

Annex C. Quick reference to CropWatch indicators, spatial units, and production estimation methodology

The following sections give a brief overview of CropWatch indicators and spatial units, along with a description of the CropWatch production estimation methodology. For more information about CropWatch methodologies, visit CropWatch online at www.cropwatch.com.cn.

CropWatch indicators

The CropWatch indicators are designed to assess the condition of crops and the environment in which they grow and develop; the indicators—RAIN (for rainfall), TEMP (temperature), and RADPAR (photosynthetically active radiation, PAR)—are not identical to the weather variables, but instead are value-added indicators computed only over crop growing areas (thus for example excluding deserts and rangelands) and spatially weighted according to the agricultural production potential, with marginal areas receiving less weight than productive ones. The indicators are expressed using the usual physical units (e.g., mm for rainfall) and were thoroughly tested for their coherence over space and time. CWSU are the CropWatch Spatial Units, including MRUs, MPZ, and countries (including first-level administrative districts in select large countries). For all indicators, high values indicate "good" or "positive."

INDICATOR			
BIOMSS			
Biomass accumulation potential			
Crop/ Ground and satellite	Grams dry matter/m ² , pixel or CWSU	An estimate of biomass that could potentially be accumulated over the reference period given the prevailing rainfall and temperature conditions.	Biomass is presented as maps by pixels, maps showing average pixels values over CropWatch spatial units (CWSU), or tables giving average values for the CWSU. Values are compared to the average value for the last five years (2011-15), with departures expressed in percentage.
CALF			
Cropped arable land and cropped arable land fraction			
Crop/ Satellite	[0,1] number, pixel or CWSU average	The area of cropped arable land as fraction of total (cropped and uncropped) arable land. Whether a pixel is cropped or not is decided based on NDVI twice a month. (For each four-month reporting period, each pixel thus has 8 cropped/uncropped values).	The value shown in tables is the maximum value of the 8 values available for each pixel; maps show an area as cropped if at least one of the 8 observations is categorized as "cropped." Uncropped means that no crops were detected over the whole reporting period. Values are compared to the average value for the last five years (2011-15), with departures expressed in percentage.
CROPPING INTENSITY			
Cropping intensity Index			
Crop/ Satellite	Number of crops growing over a year for each pixel	Cropping intensity index describes the number of times the same hectare is used over a year. It is the ratio of the total crop area of all planting seasons in a year to the total area of arable land. It can be expressed as a dimensionless number (e.g., 1.85) or percentage (185%).	Cropping intensity is presented as maps by pixels or spatial average pixels values for MPZs, 31 countries, and 7 regions for China. Values are compared to the average of the previous five years, with departures expressed in percentage.

