Chapter 1. Global environmental indices for agriculture: light, temperature, and water

Chapter 1 presents an overview of environmental indices—specifically rainfall, temperature, photosynthetically active radiation (PAR), and biomass, which form the broad and global background for the CropWatch analyses presented in subsequent chapters. The global overview of the environmental indicators presented here focuses on the sixty global Crop Production System Zones (CPSZ) and the six identified Major Production Zones (MPZ). For more information about these zones or methodologies, see the CropWatch online resources Definition of Spatial Units and Methodology, at www.cropwatch.com.cn. Environmental indices for all CPSZs are also provided in Annex A, table A.1.

1.1 Overview

Weather variables do not normally vary independently, nor do weather anomalies. Several clear examples are provided by a detailed analysis of figures 1.1 to 1.4, covering rainfall, temperature, PAR, and biomass for the sixty global CPSZ. The largest positive departures from the twelve-year average (also referred to as the "last decade" in this report) for rainfall are associated with low sunshine in boreal North America, South Africa (western Cape), Sierra Madre, Madagascar, South Asia (Punjab to Gujarat), and—to a still significant but lesser extent—in the Southern Himalayas, Qinghai-Tibet, the Amazon, and Western Europe.

Negative rainfall departures (that is, drought) usually create difficult conditions for many human activities, especially for agriculture. Listed in decreasing order of percent rainfall deficit, some notable areas with negative rainfall departures are: the North American west coast (by some accounts a one in five hundred year event), the tip of the Southern Cone in Latin America, Mediterranean north Africa, two areas in southern Australia (Nullarbor-Darling in the west and Queensland to Victoria in the east), New Zealand, the Caribbean CPSZ, and, in China, the Huanghuaihai ecological zone. Among these areas, several also underwent unusually high temperatures, especially the American west coast and adjacent sub-boreal region, along with a number of areas in Asia: eastern central Asia, Mongolia, and eastern Siberia, four ecological zones of China (the Lower Yangtze CPSZ, Huanghuaihai, the Loess region, and Inner Mongolia) and, finally, China's Gansu-Xinjiang area, where the extreme was less marked.

Mediterranean Europe, Turkey, as well as the North African Mediterranean are characterized by a combined occurrence of low rainfall and sunshine. Countries, by increasing order of drought severity, include Portugal, Algeria, Libya, Syria, Israel, Cyprus, Morocco, and Lebanon. According to information kindly provided to CropWatch by Moroccan sources, experts foresee a yield reduction of wheat in the range of 20 to 30 percent, compared to recent historical data. However, this forecast is subject to change depending on expected precipitations and the level of temperatures in the coming dekads: satisfactory rainfall from February could obliterate the drought, resulting in normal or even above normal crop output.

The biomass indicator largely follows rainfall, with negative changes in the areas where rainfall fell short of expectations, essentially the Mediterranean areas, the southwestern Southern Cone, the American west coast, Huanghuaihai, southern Australia, and New Zealand. Positive effects are identified over large expanses of central and east Asia, but actual crop growth will be subject to sufficient soil moisture becoming available when crop growth resumes, with other factors such as pest and weed overwintering also playing a role.

Table 1.1 provides a closer look at the major production zones and compares the environmental indices with their recent five-year average. The West African MPZ largely coincides with the Gulf of Guinea CPSZ, an area that underwent favorable rainfall and PAR. Considering that the southernmost part of the MPZ undergoes bimodal rainfall, even a semi-quantitative assessment of the crop impact is not immediately possible, as the main cereal season corresponds mostly with the northern hemisphere summer (with some exceptions linked with mountain conditions). In South and Southeast Asia, another MPZ with a large positive rainfall departure (+26 percent, compared with +10 percent in West Africa), crops are currently in the field. Biomass, which measures the combined impact of rainfall and temperature, increases significantly in Asia. Given the local crop calendar, there is a real chance that the biomass indicator increase will eventually manifest itself as yield increase, all the more because PAR also increased over average conditions. Among the other MPZs, North America suffered from a cold spell (-1.2°C) and South America from a mild drought. Both, however, are characterized by only a weak negative departure of biomass from the recent reference period, which suggests the areas, despite the particularly unfavorable conditions in some locations in South America, could still result in an acceptable growing season. Despite some localized floods (for example in the United Kingdom), western Europe on average did not suffer from excess water, while temperature was higher than the recent past five years and PAR increased 1 percent. In comparison, the Central Europe and Western Russia MPZ underwent a marked reduction in precipitation (-11 percent) and above average temperature. For both MPZs, the biomass indicator shows a slight increase over the previous seasons.

