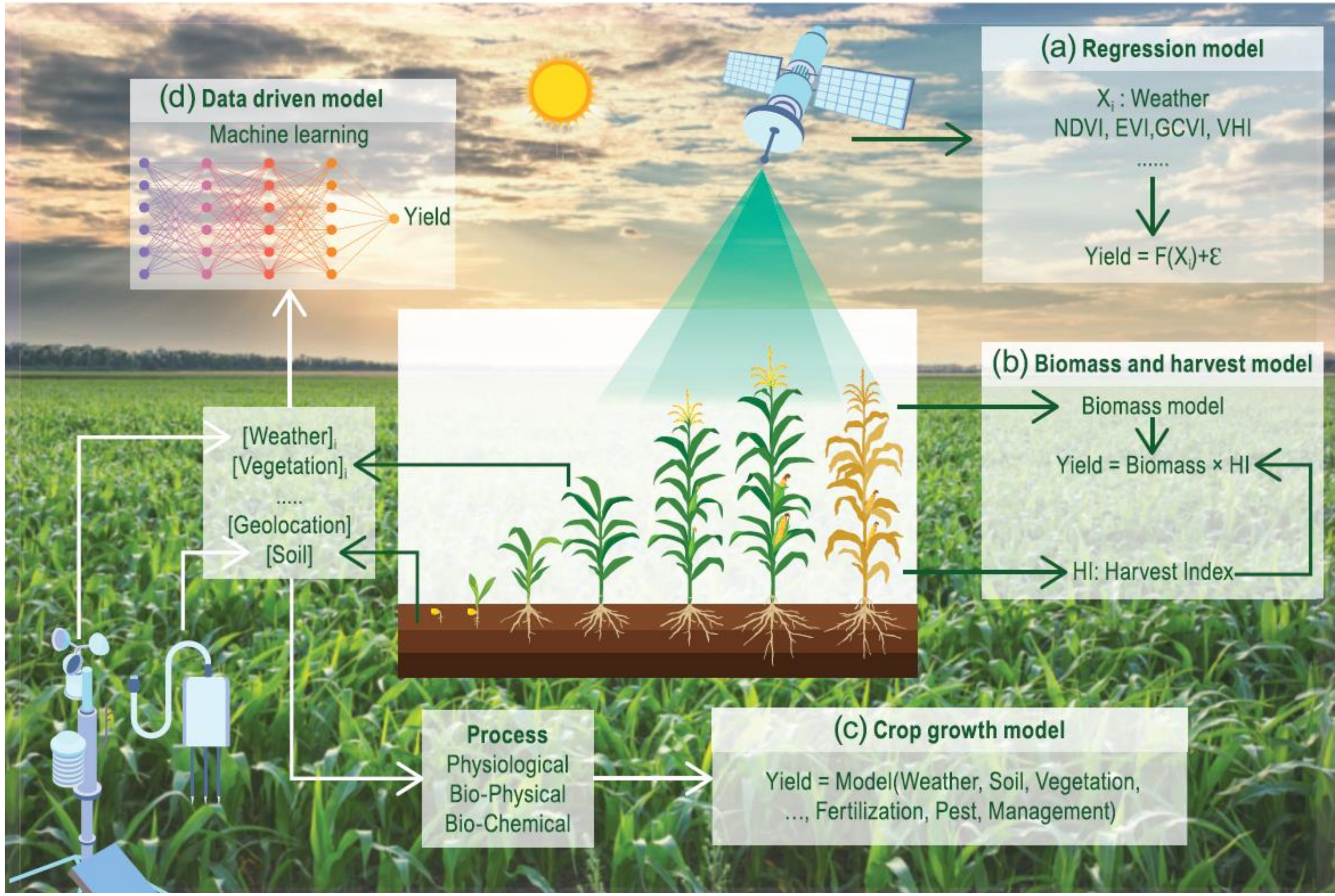
- Crop area information needs field data
- CropWatch integrates crop area estimation with geo-statistics & crop mapping
  - The CPTP method in complex agricultural landscapes (66%)
  - Transfer learning methods are integrated to reduce the reliance on in situ data (34%)





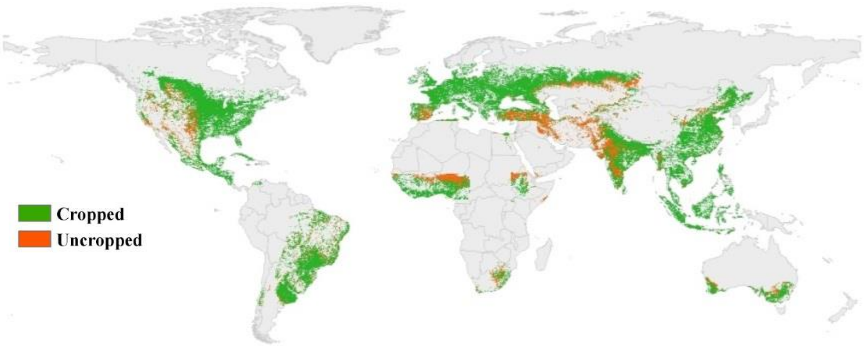
Yield models

- 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

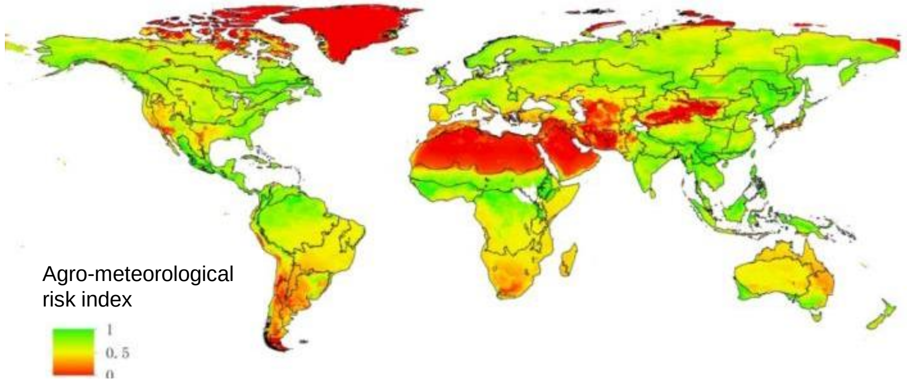


Early warning indicators

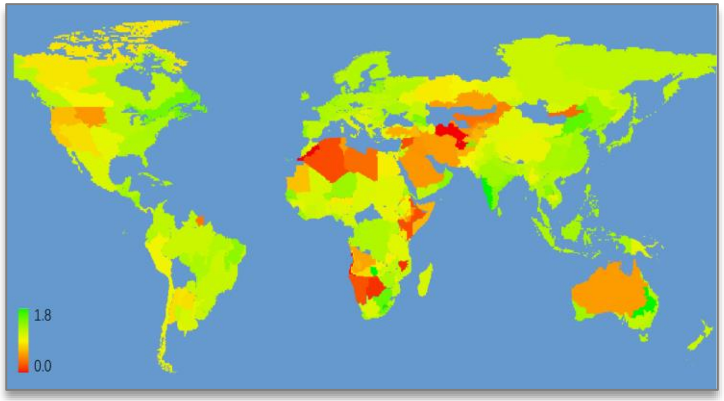
- Cropped arable land fraction (CALF) represents the total cropping proportion at early growing stage
- Agro-meteorological risk index (AMRI) considering meteorological suitability for crops at different growing stage
- Crop production index (CPI), integrating cropping area, condition, irrigation, intensity,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



CALF



AMR



CPI

Hierarchical analysis

Increasing level of detail
- from agro-climatic to agronomic
- from 25 km to 5m

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

173 countries and 110 zones

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

6 MPZ

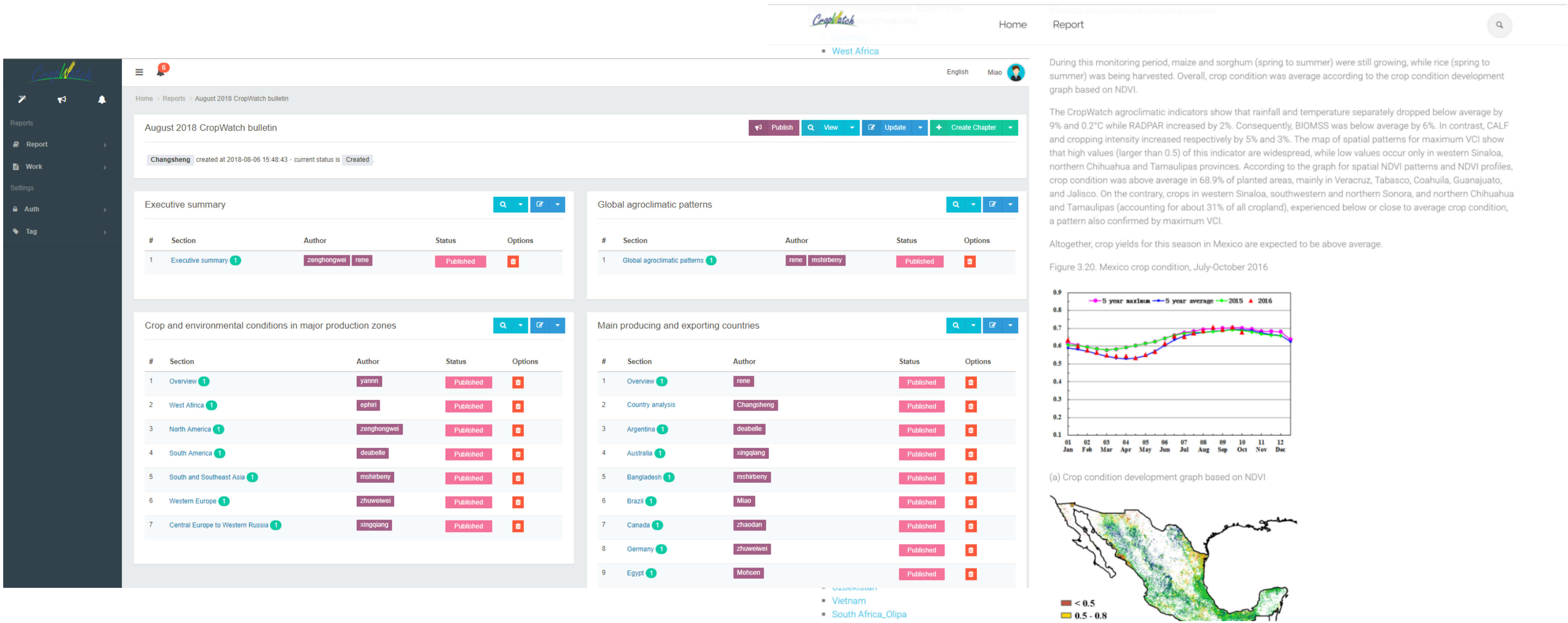
National
In addition to previous indicators, crop cultivated area, time profile clustering

