

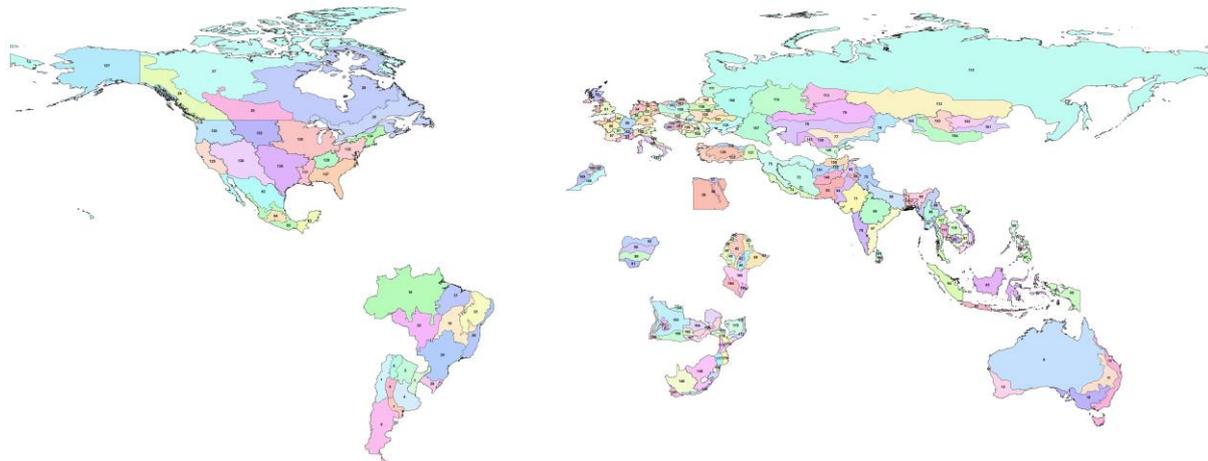
## Annex C. Quick reference to CropWatch indicators, spatial units and methodologies

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](http://www.cropwatch.com.cn).

### **Sub-national regions for 31 key countries**

#### ***Overview***

42 key agricultural countries are divided into 197 sub-national regions based on cropping systems, climatic zones, and topographic conditions. Each country is considered separately. A limited number of regions (e.g., region 001, region 031, and region 122) are not relevant for the crops currently monitored by CropWatch but are included to allow for more complete coverage of the 42 key countries. Some regions are more relevant for rangeland and livestock monitoring which is also essential for food security.



