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**.**

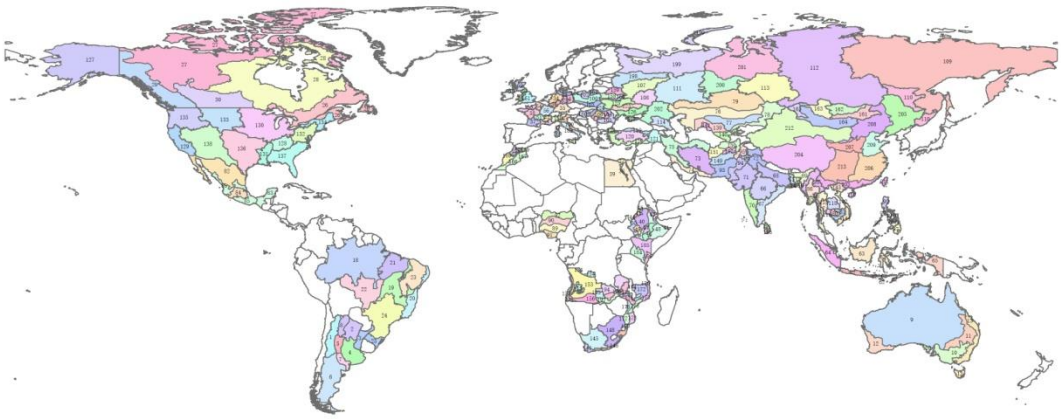
Agroecological zones for 42 key countries