47 and 225 agro-ecological zones

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

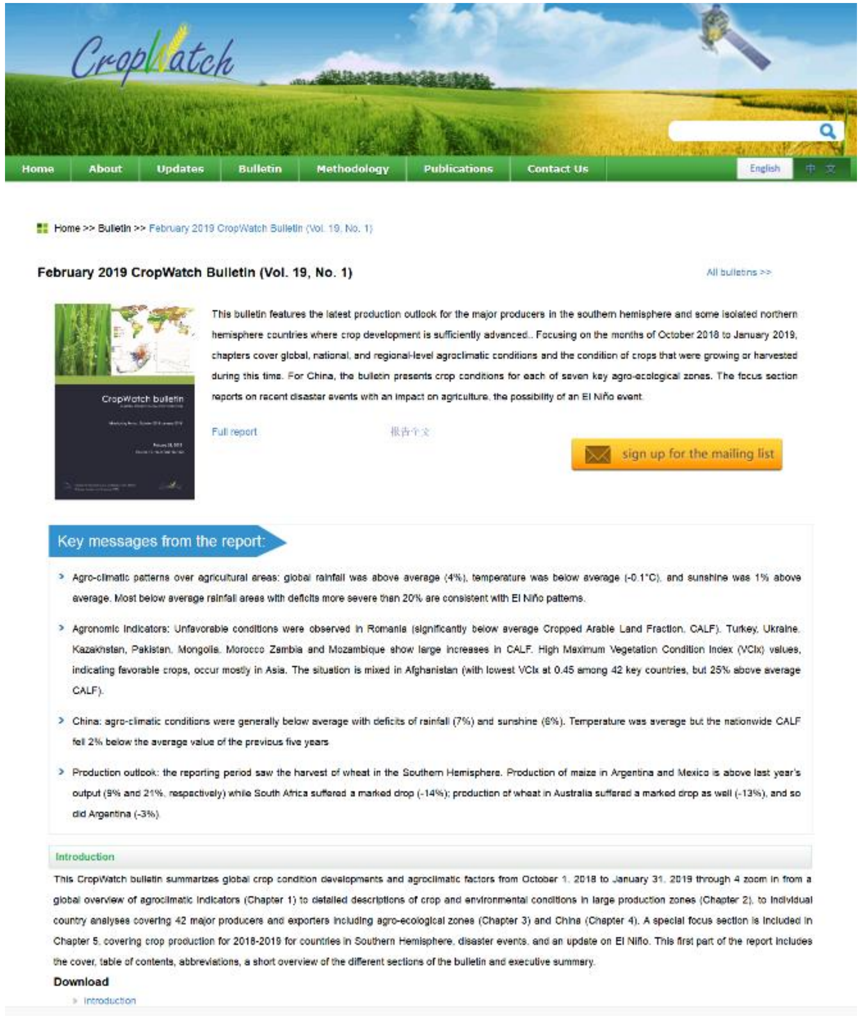
9 big countries

Collective analysis



CropWatch Bulletin

- Provide global crop report as pdf or html format in Chinese and English
- Downloaded by users from more than 170 countries, 20,000+ for each issue
- Enhancing the transparence of global crop information



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Crop Monitoring System

- Components:
  - Agro-climatic analyses,
  - crop-condition and stress monitoring,
  - crop production predictions, and
  - early warning of likely food insecurities.
  - farming activities and progress
- Operational
  - Efficient and long-term services for stakeholders
  - Cost effective, timely, location specific
- Basic elements
  - Complete Data stream from raw Earth Observation (EO) data as inputs to produce targeted information.
  - Software processes that automatically convert data into valuable information.
  - Archived product for time series analysis and comparison
  - Baseline datasets

http://cloud.cropwatch.cn/

CropWatch-Pro
- An online tool for people to produce crop monitoring products at any time and anywhere.

CropWatch-Explore
- An online interface for people to explore and analysis all the crop information data easily.

CropWatch-Project
- An online platform for people to create and write the crop bulletin.

CropWatch-Bulletin
- An webpage for people to read CropWatch bulletin.

Analysis and reporting

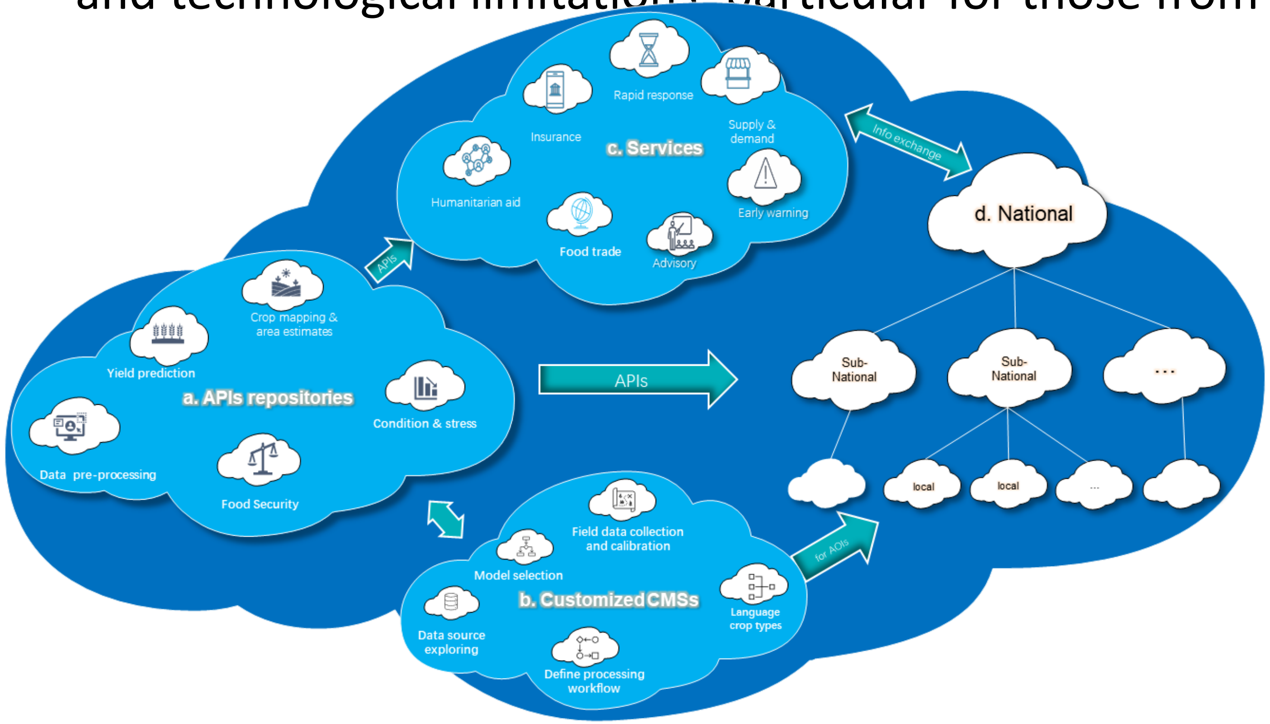
- Lack of transparent and standardized methods for synthesizing various information produced by CMSs to support decision-making
  - knowledge-based analyses are mostly applied in crop-monitoring activities, especially in the process of generating actionable reports.
  - the personal knowledge, views or preferences of the analysts all affect their working practices.
- difficult to question these reports without direct access to the algorithm code and the underlying data used to generate such information.
- alternatively, development of their own systems or obtain information from different sources to avoid unconscious biases.