- |   |   |  |   |
|---|---|--|---|
| 001. Andes  | 050. Western mixed maize zone   | 099. Lowlands  | 148. Dry Highveld and Bushveld maize areas              |
| 002. Chaco  | 051. Dry Massif Central zone  | 100. Central rye and potatoes area                         | 149. Dry region   |
| 003. Mesopotamia  | 052. Eastern Alps region  | 101. Northern oats and potatoes areas                      | 150. Mixed dry farming and irrigated cultivation region |
| 004. Pampas   | 053. Mediterranean zone   | 102. Northern-central wheat and sugarbeet area             | 151. Mixed dry farming and grazing region               |
| 005. Pampas hills   | 054. Northern barley zone   | 103. Southern wheat and sugarbeet area                     | 152. Central region with sparse vegetation              |
| 006. Arid part of Patagonia                                 | 055. Maize, barley and livestock zone along the English Channel                 | 104. Central mixed farming and pasture Carpathian hills    | 153. Sub-humid zone                                     |
| 007. Dry Pampas   | 056. Rapeseed zone of eastern France  | 105. Eastern and southern maize wheat and sugarbeet plains | 154. Arid zone  |
| 008. Subtropical highlands                                  | 057. Southwest maize zone   | 106. Western and central maize wheat and sugarbeet plateau | 155. Arid Zone  |
| 009. Arid and semiarid zone                                 | 058. Mixed maize/barley and rapeseed zone from the Centre to the Atlantic Ocean | 107. The Caucasus  | 156. Semi-Arid Zone                                     |
| 010. Southeastern wheat area                                | 059. Sparse crop area of N England, Wales and N. Ireland                        | 108. Central Economic Region                               | 157. Desert zone  |
| 011. Subhumid subtropical zone                              | 060. Barley area in Scotland  | 109. Kaliningrad oblast                                    | 158. Central Belarus                                    |
| 012. Southwest wheat area                                   | 061. South English mixed wheat and Barley zone                                  | 110. Subarctic region                                      | 159. Northern Belarus                                   |
| 013. Wet temperate and subtropical zone                     | 062. Java   | 111. Northwest region including Novgorod                   | 160. Southern Belarus                                   |
| 014. Coastal region   | 063. Kalimantan and Sulawesi  | 112. Southern Siberian area                                | 161. Central and Eastern Steppe Region                  |
| 015. Gangetic plain   | 064. Sumatra  | 113. Southern Urals  | 162. Selenge-Onon Region                                |
| 016. Hills  | 065. West Papua   | 114. Volga Basin   | 163. Hangai Khuvsgul Region                             |
| 017. Sylhet basin   | 066. Deccan Plateau   | 115. Central double and triple-cropped rice lowlands       | 164. Gobi Desert Region                                 |
| 018. Amazonas   | 067. Eastern coastal region   | 116. South-eastern horticulture area                       | 165. Altai Region                                       |
| 019. Central Savanna  | 068. Gangatic plain   | 117. Western and southern hill areas                       | 166. Arid area of Morocco                               |
| 020. East coast   | 069. Assam and north-eastern regions  | 118. Single-cropped rice north-eastern region              | 167. Cool subhumid zones                                |
| 021. Northeastern mixed forest and farmland                 | 070. Western coastal region   | 119. Black Sea region                                      | 168. Warm subhumid zones                                |
| 022. Mato Grosso  | 071. North-western dry region or Rajasthan and Gujarat                          | 120. Central Anatolia region                               | 169. Warm semiarid zones                                |
| 023. Nordeste   | 072. Western Himalayan region   | 121. Eastern Anatolia region                               | 170. Northern hinterland of Cabo Delgado                |
| 024. Parana basin   | 073. Central and Eastern wasteland region                                       | 122. Marmara Aegean Mediterranean lowland region           | 171. High altitude areas                                |
| 025. Southern subtropical rangelands                        | 074. Arid Red Sea coastal low hills and plains                                  | 123. Central wheat area                                    | 172. Mid-altitude areas                                 |
| 026. Saint Lawrence basin                                   | 075. Semi-arid to sub-tropical hills of the west and the north                  | 124. Eastern Carpathian hills                              | 173. North Coastal areas                                |
| 027. Arctic Ocean (Canada)                                  | 076. Central non-agriculture region   | 125. Northern wheat area                                   | 174. Dry areas of Zambia and Southern Tete              |
| 028. Hudson Bay   | 077. South zone   | 126. Southern wheat and maize area                         | 175. Low altitude areas of Sofala and Zambezia          |
| 029. Western Canada   | 078. Eastern plateau and southeastern zone                                      | 127. Alaska and Hawaii                                     | 176. Central medium altitude areas                      |
| 030. Prairies   | 079. Northern zone  | 128. Blue Grass region                                     | 177. North and Central Gaza and Western Inhambane       |
| 031. Sparse crop area of the east-German lake and Heathland | 080. Central Torle-Sap plain  | 129. California  | 178. Coastal areas and South of Save                    |
| 032. Central wheat zone of Saxony and Thuringia             | 081. Upland areas   | 130. Com Belt  | 179. Inland of Maputo and Southern Gaza                 |
| 033. Wheat zone of Schleswig-Holstein and the Baltic coast  | 082. Arid and semi-arid regions   | 131. Lower Mississippi                                     | 180. Transdanubia                                       |
| 034. Mixed wheat and sugarbeets zone of the north-west      | 083. Humid tropics with summer rainfall   | 132. Middle Atlantic                                       | 181. Great Plain  |
| 035. Bavarian Plateau                                       | 084. Sub-humid temperate region with summer rains                               | 133. Northern Plains                                       | 182. North Hungary                                      |
| 036. Western sparse crop area of the Rhenish massif         | 085. Sub-humid hot tropics with summer rains                                    | 134. Northeast   | 183. Central Hungary                                    |
| 037. Nile Delta and Mediterranean coastal strip             | 086. Central plain  | 135. Northwest   | 184. Southwest of Kenya                                 |
| 038. Nile Valley  | 087. Delta and southern-coast   | 136. Southern Plains                                       | 185. Northern region with sparse vegetation             |
| 039. Desert   | 088. Hills  | 137. Southeast   | 186. Eastern Coastal Area                               |
| 040. Central-northern maize-teff highlands                  | 089. Derived savanna zone   | 138. Southwest   | 187. Southern Italy                                     |
| 041. Eastern arid   | 090. Guinean savanna  | 139. Central region with sparse crops                      | 188. Northern Italy                                     |
| 042. Northern Arid  | 091. Humid forest zone  | 140. Eastern hilly cereals zone                            | 189. Western Italy                                      |
| 043. North-western cereal-root-sesame lowlands              | 092. Soudano-Sahelian zone  | 141. Aral Sea cotton zone                                  | 190. Eastern Italy                                      |
| 044. North-western sesame irrigated lowlands                | 093. Balochistan  | 142. Central coastal areas from Thanh Hoa to Khanh Hoa     | 191. Dry Zone   |
| 045. North-western semi-arid lowlands                       | 094. Lower Indus river basin in south Punjab and Sind                           | 143. Northern zone with RED river Delta                    | 192. Wet Zone of Sri Lanka                              |
| 046. South-eastern mixed maize zone                         | 095. Northern highlands   | 144. Southern zone with Mekong Delta                       | 193. Intermediate Zone                                  |
| 047. South-eastern Mendebo highlands                        | 096. Northern Punjab  | 145. Arid and desert zones                                 | 194. Northern high rainfall zone                        |
| 048. Semi-arid pastoral                                     | 097. Forest area  | 146. Humid Cape Fold mountains                             | 195. Western semi-arid plain                            |
| 049. South-western coffee-onset highlands                   | 098. Hills  | 147. Mediterranean zone                                    | 196. Central, Eastern and Southern Plateau              |
|   |   |  | 197. Luanguwa Zambezi rift valley                       |