Overview

213 agroecological zones for the 42 key countries across the globe

Description

42 key agricultural countries are divided into 213 agro-ecological zones based on cropping systems, climatic zones, and topographic conditions. Each country is considered separately. A limited number of regions (e.g., region 001, region 027, and region 127) 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
002. Chaco
003. Mesopotamia
004. Humid Pampas
005. Pampas hills
006. Arid part of Patagonia
007. Dry Pampas
008. Subtropical highlands
009. Arid and semiarid zone
010. Southeastern wheat area
011. Subhumid subtropical zone
012. Southwestern wheat area
013. Wet temperate and subtropical zone
014. Coastal region
015. Gangetic plain
016. Hills
017. Sylhet basin
018. Amazonas
019. Central Savanna
020. Coast
021. Northeastern mixed forest and farmland
022. Mato Grosso
023. Nordeste
024. Parana basin
025. Southern subtropical rangelands
026. Saint Lawrence basin
027. Arctic
028. Hudson Bay
029. Western Canada
030. Prairies
031. East-German lake and Heathland sparse crop area
032. Central wheat zone of Saxony and Thuringia
033. Wheat zone of Schleswig-Holstein and the Baltic coast
034. Mixed wheat and sugarbeets zone of the north-west
035. Bavarian Plateau
036. Western sparse crop area of the Rhenish massif
037. Nile Delta and Mediterranean coastal strip
038. Nile Valley
039. Desert
040. Central-northern maize-teff highlands
041. Eastern arid area
042. Northern Arid area
043. North-western cereal-root-sesame lowlands
044. North-western sesame irrigated lowlands
045. North-western semi-arid lowlands
046. South-eastern mixed maize zone
047. South-eastern Wendebo highlands
048. Semi-arid pastoral areas
049. South-western coffee-enset highlands
050. Western mixed maize zone
051. Massid Central dry zone
052. Alpes region
053. Mediterranean zone
054. Northern barley zone
055. Maize_barley and livestock zone along the English Channel
056. Rapeseed zone of eastern France
057. Southwest maize zone
058. Mixed maize_barley and rapessed zone from the Centre to the Atlantic Ocean
059. North England, Wales and North Ireland sparse crops area
060. Barley area in Scotland
061. South English mixed wheat and Barley zone
062. Java
063. Kalimantan and Sulawesi
064. Sumatra
065. West Papua
066. Deccan Plateau
067. Eastern coastal region
068. Gangatic plain
069. Assam and north-eastern regions
070. Western coastal region
071. North-western dry region or Rajastan and Gujarat
072. Western Himalayan region
073. Central and Eastern wasteland region
074. Arid Red Sea coastal low hills and plains
075. Semi-arid to sub-tropical western and northern hills
076. Central non-agriculture region
077. South zone
078. Eastern plateau and southeastern zone
079. Northern zone
080. Central Toole-Sap plain
081. Upland areas
082. Arid and semi-arid regions
083. Humid tropics with summer rainfall
084. Sub-humid temperate region with summer rains
085. Sub-humid hot tropics with summer rains
086. Central plain
087. Delta and southern-coast
088. Hills
089. Derived savanna zone
090. Guinean savanna
091. Humid forest zone
092. Soudano-Sahelian zone
093. Balochistan
094. Lower Indus basin in south Punjab and Sind
095. Northern highlands
096. Northern Punjab
097. Southern islands forest region
098. Negros and central Visayas Islands
099. Northern lowlands of Mindanao to western Visayas
100. Central rye and potatoes area
101. Northern oats and potatoes areas
102. Northern-central wheat and sugarbeet area
103. Southern wheat and sugarbeet area
104. Central mixed farming and pasture Carpathian hills
105. Eastern and southern maize wheat and sugarbeet plains
106. Western and central maize wheat and sugarbeet plateau
107. Central Russia
108. Central black soils area
109. Eastern Siberia
110. Amur and Primorsky Krai
111. Middle Volga
112. Middle Siberia
113. Western Siberia
114. South Caucasian
115. Central double and triple-cropped rice lowlands
116. South-eastern horticulture area
117. Western and southern hill areas
118. Single-cropped rice north-eastern region
119. Black Sea region
120. Central Anatolia region
121. Eastern Anatolia region
122. Marmara Agean Mediterranean lowland region
123. Central wheat area
124. Eastern Carpathian hills
125. Northern wheat area
126. Southern wheat and maize area
127. Alaska and Hawaii
128. Blue Grass region
129. California
130. Corn Belt
131. Lower Mississippi
132. Middle Atlantic
133. Northern Plains
134. Northeast
135. Northwest
136. Southern Plains
137. Southeast
138. Southwest
139. Central region with sparse crops
140. Eastern hilly cereals zone
141. Aral Sea cotton zone
142. Central coastal areas from Thanh Hoa to Khanh Hoa
143. Northern zone with Red river Delta
144. Southern zone with Mekong Delta
145. Arid and desert zones
146. Humid Cape Fold mountains
147. Mediterranean zone
148. Dry Highveld and Bushveld maize areas
149. Dry region
150. Mixed dry farming and irrigated cultivation region
151. Mixed dry farming and grazing region
152. Central region with sparse vegetation
153. Sub-humid zone
154. Humid zone
155. Arid Zone
156. Semi-Arid Zone
157. Central Plateau
158. Center
159. North
160. South-west
161. Central and Eastern Steppe
162. Selenge-Onon Region
163. Hangai Khuvsgul Region
164. Gobi Desert
165. Altai Region
166. Desert
167. Sub-humid northern highlands
168. Warm subhumid zones
169. Warm semiarid zones
170. Northern hinterland of Cabo Delgado
171. High altitude areas
172. Mid-altitude areas
173. Northern coast
174. Dry areas of Zambezia and Southern Tete
175. Low altitude areas of Sofala and Zambezia
176. Central medium altitude areas
177. North and Central Gaza and Western Inhambane
178. Coastal areas and South of Save
179. Inland of Maputo and Southern Gaza
180. Transdanubia
181. Puszta
182. North Hungary
183. Central Hungary
184. South-west
185. Nothern rangelands
186. Coast
187. Sicily
188. Northern Italy
189. Western Italy
190. Eastern Italy
191. Dry Zone
192. Wet zone
193. Intermediate Zone
194. Northen high rainfall zone
195. Western semi-arid plain
196. Central-eastern and southern plateau
197. Luangwa Zambezi rift valley
198. Northwest Region including Novgorod
199. West subarctic region
200. Ural and wetsrn Volga region
201. Subarctic region
202. Northern Caucasus
203. Southern China
204. Qinghai-Tibet
205. North East China
206. Lower Yangtze rtegion
207. Loess region
208. Inner Mongolia
209. Huang Huaihai
210. Hainan
211. China Taiwan
212. Gansu-Xinjiang
213. South-West China

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 (2013-2017), 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 (2013-2017), with departures expressed in percentage.
CROPPING INTENSITY			
Cropping intensity Index			
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, 42 countries, and 7 regions for China. Values are compared to the average of the previous five years, with departures expressed in percentage.
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 (2014-2018), 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 (2003-2017),

INDICATOR			
			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 (2003-17), 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 (2003-17), 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 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.
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.