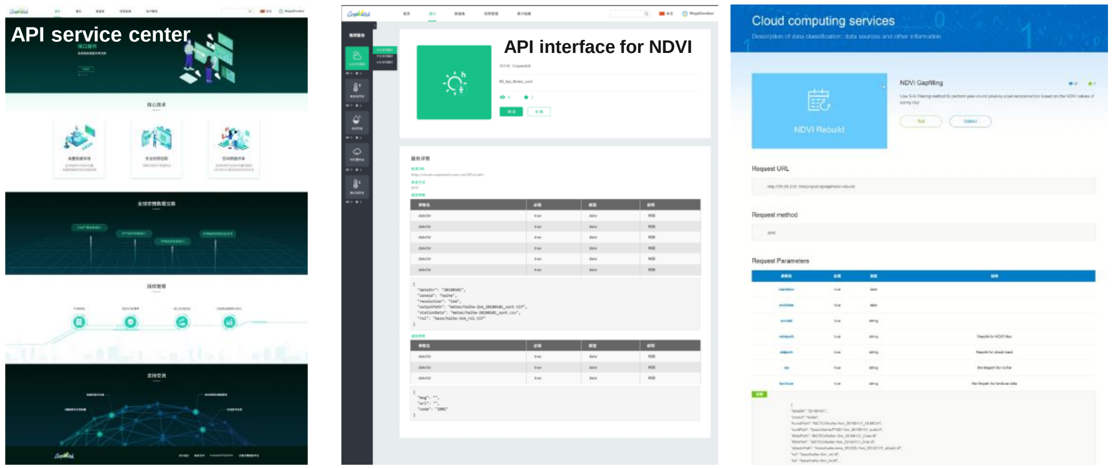
Constraints

- Set up a crop monitoring system is neither easy nor inexpensive
  - Combining of crops, phenology, location makes crop monitoring data streams very complex
  - Initiative input and operational cost as well as adequate technical skills constrain developing countries to set-up, operate, and maintain crop monitoring facilities.
- Most countries in the world do not have an operational crop monitoring system
  - resulting in a reduced ability of such countries to rapidly respond to issues around food production.
  - over-dependence on information provided by third parties and often
  - poses the danger of taking decisions based on delayed and on not easily verifiable information

CropWatch Cloud and APIs

- CropWatch cloud can be accessed at anywhere and anytime and by anyone
- CropWatch APIs can be customized and tailored for specific requirements
  - All components and functions of CropWatch, including the self-calibration of models are packaged as APIs in the CropWatch-Cloud, for use and tailor
  - Modules: Agri-climatic, agronomic, production, and early warning
- Opening cropwatch to other interested stakeholders can help overcome hardware and technological limitations, particular for those from developing countries





Participatory architecture

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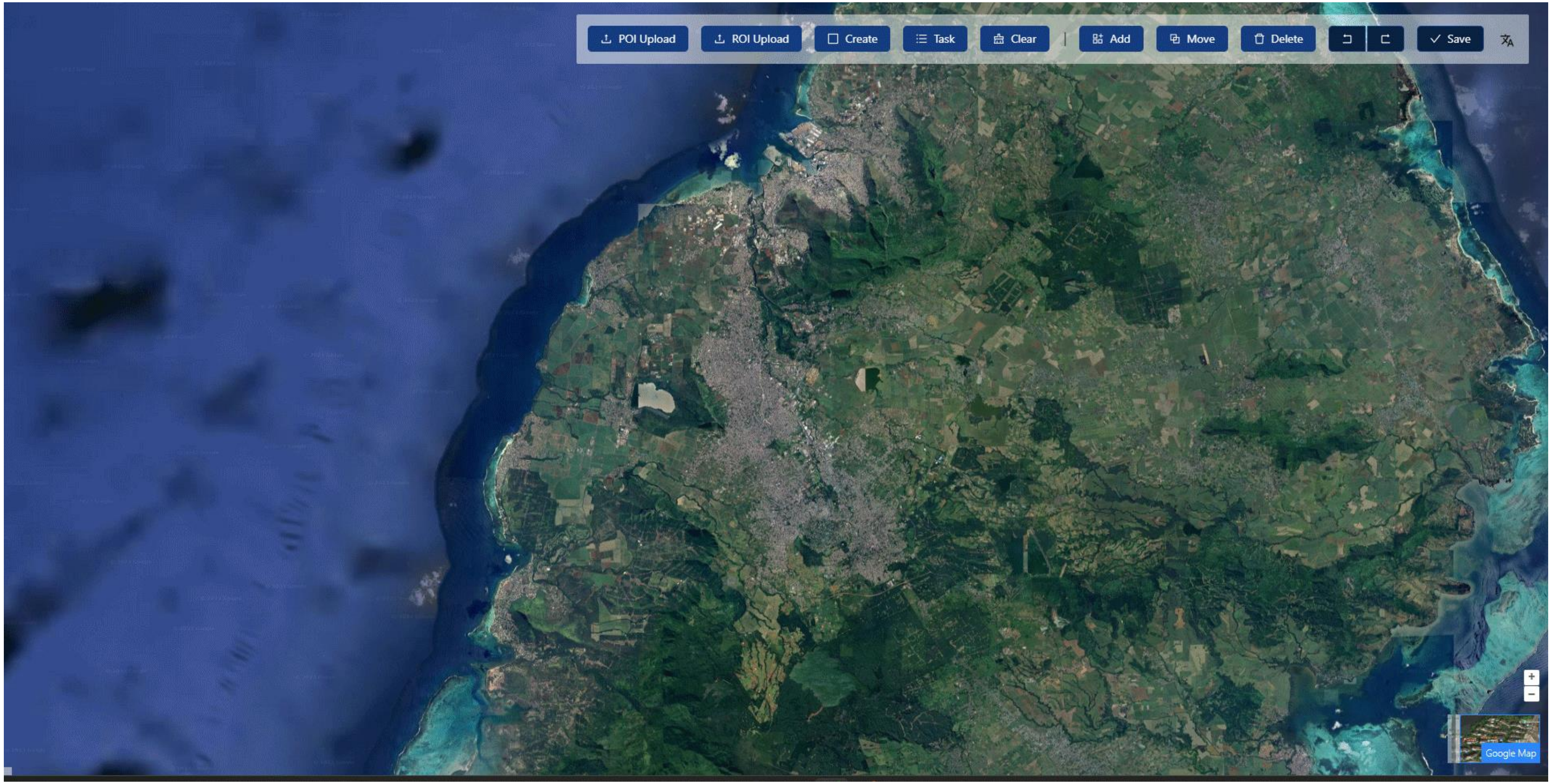
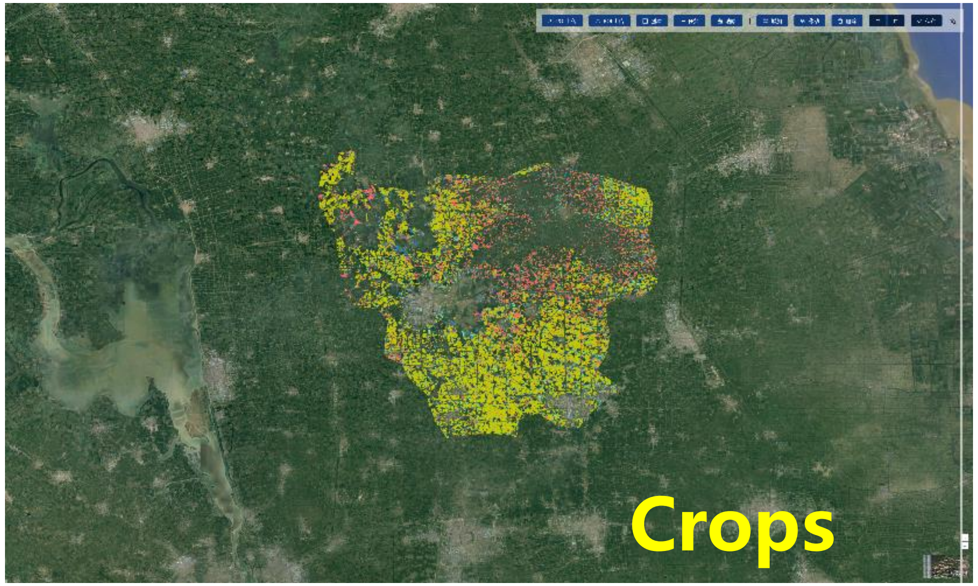
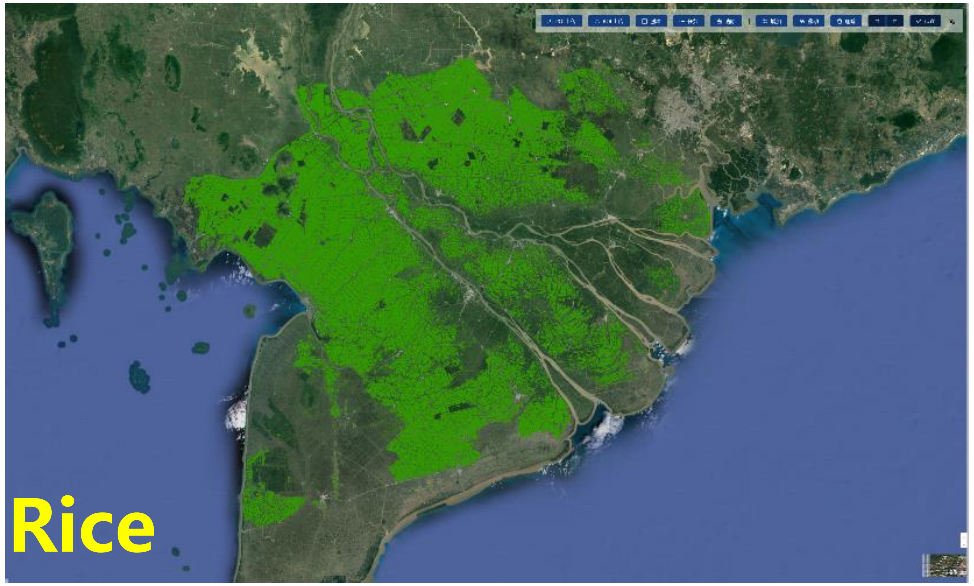
Participatory architecture with microservice, APIs and model library, provides users with the accessibility to independently carry out crop monitoring with different needs