Table 1.1. Environmental indices by Major Production Zones, October 2013-January 2014

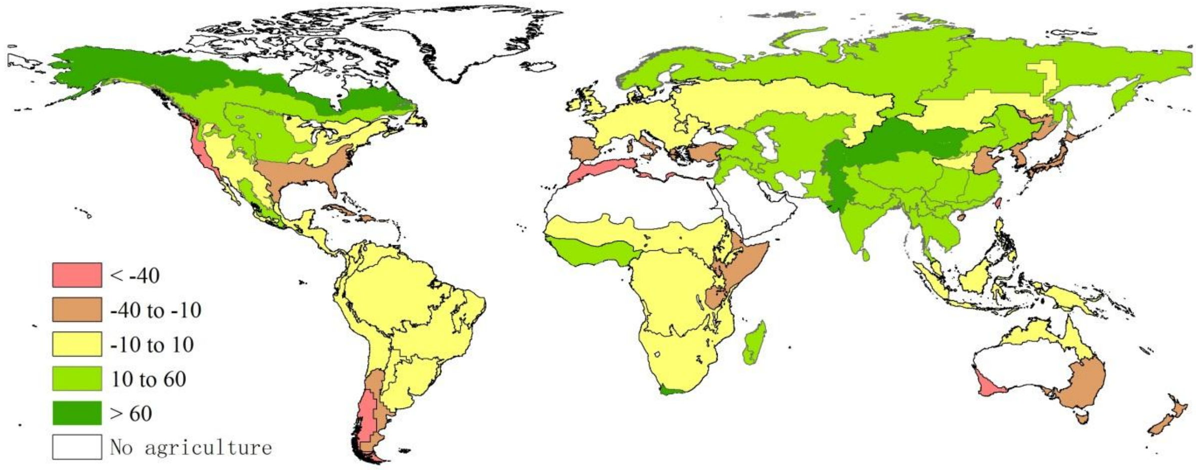
	Rainfall		Temperature		PAR		Biomass	
	Current (mm)	Dep. from 5YA (2008-13) (%)	Current (°C)	Departure from 5YA (°C)	Current (MJ/m^2)	Departure from 5YA (%)	Current (gDM/m^2)	Dep. From 5YA (%)
West Africa	239	10	26.8	0.0	1007	9	639	12
South America	660	-5	24.1	0.6	1385	3	1763	-0.2
North America	284	3	3.5	-1.2	534	2	707	-2
South and Southeast Asia	250	26	21.4	-0.5	953	2	573	22
Western Europe	283	-1	6.7	1.3	284	1	947	3
Central Europe and Western Russia	181	-11	0.8	1.0	226	1	659	2

Note: Current season indicators are compared to the five-year average (5YA) for the months of October-January between October 2008 and January 2013.

1.2 Rainfall

Figure 1.1 shows the October 2013 to January 2014 rainfall anomaly. Unusually dry winter conditions occurred in the regions of North China plain, northeast Asia (including the Korean peninsula and Japan), Turkey, the Iberian Peninsula, north Africa, and southeastern United States and the U.S. west coast; rainfall decreased more than 40 percent in comparison with the twelve-year average (2001-13) for the same period. At the same time, abnormal dry summer conditions occurred in eastern Africa, eastern Australia, and particularly in southern Argentina and southwest Australia. Wet winter conditions occurred in major regions of China, Southeast Asia, the Indian subcontinent, central Asia, the northern region of Russia, Europe, and North America, and especially in west China, Pakistan, and West Africa. Major regions of the southern hemisphere recorded average rainfall compared to the twelve-year average.

Figure 1.1. Rainfall by Crop Production System Zone, October 2013-January 2014 compared with the 12YA (2001-13), difference expressed as percentage



Note: 12YA=Twelve-year average for the October-January periods between October 2001 to January 2013.