INDICATOR			
NDVI			
Normalized Difference Vegetation Index			
Crop/ Satellite	[0.12-0.90] number, pixel or CWSU average	An estimate of the density of living green biomass.	NDVI is shown as average profiles over time at the national level (cropland only) in crop condition development graphs, compared with previous year and recent five-year average (2011- 15), and as spatial patterns compared to the average showing the time profiles, where they occur, and the percentage of pixels concerned by each profile.
RADPAR			
CropWatch indicator for Photosynthetically Active Radiation (PAR), based on pixel based PAR			
Weather /Satellite	W/m ² , CWSU	The spatial average (for a CWSU) of PAR accumulation over agricultural pixels, weighted by the production potential.	RADPAR is shown as the percent departure of the RADPAR value for the reporting period compared to the recent fifteen-year average (2001-15), per CWSU. For the MPZs, regular PAR is shown as typical time profiles over the spatial unit, with a map showing where the profiles occur and the percentage of pixels concerned by each profile.
RAIN			
CropWatch indicator for rainfall, based on pixel-based rainfall			
Weather /Ground and satellite	Liters/m ² , CWSU	The spatial average (for a CWSU) of rainfall accumulation over agricultural pixels, weighted by the production potential.	RAIN is shown as the percent departure of the RAIN value for the reporting period, compared to the recent fifteen-year average (2001-15), per CWSU. For the MPZs, regular rainfall is shown as typical time profiles over the spatial unit, with a map showing where the profiles occur and the percentage of pixels concerned by each profile.
TEMP			
CropWatch indicator for air temperature, based on pixel-based temperature			
Weather /Ground	°C, CWSU	The spatial average (for a CWSU) of the temperature time average over agricultural pixels, weighted by the production potential.	TEMP is shown as the departure of the average TEMP value (in degrees Centigrade) over the reporting period compared with the average of the recent fifteen years (2001-15), per CWSU. For the MPZs, regular temperature is illustrated as typical time profiles over the spatial unit, with a map showing where the profiles occur and the percentage of pixels concerned by each profile.
VCIx			
Maximum vegetation condition index			
Crop/ Satellite	Number, pixel to CWSU	Vegetation condition of the current season compared with historical data. Values usually are [0,1], where 0 is "NDVI as bad as the worst recent year" and 1 is "NDVI as good as the best recent year." Values can exceed the range if the current year is the best or the worst.	VCIx is based on NDVI and two VCI values are computed every month. VCIx is the highest VCI value recorded for every pixel over the reporting period. A low value of VCIx means that no VCI value was high over the reporting period. A high value means that at least one VCI value was high. VCI is shown as pixel-based maps and as average value by CWSU.
VHI			
Vegetation health index			
Crop/ Satellite	Number, pixel to CWSU	The average of VCI and the temperature condition index (TCI), with TCI defined like VCI but for	Low VHI values indicate unusually poor crop condition, but high values, when due to low temperature, may be difficult to interpret. VHI is

INDICATOR			
		temperature. VHI is based on the assumption that "high temperature is bad" (due to moisture stress), but ignores the fact that low temperature may be equally "bad" (crops develop and grow slowly, or even suffer from frost).	shown as typical time profiles over Major Production Zones (MPZ), where they occur, and the percentage of pixels concerned by each profile.
VHIn			
Minimum Vegetation health index			
Crop/Satellite	Number, pixel to CWSU	VHIn is the lowest VHI value for every pixel over the reporting period. Values usually are [0, 100]. Normally, values lower than 35 indicate poor crop condition.	Low VHIn values indicate the occurrence of water stress in the monitoring period, often combined with lower than average rainfall. The spatial/time resolution of CropWatch VHIn is 16km/week for MPZs and 1km/dekad for China.

Note: Type is either "Weather" or "Crop"; source specifies if the indicator is obtained from ground data, satellite readings, or a combination; units: in the case of ratios, no unit is used; scale is either pixels or large scale CropWatch spatial units (CWSU). Many indicators are computed for pixels but represented in the CropWatch bulletin at the CWSU scale.

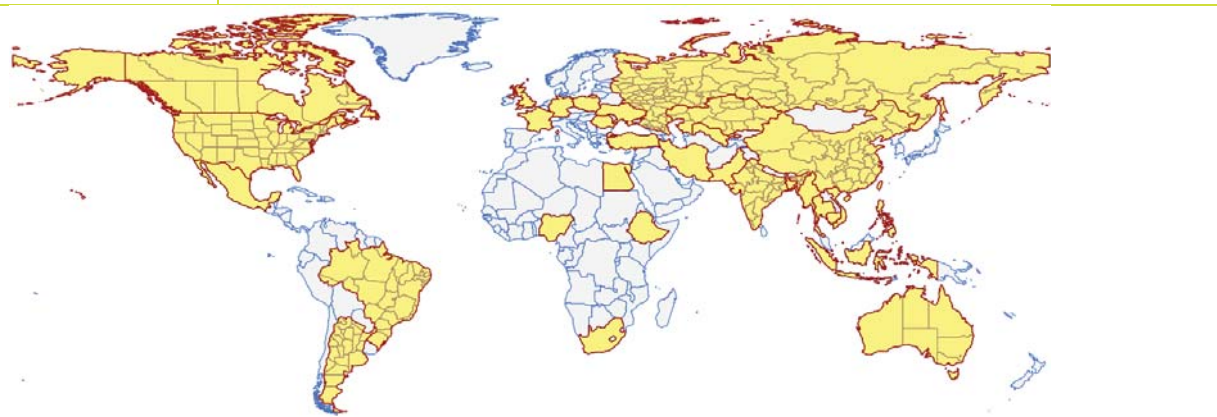
CropWatch spatial units (CWSU)

CropWatch analyses are applied to four kinds of CropWatch spatial units (CWSU): Countries, China, Major Production Zones (MPZ), and global crop Monitoring and Reporting Units (MRU). The tables below summarize the key aspects of each spatial unit and show their relation to each other. For more details about these spatial units and their boundaries, see the CropWatch bulletin online resources.