### 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			
<b>BIOMSS</b>			
<b>Biomass accumulation potential</b>			
Crop/ Ground and satellite	Grams dry matter/m <sup>2</sup> , 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 (2012-2016), with departures expressed in percentage.
<b>CALF</b>			
<b>Cropped arable land and cropped arable land fraction</b>			
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 (2012-2016), with departures expressed in percentage.
<b>CROPPING INTENSITY</b>			
<b>Cropping intensity Index</b>			
Crop/ Satellite	0, 1, 2, or 3; Number of crops growing over a year for each pixel	Cropping intensity index describes the extent to which arable land 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.	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.
<b>NDVI</b>			
<b>Normalized Difference Vegetation Index</b>			
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 (2012-2016), and as spatial patterns compared to the average showing the time profiles, where they occur, and the percentage of pixels concerned by each profile.
<b>RADPAR</b>			
<b>CropWatch indicator for Photosynthetically Active Radiation (PAR), based on pixel based PAR</b>			
Weather /Satellite	W/m <sup>2</sup> , 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 (2002-2016), 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.
<b>RAIN</b>			
<b>CropWatch indicator for rainfall, based on pixel-based rainfall</b>			
Weather /Ground and satellite	Liters/m <sup>2</sup> , 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 (2002-16), 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.