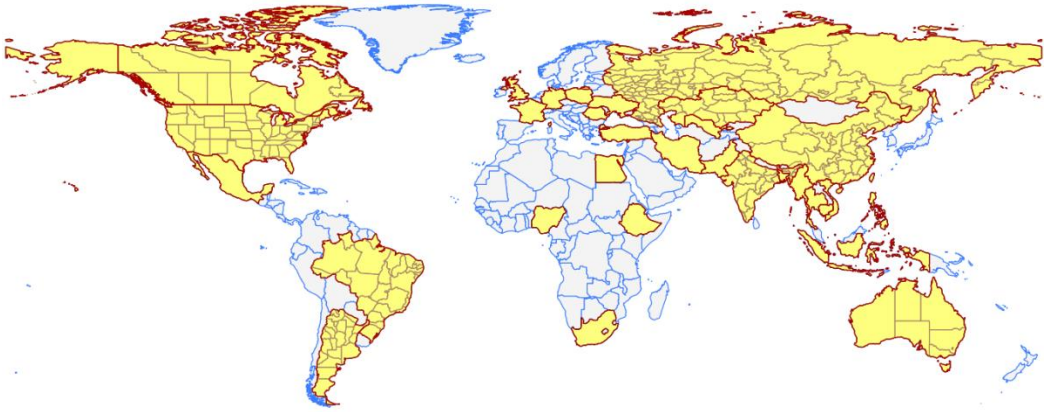
Note: Type is either "Weather" or "Crop"; source specifies if the indicator is obtained from ground data, satellite readings, or a combination; units: in the case of ratios, no unit is used; scale is either pixels or large scale CropWatch spatial units (CWSU). Many indicators are computed for pixels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

CropWatch spatial units (CWSU)

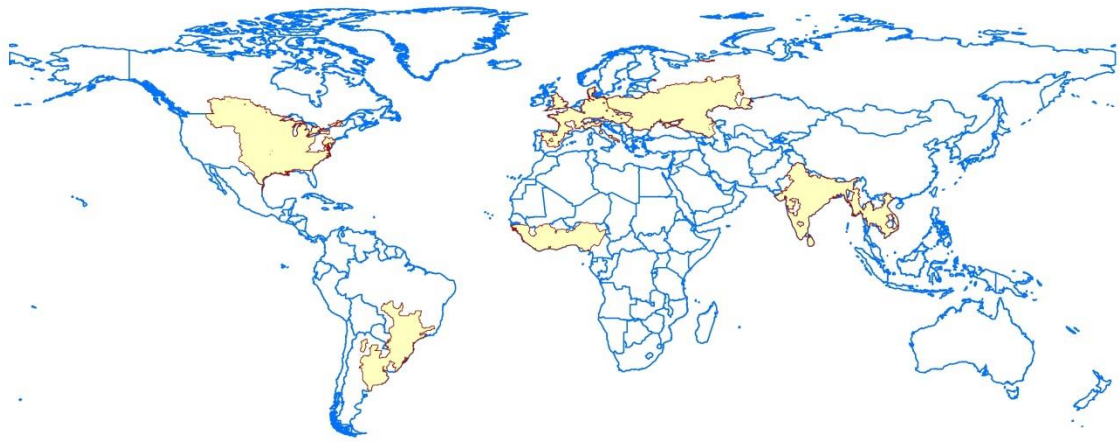
CropWatch analyses are applied to four kinds of CropWatch spatial units (CWSU): Countries, China, Major Production Zones (MPZ), and global crop Monitoring and Reporting Units (MRU). The tables below summarize the key aspects of each spatial unit and show their relation to each other. For more details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