SPATIAL LUNITS	
CHINA	
Overview	Description
Seven monitoring regions	The seven regions in China are agro-economic/agro-ecological regions that together cover the bulk of national maize, rice, wheat, and soybean production. Provinces that are entirely or partially included in one of the monitoring regions are indicated in color on the map below.

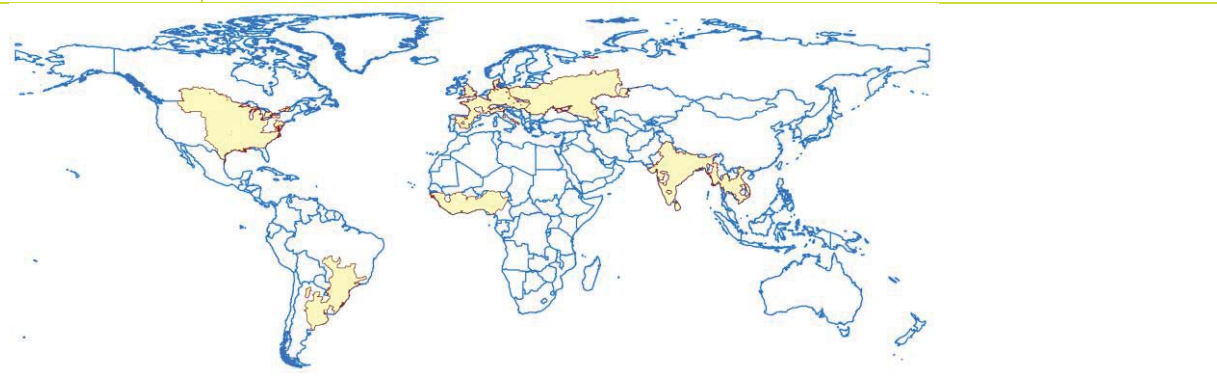
Countries (and first-level administrative districts, e.g., states and provinces)