INDICATOR			
<b>TEMP</b>			
<b>CropWatch indicator for air temperature, based on pixel-based temperature</b>			
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 (2002-16), 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.
<b>VCIx</b>			
<b>Maximum vegetation condition index</b>			
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.
<b>VHI</b>			
<b>Vegetation health index</b>			
Crop/Satellite	Number, pixel to CWSU	The average of VCI and the temperature condition index (TCI), with TCI defined like VCI but for 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).	Low VHI values indicate unusually poor crop condition, but high values, when due to low temperature, may be difficult to interpret. VHI is shown as typical time profiles over Major Production Zones (MPZ), where they occur, and the percentage of pixels concerned by each profile.
<b>VHIn</b>			
<b>Minimum Vegetation health index</b>			
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 UNITS	
<b>CHINA</b>	
<i>Overview</i>	<i>Description</i>

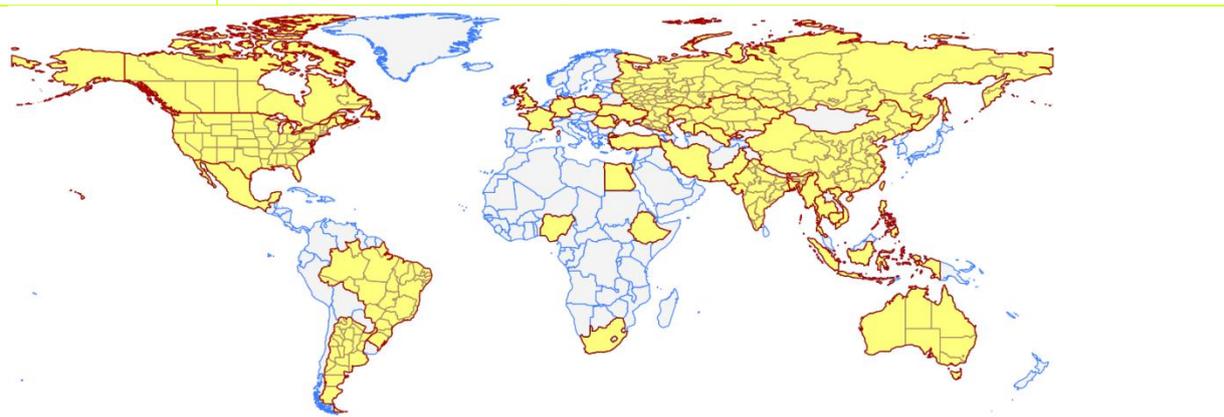
Seven monitoring regions

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.