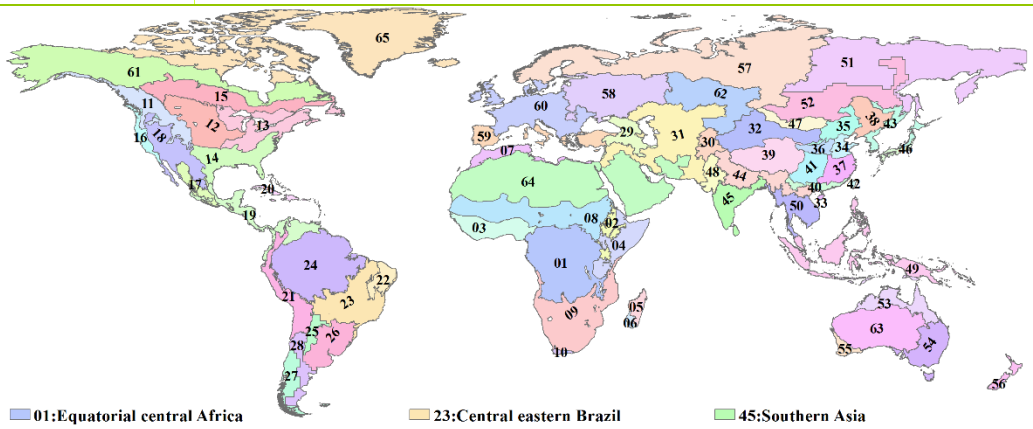
Countries (and first-level administrative districts, e.g., states and provinces)	
Overview	*Description*
42 countries to represent main producers/exporters and other key countries.	CropWatch monitored countries together represent more than 80% of the production of maize, rice, wheat and soybean, as well 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 "41 + 1," referring to 41 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**.



Major Production Zones (MPZ)	
Overview	*Description*
Seven globally important areas of agricultural production	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.



Global Monitoring and Reporting Unit (MRU)	
Overview	*Description*
65 agro-ecological/agro-economic units across the world	MRUs are reasonably homogeneous agro-ecological/agro-economic units spanning the globe, selected to capture major variations in worldwide farming and crops patterns while at the same time providing a manageable (limited) number of spatial units to be used as the basis for the analysis of environmental factors affecting crops. Unit numbers and names are shown in the figure below. A limited number of units (e.g., MRU-63 to 65) are not relevant for the crops currently monitored by CropWatch but are included to allow for more complete coverage of global production. Additional information about the MRUs is provided online under **www.cropwatch.com.cn** .



01:Equatorial central Africa
02:East African highlands
03:Gulf of Guinea
04:Horn of Africa
05:Madagascar (main)
06:Southwest Madagascar
07:North Africa Mediterranean
08:Sahel
09:Southern Africa
10:Western Cape (South Africa)
11:British Columbia to Colorado
12:Northern Great Plains
13:Corn Belt
14:Cotton Belt to Mexican Noreste
15:Sub-boreal America
16:West Coast (North America)
17:Sierra Madre
18:Southwest U.S. and north Mexican highlands
19:Northern South and Central America
20:Caribbean
21:Central-northern Andes
22:Nordeste (Brazil)
23:Central eastern Brazil
24:Amazon
25:Central-north Argentina
26:Pampas
27:Western Patagonia
28:Semi-arid Southern Cone
29:Caucasus
30:Pamir area
31:Western Asia
32:Gansu-Xinjiang (China)
33:Hainan (China)
34:Huanghuaihai (China)
35:Inner Mongolia (China)
36:Loess region (China)
37:Lower Yangtze (China)
38:Northeast China
39:Qinghai-Tibet (China)
40:Southern China
41:Southwest China
42:Taiwan (China)
43:East Asia
44:Southern Himalayas
45:Southern Asia
46:Southern Japan and Korea
47:Southern Mongolia
48:Punjab to Gujarat
49:Maritime Southeast Asia
50:Mainland Southeast Asia
51:Eastern Siberia
52:Eastern Central Asia
53:Northern Australia
54:Queensland to Victoria
55:Nullarbor to Darling
56:New Zealand
57:Boreal Eurasia
58:Ukraine to Ural mountains
59:Mediterranean Europe and Turkey
60:W. Europe (non Mediterranean)
61:Boreal America
62:Ural to Altai mountains
63:Australian desert
64:Sahara to Afghan deserts
65:Sub-arctic America

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

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

Online Resources posted on www.cropwatch.com.cn , http://cloud.cropwatch.com.cn/

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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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