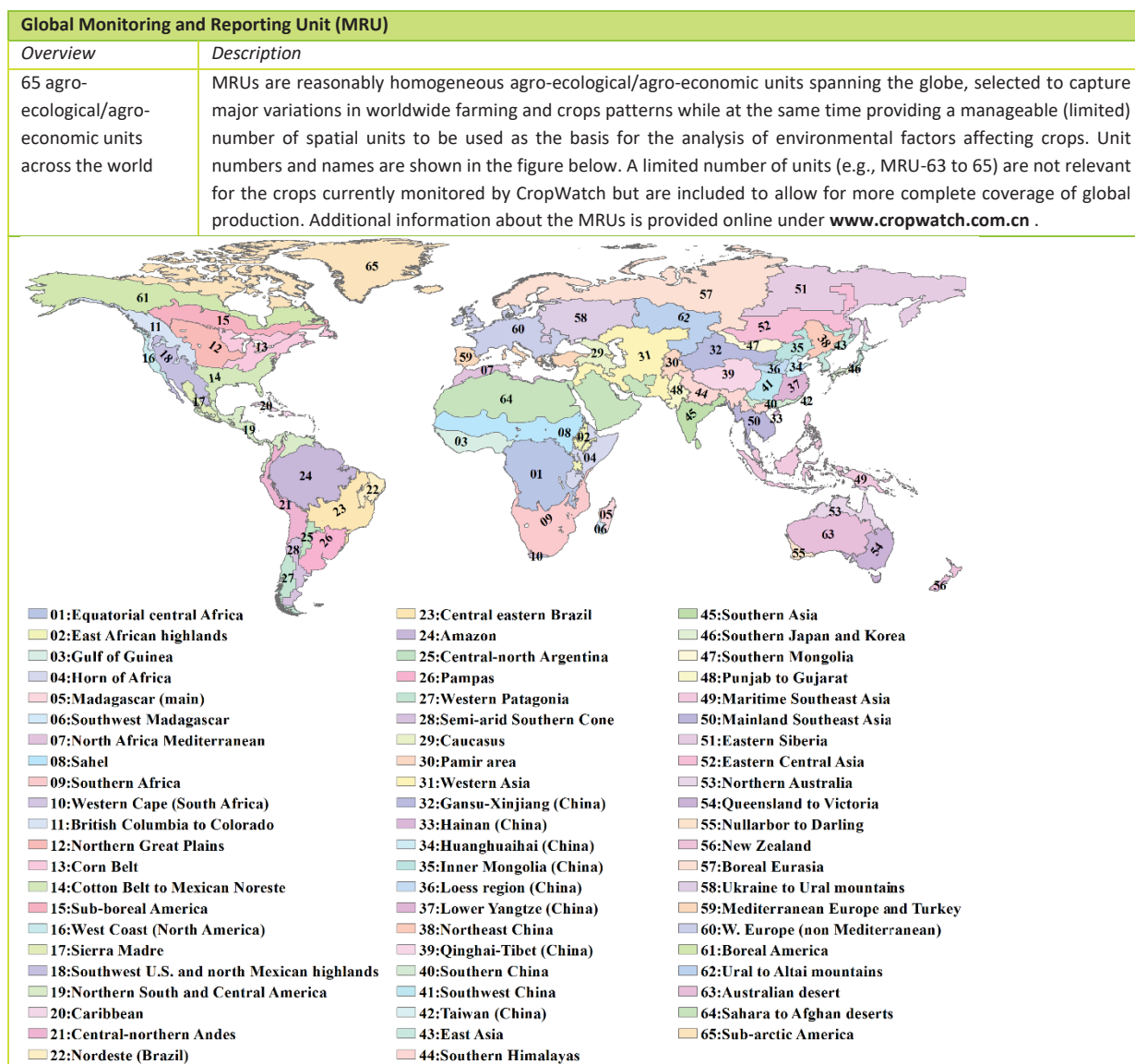
Overview	Description
<p>“Thirty plus one” countries to represent main producers/exporters and other key countries.</p>	<p>CropWatch monitored countries together represent more than 80% of the production of maize, rice, wheat and soybean, as well as 80% of exports. Some countries were included in the list based on criteria of proximity to China (Uzbekistan, Cambodia), regional importance, or global geopolitical relevance (e.g., four of five most populous countries in Africa). The total number of countries monitored is “thirty plus one,” referring to thirty countries and China itself. For the nine largest countries—, United States, Brazil, Argentina, Russia, Kazakhstan, India, China, and Australia, maps and analyses may also present results for the first-level administrative subdivision. The CropWatch agroclimatic indicators are computed for all countries and included in the analyses when abnormal conditions occur. Background information about the countries’ agriculture and trade is available on the CropWatch Website, www.cropwatch.com.cn.</p>



Major Production Zones (MPZ)

Overview	Description
<p>Seven globally important areas of agricultural production</p>	<p>The six MPZs include West Africa, South America, North America, South and Southeast Asia, Western Europe and Central Europe to Western Russia. The MPZs are not necessarily the main production zones for the four crops (maize, rice, soybean, wheat) currently monitored by CropWatch, but they are globally or regionally important areas of agricultural production. The seven zones were identified based mainly on production statistics and distribution of the combined cultivation area of maize, rice, wheat and soybean.</p>





Production estimation methodology

The main concept of the CropWatch methodology for estimating production is the calculation of current year production based on information about last year's production and the variations in crop yield and cultivated area compared with the previous year. The equation for production estimation is as follows:

$$Production_i = Production_{i-1} * (1 + \Delta Yield_i) * (1 + \Delta Area_i)$$

Where i is the current year, $\Delta Yield_i$ and $\Delta Area_i$ are the variations in crop yield and cultivated area compared with the previous year; the values of $\Delta Yield_i$ and $\Delta Area_i$ can be above or below zero.