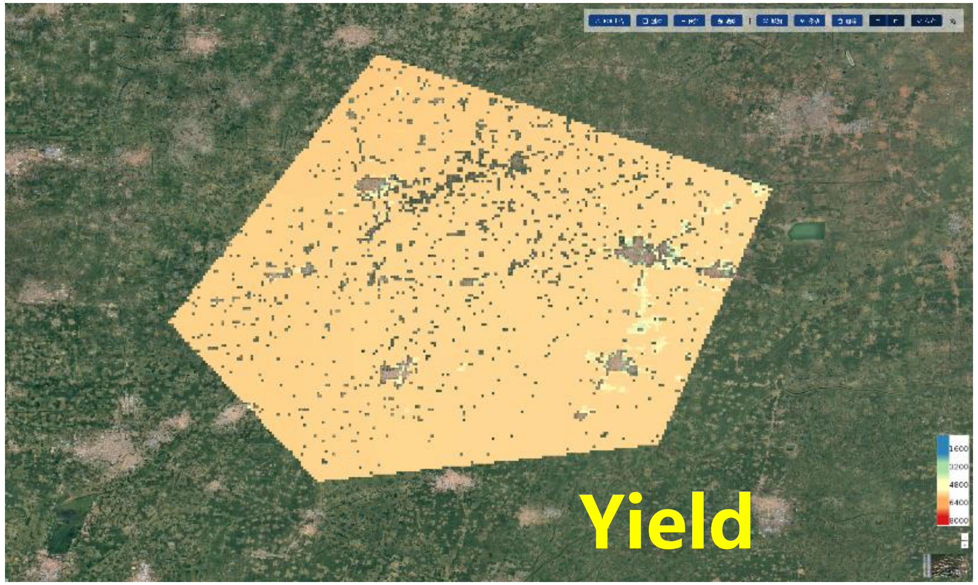


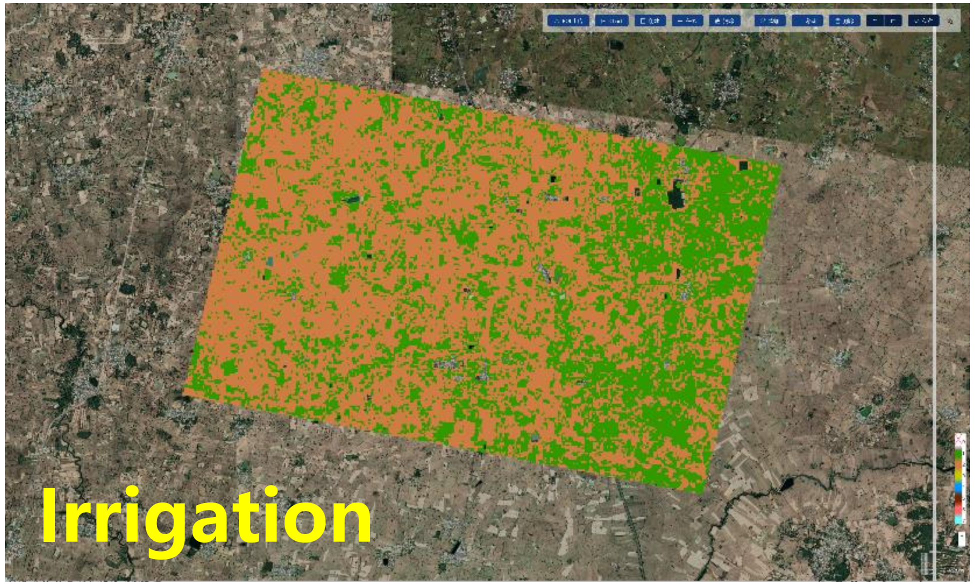
Customized methods

- Interactive high-resolution
  - All crops
  - Rice
  - Yield
  - Irrigation and rainfed
- Meet user's demand for high-resolution monitoring
- Support for iterative parameter calibration









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 or IOA (Argentina, Cambodia, Mongolia)
- Reducing the cost and technical barrier of establishing CMS


#36 Thailand English

Choose a new editor

This monitoring period covers the harvest of the main rice crop as well as the planting of second season rice (dry season). According to the agroclimatic indicators, Thailand experienced wetter and cooler weather than usual in this monitoring period with above-average rainfall (RAIN +23%), slightly below average temperature (TEMP -0.3°C) and average radiation (RADPAR 0%). As a result of these indicators, a slight increase in crop biomass production potential was estimated (BIOMSS +3%). The ratio of irrigated cropland in Thailand is approximately 22.5%. It is located in the central region of Thailand. Therefore, rainfall is important for crop growth.

The NDVI development graph demonstrates that the crop conditions were generally below the 5-year average during the whole monitoring period. The large negative departures are artifacts, caused by cloud cover in the satellite images. The temperature was mainly below the 15-year average although the temperature from November to December was slightly higher than unusual. The rainfall was high at the beginning of October and at end of the November 2022, when it reached levels close to the 15-year maximum. Subsequently, it followed the 15YA. According to the NDVI departure clustering and the corresponding profiles, crop conditions were generally close to average on 65.5% of total arable land, located in the northeast, eastern, central, and some areas in the northern region. In the other regions, cloud cover in the satellite images affected the trends.

At the national level, most of the arable land was cropped during the season (CALF 99%). VCIx values were around 0.86. The Crop Production Index (CPI) in Thailand was 1.05. CropWatch estimates that the crop conditions were close to average.

Regional analysis

The regional analysis below focuses on some of the already mentioned agro-ecological zones of Thailand, which are mostly defined by the rice cultivation typology. Agro-ecological zones include **Central double and triple-cropped rice lowlands (187)**, the **South-eastern horticulture area (188)**, the **Western and southern hill areas (189)**, and the **Single-cropped rice north-eastern region (190)**.

Compared to the 15YA, the **Central double and triple-cropped rice lowlands** experienced cooler and wetter conditions. Radiation (RADPAR +3%) was above average accompanied by lower temperatures (TEMP -0.3°C) and higher rainfall (RAIN +30%). These conditions led to a slightly above-average estimate for BIOMSS (BIOMSS +1%). The NDVI development graph shows that crop conditions were below the five-year average for most of the monitoring period except for January, as was the moderate VCIx value of 0.83. Overall, conditions were slightly below average.

Indicators for the **South-eastern horticulture area** show that temperature (TEMP -0.7°C) and radiation (RADPAR -2%) were below average accompanied by higher rainfall (RAIN +21%). This led to a slightly above-average estimate for BIOMSS (BIOMSS +2%). According to the NDVI development graph, however, the crop conditions were slightly below average during this monitoring period except in early January. The VCIx was at 0.85. All in all, conditions were slightly below average.

Agroclimatic indicators show that the conditions in the **Western and Southern Hills** were slightly below average: radiation (RADPAR -2%) and temperature (TEMP -0.1°C) were below average, while the rainfall (RAIN, +29%) was above average. The average weather conditions led to a 3% increase in BIOMSS. According to the NDVI development graph, the crop conditions were significantly below average. According to the VCIx value of 0.89, crop conditions were assessed as below average.

In the **Single-cropped rice north-eastern region**, the temperature was below average (TEMP -0.5°C), while radiation (RADPAR +3%) and rainfall (RAIN, +7%) were above average. All these agroclimatic indicators led to an increase in potential biomass (BIOMSS +3%). According to the NDVI development graph, the crop conditions were close to average. Considering the moderate VCIx value of 0.86, the crop conditions are considered normal.

Figure 3.41 Thailand's crop condition, October 2022- January 2023.