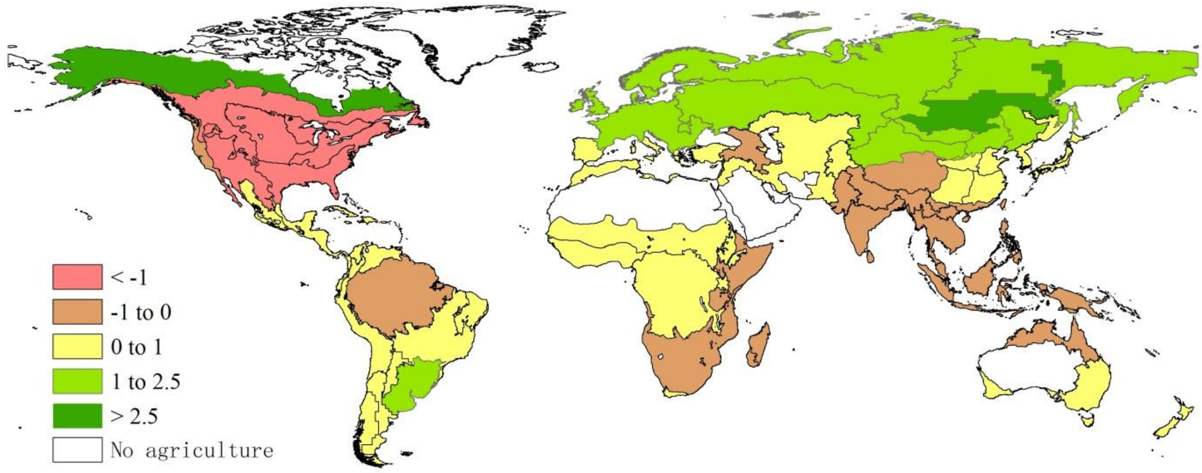
1.3 Temperature

As shown by the temperature departures from the recent twelve-year average (figure 1.2), sharply contrasting temperature patterns developed between the northern and southern hemispheres and between the continents for the recent monitoring period.

Specifically, in the extreme north of Canada and Alaska, the CPSZ of boreal America presents significantly warmer than average weather. According to NOAA National Climatic Data Center (NCDC) climate anomalies, Alaska experienced warmer than usual weather in October and January, which is confirmed by the positive thermal anomaly in this region. In contrast, the remaining areas of the United States and Canada (down to and including the cotton belt) and the Mexican coastal plain CPSZ, the north Mexican highlands, and the southwestern Mexico CPSZ experienced lower than average temperatures. A closer look at the country and sub-country temperature map indicates that the cooling was more marked in the United States than in Mexico. The North American boreal high temperatures are paralleled in Eurasia where, however, the warming extends much further south, to the latitude of the Inner Mongolia CPSZ and Gansu-Xinjiang in China, all the way to western Europe, avoiding only the western Asia CPSZ and Mediterranean Europe. These findings are confirmed by JRC/MARS, reporting that Europe experienced a mild winter with above-average temperature from December to February. In Spain a cold November followed a warm October, resulting in overall temperature conditions closer to average. Other noteworthy positive anomalies include areas showing temperature increases, including Mongolia and the southeastern Brazil-Conception-Bahia Blanca CPSZ, which largely overlaps with the main agricultural areas of the South America MPZ.

A closer look at the data indicates that, as a country, the United States experienced one of the largest negative temperature departures (-1.0°C)—widely presented in the media as “the October blizzard”—and later extreme cold weather manifestations. Although this is not so apparent in the figure, it is stressed that the largest national negative departures also include a group of near-eastern countries: Turkey (-1.1°C), Azerbaijan (-1.3°C), Georgia (-1.3°C), and Armenia (-2.1°C).

Figure 1.2. Air temperature for Crop Production System Zones, October 2013-January 2014 compared with the 12YA, difference expressed in degrees Celsius

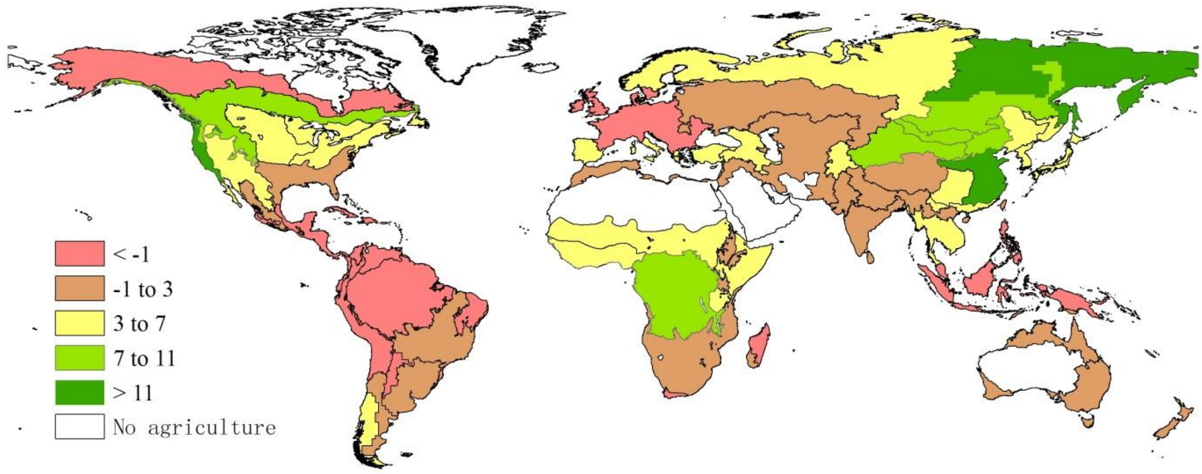


Note: 12YA=Twelve-year average for the October-January periods between October 2001 to January 2013.