For the 31 countries monitored by CropWatch, yield variation for each crop is calibrated against NDVI time series, using the following equation:

$$\Delta Yield_i = f(NDVI_i, NDVI_{i-1})$$

Where $NDVI_i$ and $NDVI_{i-1}$ are taken from the time series of the spatial average of NDVI over the crop specific mask for the current year and the previous year. For NDVI values that correspond to periods after the current monitoring period, average NDVI values of the previous five years are used as an average expectation. $\Delta Yield_i$ is calculated by regression against average or peak NDVI (whichever yields the best regression), considering the crop phenology of each crop for each individual country.

A different method is used for areas. For China, CropWatch combines remote-sensing based estimates of the crop planting proportion (cropped area to arable land) with a crop type proportion (specific type area to total cropped area). The planting proportion is estimated based on an unsupervised classification of high resolution satellite images from HJ-1 CCD and GF-1 images. The crop-type proportion for China is obtained by the GVG instrument from field transects. The area of a specific crop is computed by multiplying farmland area, planting proportion, and crop-type proportion of the crop.

To estimate crop area for wheat, soybean, maize, and rice outside China, CropWatch relies on the regression of crop area against cropped arable land fraction of each individual country (paying due attention to phenology):

$$Area_i = a + b * CALF_i$$

where a and b are the coefficients generated by linear regression with area from FAOSTAT or national sources and CALF the Cropped Arable Land Fraction from CropWatch estimates. $\Delta Area_i$ can then be calculated from the area of current and the previous years.

The production for "other countries" (outside the 31 CropWatch monitored countries) was estimated as the linear trend projection for 2014 of aggregated FAOSTAT data (using aggregated world production minus the sum of production by the 31 CropWatch monitored countries).