(a) Phenology of major crops

b) Crop condition development graph based on NDVI c) Maximum VCI

Wu F, 等. Environmental Modelling and Software , 2021; Wu B, et al. National Science Review, 2022

GEO Knowledge HUB

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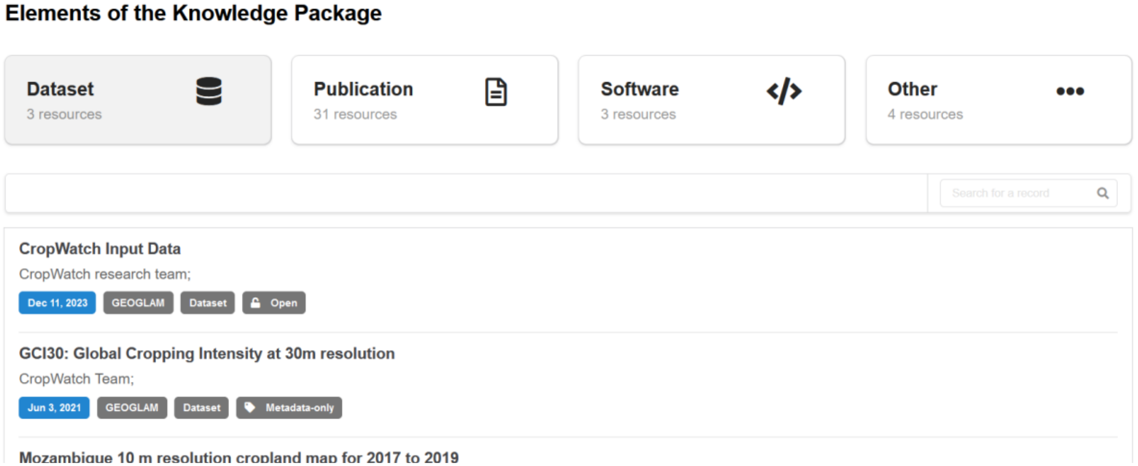
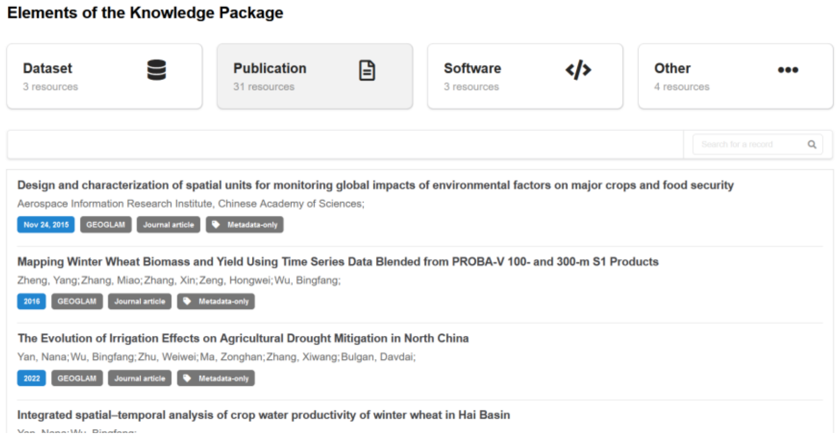
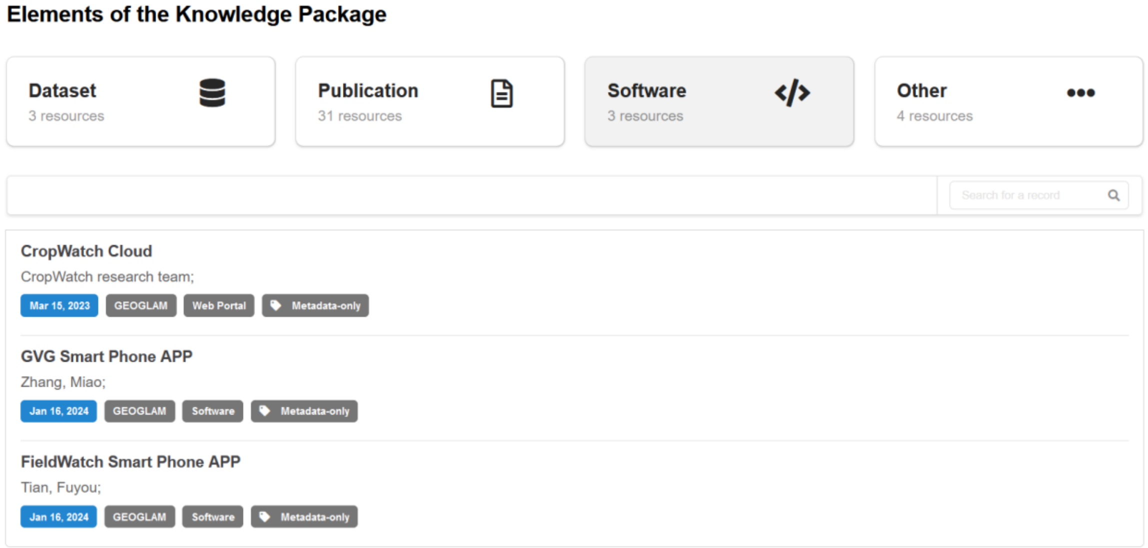
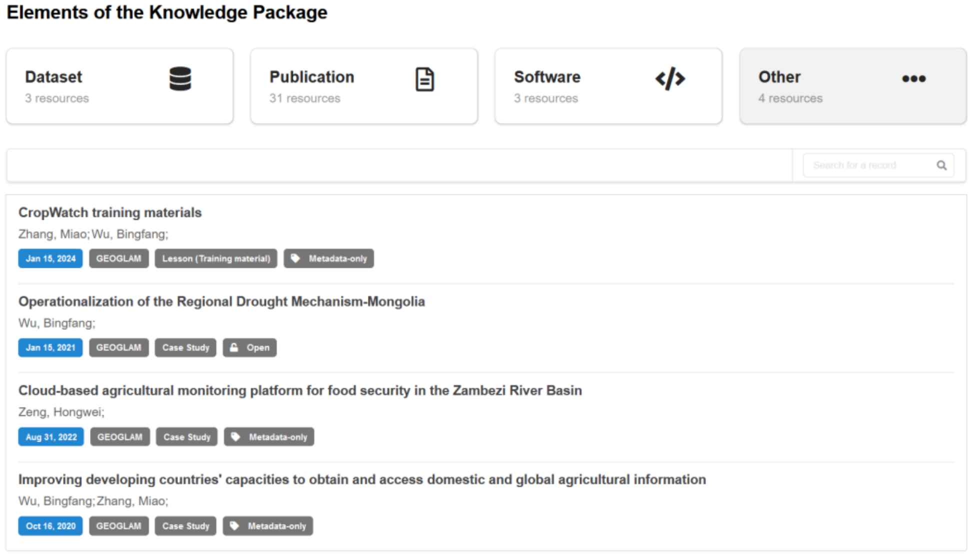
- CropWatch is the first system from China indexed in GEO Knowledge HUB, providing comprehensive information for new users from developing countries









Capacity building activities

- Regional workshops and training seminars
- Bilateral works for country, including requirement analysis, field training, local language support…
- System customization
- Baseline data preparation
- CropWatch development to incorporate new requirements
- Regional center to enhance sustainable

Capacity building activities

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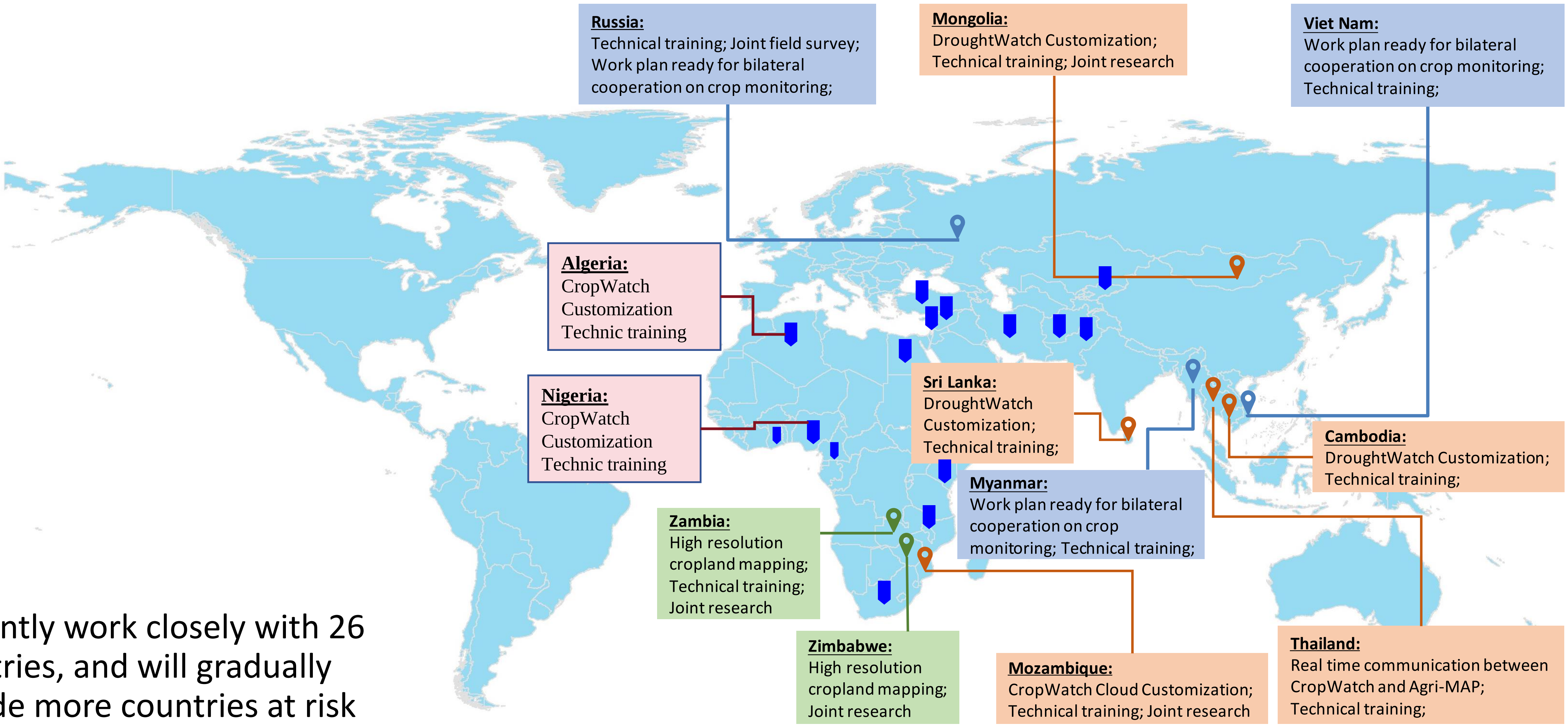
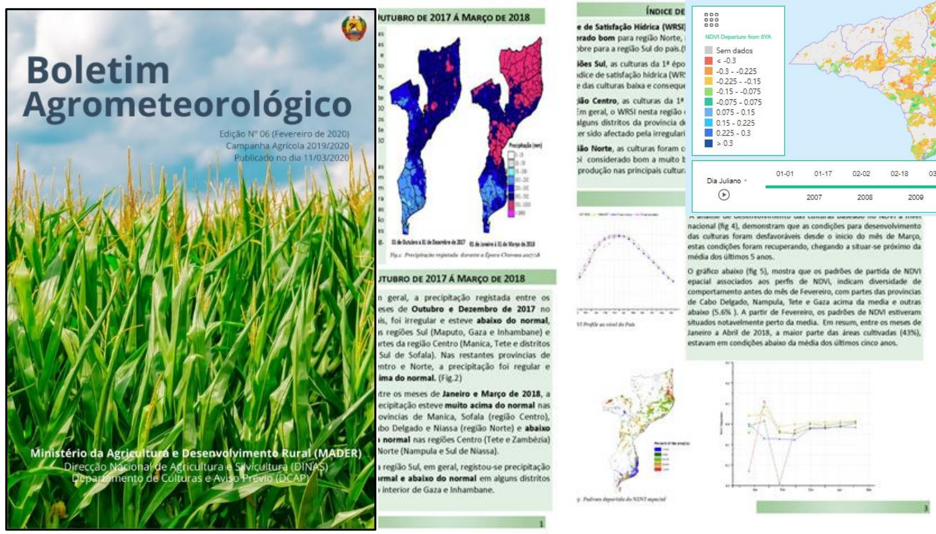