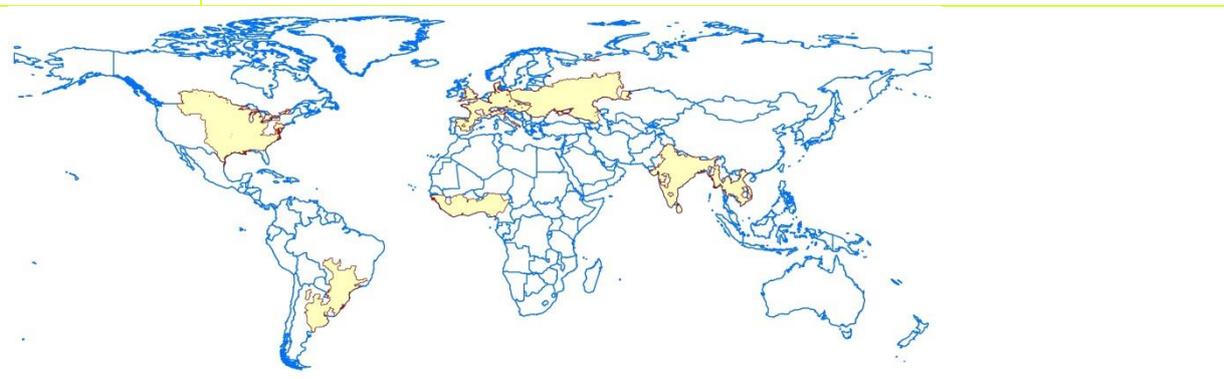


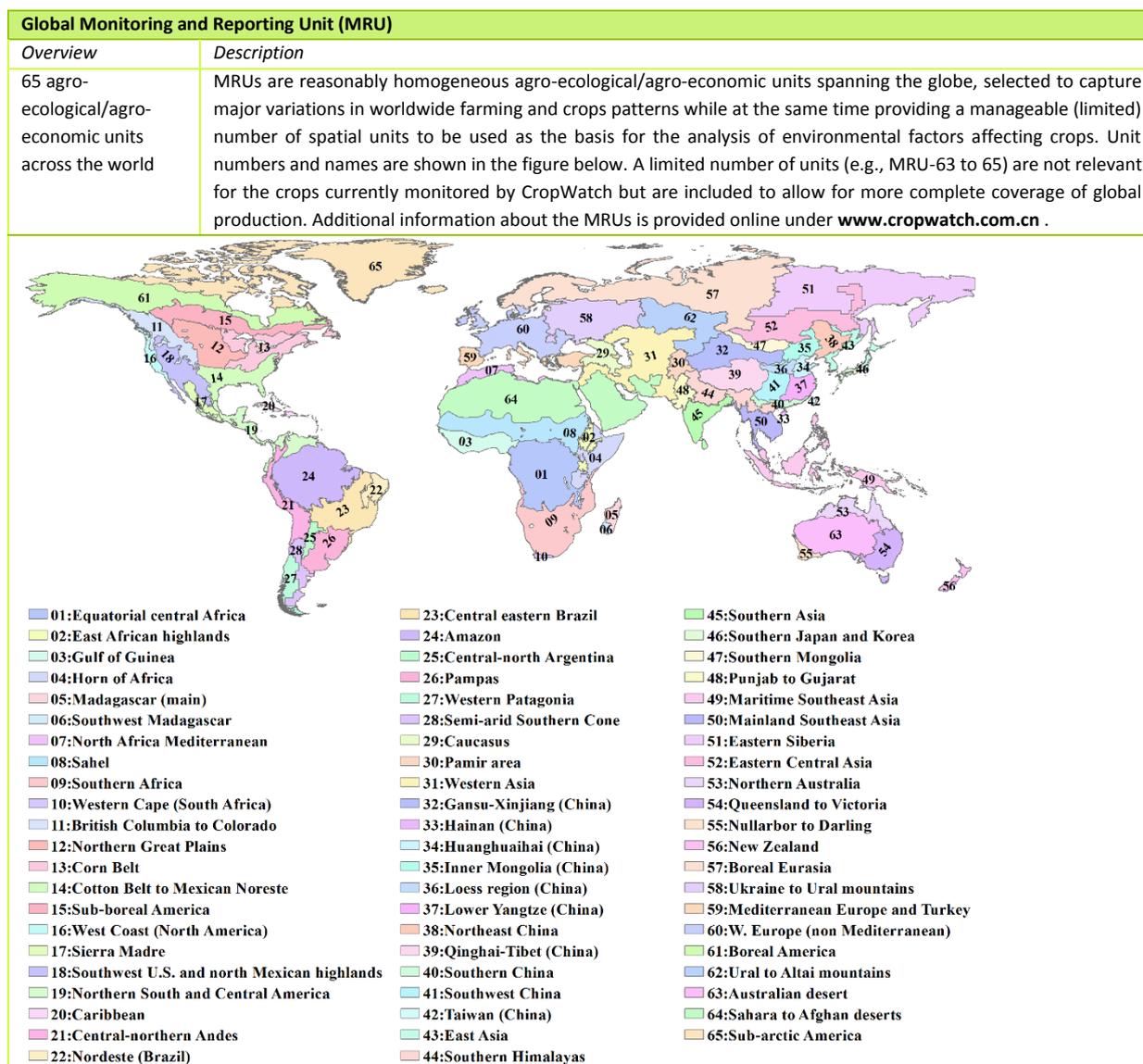
**Countries (and first-level administrative districts, e.g., states and provinces)**

<i>Overview</i>	<i>Description</i>
<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, <a href="http://www.cropwatch.com.cn">www.cropwatch.com.cn</a>.</p>

**Major Production Zones (MPZ)**

<i>Overview</i>	<i>Description</i>
<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).

### Classification of pests and diseases

The criteria for the classification of pests and diseases in this report are based on industry standards and plant protection survey and evaluation specifications issued by the Chinese Ministry of Agriculture, combined with crop growth information and conditions obtained through remote sensing.