Data notes and bibliography

- ACAPS, <https://www.acaps.org/>.
- China Meteorological Administration (CMA),
<http://www.scio.gov.cn/xwfbh/gbwxwfbh/xwfbh/qxj/Document/1473467/1473467.htm>).
- Climate gov. 2016. <https://www.climate.gov/sites/default/files/geopolar-ssta-monthly-nnvl--1000X555--2016-07-00.png> and
<https://www.climate.gov/enso>.
- CRED: <http://www.cred.be/>.
- Disaster report, <http://www.disaster-report.com/>.
- FAO, 2016. Global map of irrigated agriculture, GMIA, version 4.0.1.
<http://www.fao.org/nr/water/aquastat/irrigationmap/index.stm>.
- FAO, 2017. Global Administrative Units Layers (GAUL).
<http://www.fao.org/geonetwork/srv/en/metadata.show?currTab=simple&id=12691>.
- FAOSTAT, <http://faostat3.fao.org/faostat-gateway/go/to/home/E>.
- GEO5 2012. Global environmental outlook: environment for the future we want. UNEP, Nairobi. 528 pp.
- GMIA, 2017. Global map of irrigated areas, available from <http://www.fao.org/nr/water/aquastat/irrigationmap/index10.stm>.
- Guardian, <https://www.theguardian.com/world/natural-disasters?page=1>.
- Hallegette, Stephane; Vogt-Schilb, Adrien; Bangalore, Mook; Rozenberg, Julie. 2017. Unbreakable : Building the Resilience of the Poor in the Face of Natural Disasters. Climate Change and Development; Washington, DC: World Bank. World Bank.
<https://openknowledge.worldbank.org/handle/10986/25335>.
- Hendrix, C and Brinkman, H 2013 Food Insecurity and Conflict Dynamics: Causal Linkages and Complex Feedbacks. Stability: International Journal of Security & Development, 2(2): 26, pp. 1-18, DOI: <http://dx.doi.org/10.5334/sta.bm>.
- Irin, <http://www.irinnews.org/>.
- Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel. 2006: World Map of Köppen-Geiger Climate Classification updated. Meteorol. Z., 15, 259-263. The map used in this note is based on 1971 to 2000 data.
- Kriticos, D.J., Webber, B.L., Leriche, A., Ota, N., Macadam, I., Bathols, J. & Scott, J.K. (2012) CliMond: global high resolution historical and future scenario climate surfaces for bioclimatic modelling. Methods in Ecology & Evolution 3: 53-64. DOI: 10.1111/j.2041-210X.2011.00134.x.
- NOAA, Snow Cover Maps, <https://www.ncdc.noaa.gov/snow-and-ice/snow-cover/>.
- RCRC 2008. Public health guide for emergencies. The Johns Hopkins and the International Federation of Red Cross and Red Crescent Societies, Geneva, Switzerland. 603 pp. http://www.jhsph.edu/research/centers-and-institutes/center-for-refugee-and-disaster-response/publications_tools/publications/_CRDR_ICRC_Public_Health_Guide_Book/Forward.pdf.
- Reliefweb <http://reliefweb.int/> and <http://reliefweb.int/map/mongolia/mongolia-dzud-response-planning-22-december-2016>.
- Unitar, United Nations Institute for Training and Research. Population Exposure Heavy Rains in Mozambique and Zimbabwe, January 2017, http://unosat-maps.web.cern.ch/unosat-maps/MZ/FL20170118MOZ/UNOSAT_Pop_Exposure_Analysis_FL20170118MOZ_Mozambique_Zimbabwe.pdf;
<http://www.unitar.org/unosat/maps/MOZ>.
- Vancutsem, C., Marinho, E., Kayitakire, F., See, L., & Fritz, S. . 2013. Harmonizing and combining existing land cover/land use datasets for cropland area monitoring at the African continental scale. Remote Sensing,5(1), 19-41.
- Wikipedia, https://en.wikipedia.org/wiki/Hurricane_Matthew; [https://en.wikipedia.org/wiki/Typhoon_Sarika_\(2016\)](https://en.wikipedia.org/wiki/Typhoon_Sarika_(2016));
[https://en.wikipedia.org/wiki/Typhoon_Nock-ten_\(2016\)](https://en.wikipedia.org/wiki/Typhoon_Nock-ten_(2016)).
- World Bank, 2016, <http://data.worldbank.org/indicator>.
- Zomer R J, Trabucco A, Bossio D A, Verchot L V. 2008. Climate change mitigation: A spatial analysis of global land suitability for clean development mechanism afforestation and reforestation. Agriculture, Ecosystems and Environment 126:67–80.
- Zomer, R. J.; Trabucco, A.; van Straaten, O.; Bossio, D. A. 2006. Carbon, land and water: A global analysis of the hydrologic dimensions of climate change mitigation through afforestation/reforestation. Colombo, Sri Lanka: International Water Management Institute. 44p. (IWMI Research Report 101). <http://www.cgiar-csi.org/wp-content/uploads/2012/11/Zomer-et-al-2007-A-Global-Analysis-of-the-Hydrologic-Dimensions-of-Climate-Change-Mitigation-through-Afforestation-and-Reforestation.pdf>.

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Online resources



This bulletin is only part of the CropWatch resources available. Visit www.cropwatch.com.cn for access to additional resources, including the methods behind CropWatch, country profiles, and other CropWatch publications. For additional information or to access specific data or high-resolution graphs, simply contact the CropWatch team at cropwatch@radi.ac.cn.

Online Resources posted on www.cropwatch.com.cn:

- ✓ **Definition of spatial units**
A description of the four spatial levels of analysis: Monitoring and Reporting Units (MRU), Major Production Zones (MPZ), selected countries, and the use of sub-national administrative areas.
- ✓ **Methodology**
Overview of CropWatch data sources and methods.
- ✓ **Time series of indicators**
Background data on agroclimatic indicators presented in a series of tables.
- ✓ **Country profiles**
Short profiles for each of the 30 countries and China highlighting key facts of interest to agriculture.
- ✓ **Country long term trends**
Quick overview of average crop area, yield, and production values for maize, rice, soybean, and wheat for recent years, along with long-term (2001-12) trends (based on FAOSTAT data).

CropWatch bulletins introduce the use of several new and experimental indicators. We would be very interested in receiving feedback about their performance in other countries. With feedback on the contents of this report and the applicability of the new indicators to global areas, please contact:

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