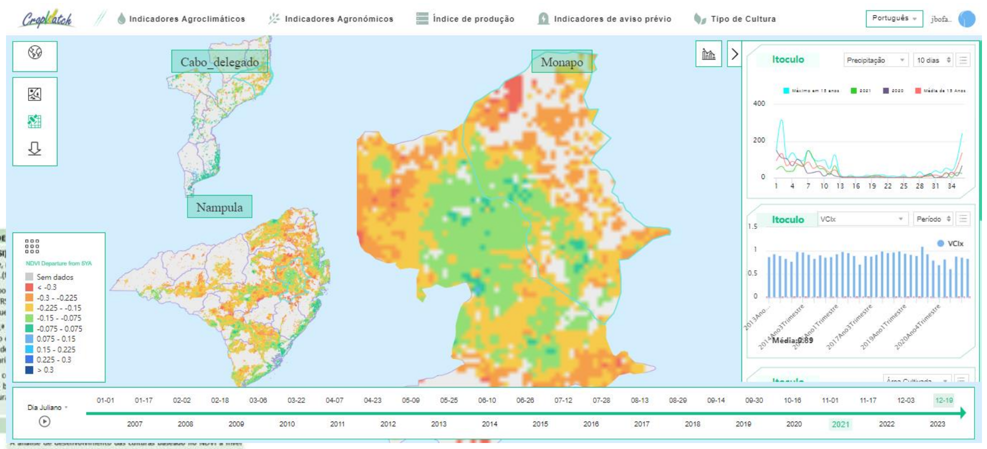
Currently work closely with 26 countries, and will gradually include more countries at risk

Capacity building in Mozambique

- Sponsor by World Bank
- First CropWatch training for selected experts (3 persons)
- Extended CropWatch training (29 participants)
- In-situ data collection training
- National Meteorological Bulletin powered by CropWatch
- CropWatch Cloud for Mozambique was included in Rural Solutions Portal by IFAD in 2020.

Activities	Outputs
Requirement analysis	Detailed Requirement report
Discussion and finalize the **implementation plan**	Detailed implementation plan
Discussion and **joint field trip** in Mozambique	In situ data in Maputo and Nampula
First **technical training** of CropWatch in Beijing	Agricultural monitoring report done by MOZ experts using CropWatch
Second technical training of CropWatch in MOZ	CropWatch based crop condition monitoring included in MOZ national meteorological bulletin
Training for national and provincial office	Mozambicans get some knowledge about crop monitoring on their own
Customize the CropWatch system for Mozambique	Provide system in Portuguese; Include all provinces for MOZ; Yield model calibrated

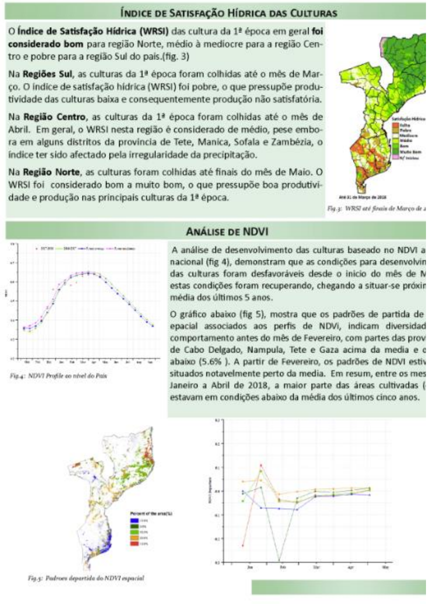


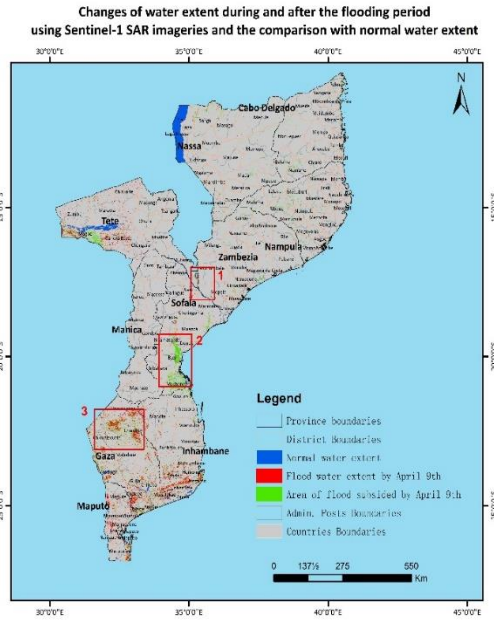


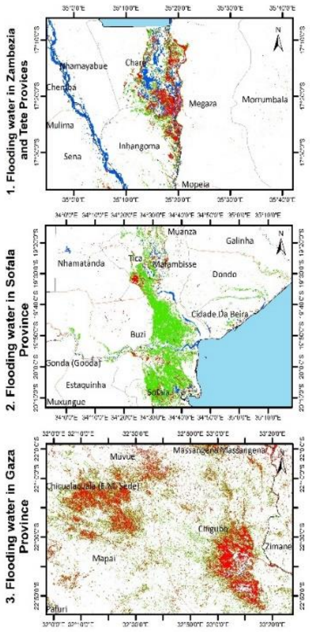
A customized CropWatch cloud (IN PORTUGUESE) platform provides crop-condition monitoring on the National, Provincial, district and region unites…

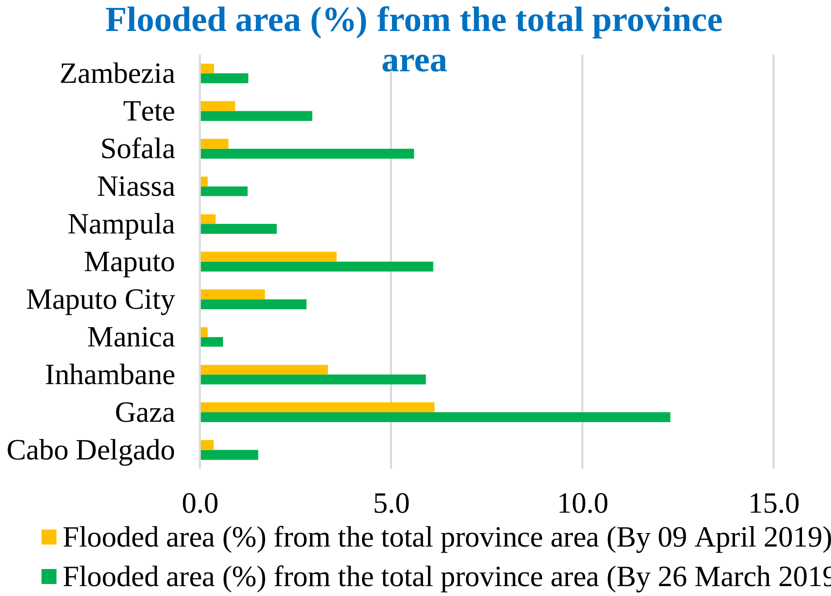
CropWatch-Mozambique

- Mozambique Ministry of Agricultural and Food Security used CropWatch monthly during the rainy season to produce Monthly Agro-meteorological Bulletin in Portuguese
- Flooding information was generated after IDAI Cyclone in 2019 for emergence responses
- One PhD student from Mozambique provides technical support at local