Table C.1 presents the criteria for determining the level of wheat yellow rust occurrence, which is based on the "Rules for the investigation and forecast of wheat yellow rust" (GB/T15795-2011). Based on this standard, a disease index model was established, integrating the remote sensing disease data and in-field survey disease data. The term "mildly severe" used in this report to describe the occurrence of wheat yellow rust corresponds with levels 1 and 2, while "moderately severe" refers to level 3, and "severe" comprises levels 4 and 5.

**Table C.1. Criteria for wheat yellow rust occurrence level**

Index	Level				
	1	2	3	4	5
Disease index	0.001<Y≤5	5<Y≤10	10<Y≤20	20<Y≤30	Y>30
Disease field rate/%	1<R≤5	5<R≤10	10<R≤20	20<R≤30	R>30

*Note:* In the table, Y is the disease index; it shows the impact of the disease and is defined as:  $Y=F*D*100$ , in which F is the rate of disease leaves and D is the average of the severity level of disease leaves. R is the disease field rate, which means the rate of disease field in the whole region.

*Source:* Standardization Administration of China, Rules for the investigation and forecast of wheat yellow rust (GB/T 15795-2011), 2011. <http://doc.mbalib.com/view/2e0ae53c7f397af70deb37edb07c5a12.html>

Tables C.2 and C.3 respectively list the criteria for wheat sheath blight (table C.2 and based on the "Rules for the investigation and forecast of wheat sheath blight" (NY/T614-2002)) and wheat aphid (table C.3, following "Rules for the investigation and forecast of wheat aphid" (NY/T612-2002)). The terms mildly severe, moderately severe, and severe—as used in this report—again refer to levels 1-2, 3, and 4-5 in the table.

**Table C.2. Criteria for wheat sheath blight occurrence level**

Index	Level				
	1	2	3	4	5
Disease index	$Y \leq 5$	$5 < Y \leq 15$	$15 < Y \leq 25$	$25 < Y \leq 35$	$Y > 35$

Source: Standardization Administration of China, Rules for the investigation and forecast of wheat sheath blight (NY/T614-2002), 2002. <http://doc.mbalib.com/view/4c9d23d380f36d038af855fcdf089f93.html>

**Table C.3. Criteria for wheat aphid occurrence level**

Index	Level				
	1	2	3	4	5
Aphid (heads/ hundred plants, Y)	$Y \leq 500$	$500 < Y \leq 1500$	$1500 < Y \leq 2500$	$2500 < Y \leq 3500$	$Y > 3500$

Source: Standardization Administration of China, Rules for the investigation and forecast of wheat aphid (NY/T612-2002), 2002. <http://www.doc88.com/p-7708315673411.html>

## Data notes and bibliography

### Notes

- [1] Although Yemen is not part of the Horn of Africa (HoA), it is geographically close and maintains close links to the region. The countries of the HoA are grouped in the regional development association IGAD (Inter-governmental Authority on Development, with headquarters in Djibouti). IGAD has recently established the IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI, 2016).
- [2] Under-investment in agriculture was one of the main drivers of the 2008 crisis of high food prices (Mittal 2009, ATV 2010), even if several other local and global triggering factors can be identified (Evans 2008).
- [3] Previous large humanitarian crises were those of the West African Sahel (from the early sixties to the mid eighties), the Ethiopian droughts of the mid-eighties, the Indian Ocean tsunami of 2004, several large earthquakes (for example, Haiti, 2010), and floods and medical emergencies (such as the West African Ebola outbreak, 2013-16).
- [4] <http://www.agrhymet.ne/eng/index.html>
- [5] <http://www.icpac.net/>
- [6] Belg is harvested before or during July.
- [7] "Purely man-made disasters" is, however, a concept that deserves a closer look, as many wars and insurgencies are partially triggered by shortages of natural resources, including land. As such, most "man-made disasters" do have an environmental component.

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## Online resources

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### **Online Resources posted on [www.cropwatch.com.cn](http://www.cropwatch.com.cn)**

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CropWatch bulletin introduces 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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