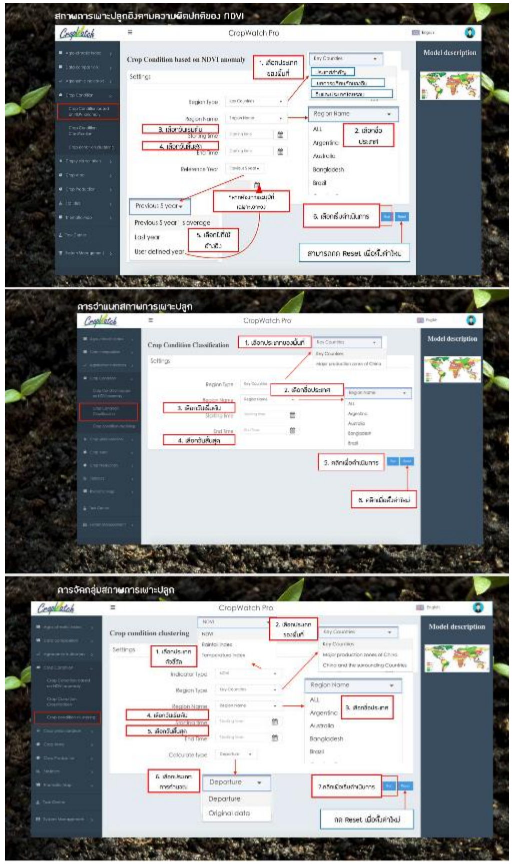
Lower Mekong countries

- Coordinated by ESCAP
- Targeting countries： Cambodia, Laos, Myanmar, Thailand, Vietnam
- Indonesia, Malaysia, Philippine, Sri Lanka are joining
- Requirement analysis for each country during Inception workshop in 20-22 March 2019, Bangkok, Thailand
- CropWatch Cloud Customization during May to November 2019；
- Online Technical trainings in August 2020;
- ……

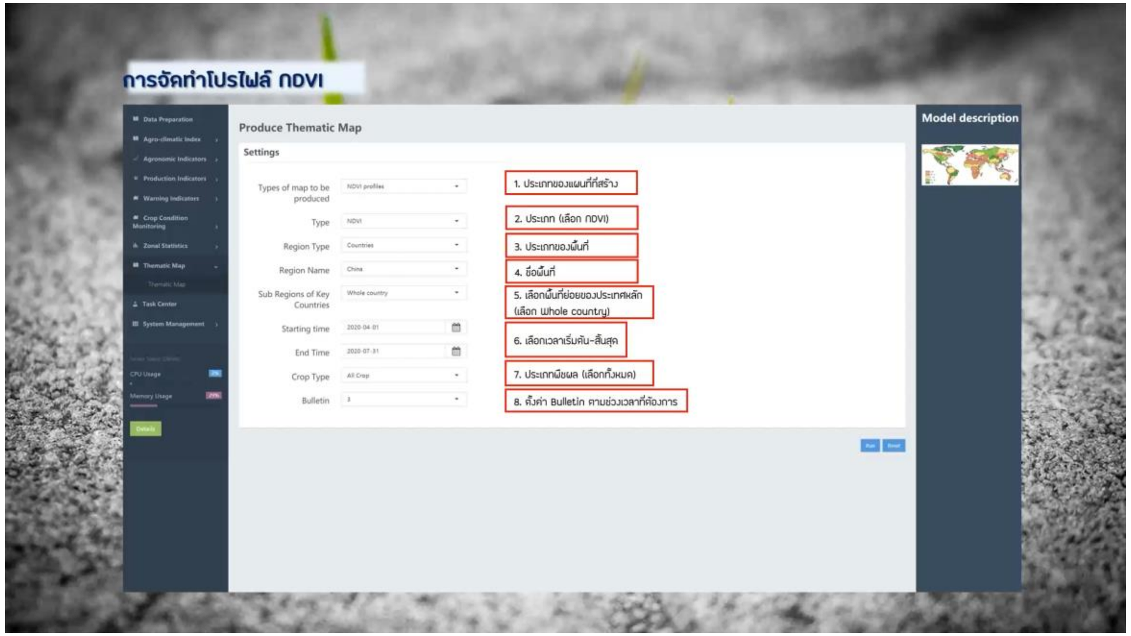
Online training with 45 participants

Southeast Asia

Under the coordination from UNESCAP, CropWatch user manual and video of the training courses were translated into local language including Cambodian, and other languages



Training video in Thai



https://www.unescap.org/kp/2021/cropwatch-pro-user-manual-english-cambodian-lao-thai-and-vietnamnese?fbclid=IwAR0xlyWu5fOL1XSftjAV8lMv7aG2SFFbBnosfkYpSNnEFlxNhqf0WdHqlBA

Customization for Cambodia

- Interfaces translated into the local language
- CropWatch4Cambodia provides detailed information of all available indicators (agro-climatic, agronomic, production, etc) for both national and sub-national units

អ្នកប្រើប្រាស់កំណត់ពពកឃ្លាំមើលដំណាំដោយខ្លួនឯង

សូចនាករកំពស់ទឹកភ្លៀង	អតិបរមាVCI	សន្ទស្សន៍ភាពខុសគ្នាធម្មតារុក្ខជាតិ	លក្ខខណ្ឌដំណាំផ្អែកលើភាពមិនប្រក្រតីNDVI
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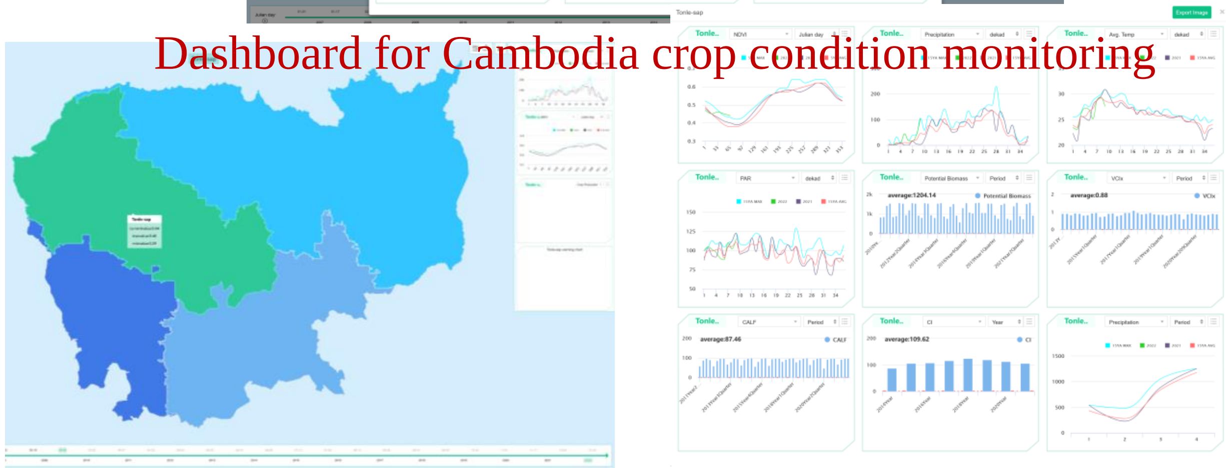
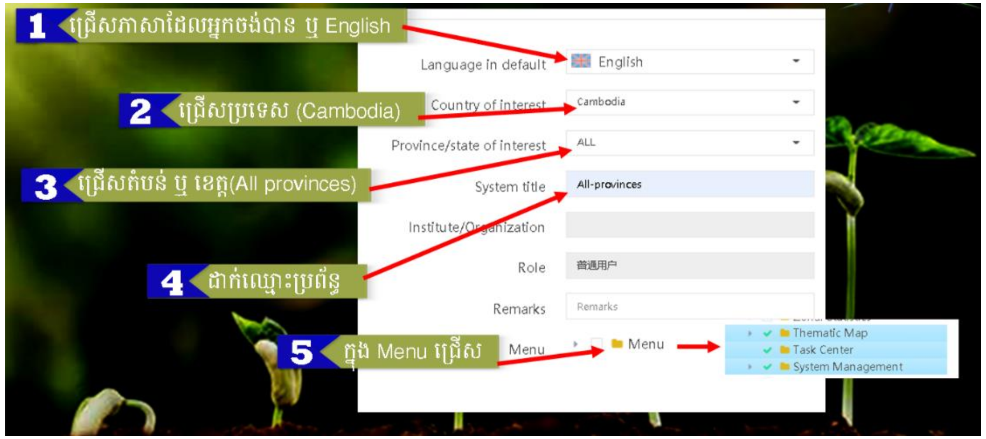
រំភាយរស្មីសកម្មរស្មីសំយោគ	ចំណាត់ថ្នាក់ដីដាំដុះដំណាំបាន	ប្រភាគនៃរំភាយរស្មីស្រូបដោយរស្មីសំយោគ	បណ្តុំលក្ខខណ្ឌដំណាំ
សក្តានុពលជីវម៉ាស	អាំងតង់ស៊ីតេដំណាំ	សន្ទស្សន៍ភាពខុសគ្នាធម្មតានៃទឹក	ចំណាត់ថ្នាក់លក្ខណ្ឌដំណាំ

Dashboard for Cambodia crop condition monitoring

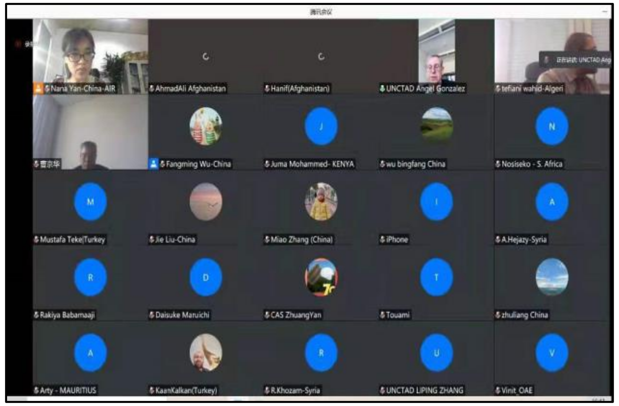


System configuration



CropWatch-ICP

- Launching at 23rd UNCTAD annual meeting
- Kickoff at 22 March 2021
- Online Training Workshop of Earth Observation Applications for crop Monitoring, coordinated by CTAD, for three months over 23 March- 25 May, 2021
- Participating countries: Nigeria, Zambia, Malawi, Mozambique, Kenya, South Africa, Lebanon, Turkey, Syria, Afghanistan, Iran, Laos, Myanmar, Thailand,
- Theory, Methodology and Application: 12 courses from invited experts and 6 courses from CropWatch team
- Online practices: Participants from Algeria, Myanmar, Nigeria, Syria, Thailand and Mauritius finished the country analysis for May Bulletin 2021



Regional workshop

- Coordinated by UNCTAD, for four days during 7- 10 AUG, 2023
- 27 trainees from 11 participating countries: Algeria, Cameroon, Ghana, Kenya, Lebanon, Malawi, Mauritius, Nigeria, Syria, Zambia, Zimbabwe
- Theory, Methodology and Application: courses from CropWatch team for in situ data collection, high resolution crop type mapping and area estimation
- Field work: GVG practice for sample collection

UNITED NATIONS
UNCTAD

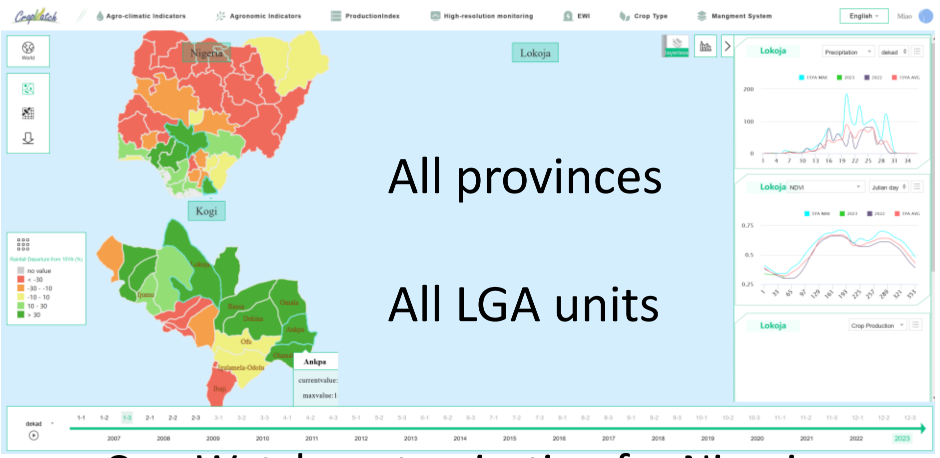
UNCTAD Regional training workshop for satellite crop monitoring using the CropWatch system, Mauritius, 7-10 August 2023

Regional workshop for west Africa

- Coordinated by UNCTAD, for four days during 2- 5 July, 2024
- 23 trainees from 8 participating countries: Nigeria, Cameroon, Ghana, Senegal, Niger, Mali, Burkina Faso, Liberia
- Field campaign was conducted for in situ data collection training
- CropWatch-ICP Regional Center at Nigeria was launched during the training workshop

Activities in Nigeria

- Activities
  - Implementation team
  - Work plan
  - All indicators for all provinces, and 775 LGA units available
  - Stakeholder meetings involving 11 agencies
- After trainings, NASRDA is able to carry out independent crop analysis for Nigeria since the end of 2021

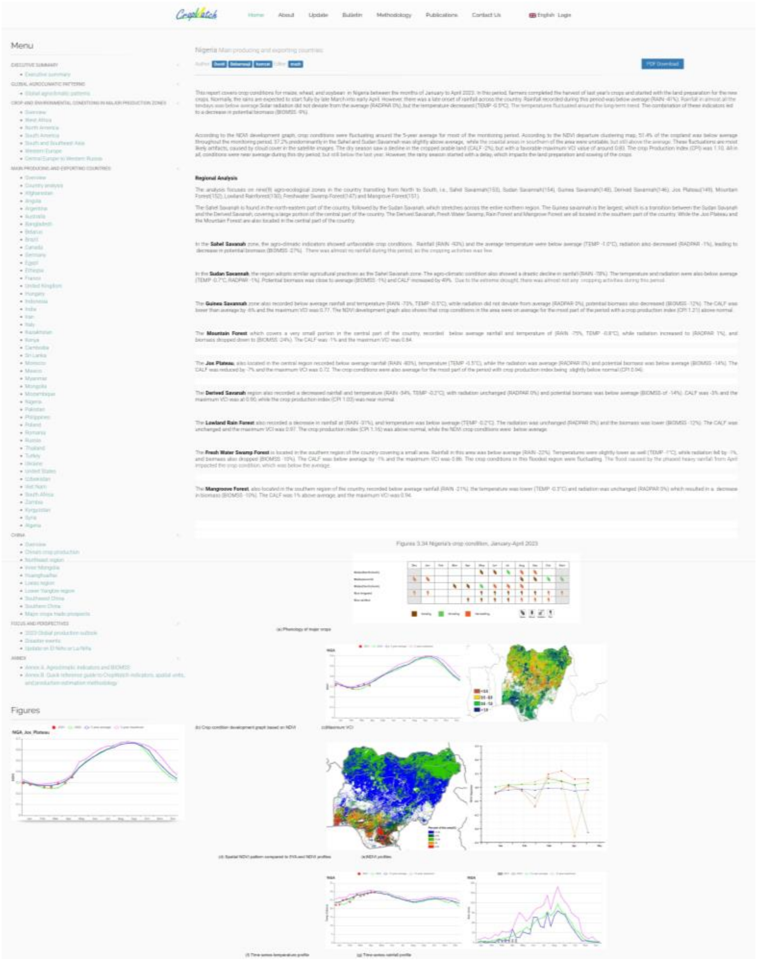


CropWatch customization for Nigeria

DATA FOR CROPWATCH Shared by NASRDA

S/N	Data	Source	Resolution	Coverage	Date	Size
1	Agro-Ecological Zone	IITA, Ibadan	Shapefile	Nigeria	2021	**0.253692 MB**
2	LULC	Landsat	30m	Nigeria	2000,2010,2020	**4.348 GB**
4	Multispectral Satellite Image	NigeriaSat-X (NASRDA)	22m (Green, Red, Blue and NIR)	Nigeria	2011	**4.0471 GB**
5	Multispectral Satellite Image	NigeriaSat-1 (NASRDA)	32m (Green Red and NIR bands)	Nigeria	2007	**13.0462 GB**
6	Nigeria Administrative Boundary	OSGOF	Shapefile	Nigeria	2021	**10.6502 MB**
7	Nigeria Soil	FAO	1000m	Nigeria	2011	**30.5527 MB**
8	Rainfall	TRMM	0.25 degrees	Africa	1989-2017	**27.1 MB**
9	SPOT		2.5m	Nigeria	2015	**294.6 GB Packed on Zip**
10	Wetlands	FAO	1000m	Nigeria	2020	**1.9866 GB**
11	Weather Stations	NIMET	Shapefile	Nigeria	2022	**0.00769329 MB**

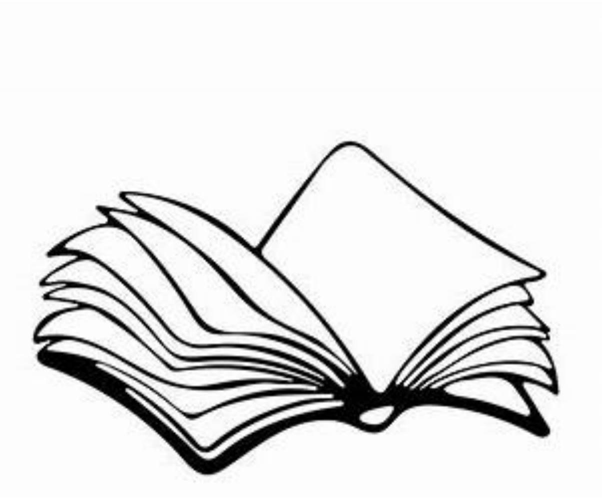
Data shared from NASRDA



Outline

UN GEONOW 2024
首届联合国地信周

- Background
- CropWatch programme
- Capacity building
- Outlook



CropWatch Vision

- Promoting ownership
  - Customized according to the specific demand for each country and work as a national/regional system
- Respecting privacy
  - 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

Steps to implement CropWatch

Support developing countries for implementation of UN SDG 2 zero hunger, to enhance geospatial tools and support for food security

- Requirements analysis, targeting crops, monitoring units
- 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

Sustainability

- However, sustainability is big issue after training. We need to find out solutions
  - Regional center
  - Fellowships: PIFI, ANSO,
  - Commitment, responsible for crop monitoring and early warning

THANK YOU