1.4 Photosynthetically active radiation

Figure 1.3 compares the current season with the recent twelve-year average for PAR over the global CPSZs. About 20 percent of the CPSZs are below this average, which, of course, does not take into account their respective areas. Altogether, Latin America experienced less than average PAR conditions, particularly in the center of the continent, including the Amazon, northern South America and Central America, the Caribbean islands, and central-north Argentina. The same observation applies to boreal North America, southeast Asia islands, Madagascar, South Africa's Western Cape, and non-mediterranean western Europe, the area with the largest departure of all CPSZs (-5 percent). All of the departures are in the range of -1 to -5 percent.

Figure 1.3. PAR by Crop Production System Zone, October 2013-January 2014 compared with the 12YA (2001-13), difference expressed as percentage



Note: 12YA=Twelve-year average for the October-January periods between October 2001 to January 2013.

Other areas such as New Zealand, the American cotton belt, the Mexican coastal plain, Nullarbor to Darling in Australia, South Asia, West Asia, and eastern Africa, received average PAR in 2014.

Particularly favorable PAR conditions, with increases of 7 to 15 percent compared to the reference period (as illustrated in table A.1 in Annex A), affected the American west coast, north-western South America, equatorial central Africa, as well as large areas of Russia and China. They are listed here by increasing departure values, from Inner Mongolia (7 percent) to eastern central Asia, Mongolia, Gansu-Xinjiang, eastern Siberia, the China Loess region, Huanghuaihai (13 percent), and the Lower Yangtze region (14 percent).

1.5 Biomass

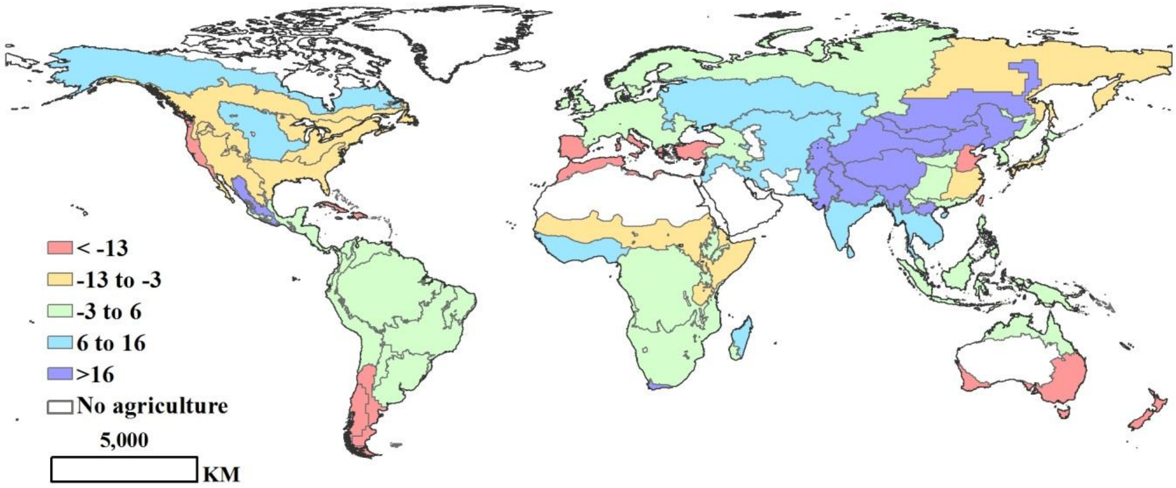
The biomass index (referred to as “biomass” or “biomass accumulation” in this report) expresses the combined effect of rainfall and temperature on the biomass accumulation during the reference period (see the online resources for more details about this methodology.) It is expressed in grams of dry matter per square meter over one year.

At CPSZ level (figure 1.4a), the greatest positive biomass departures (in percentage) are found in Asia, especially in the Mongolia CPSZ, followed by Gansu-Xinjiang, Punjab to Gujarat, Qinghai-Tibet, Inner Mongolia, the Central Asia-Pamir mountains, and Southern China, in decreasing order of departure. These regions correspond well with the area where significant positive thermal anomaly occurred during the reference period. When scaled down to pixel level (figure 1.4b), the general pattern remains unchanged and more subtle areas with large above-average temperature are captured, such as the center of America (covering Montana and South Dakota), north of Somalia, Kyzylordinskaya of Kazakhstan, and Navoiy of Uzbekistan.

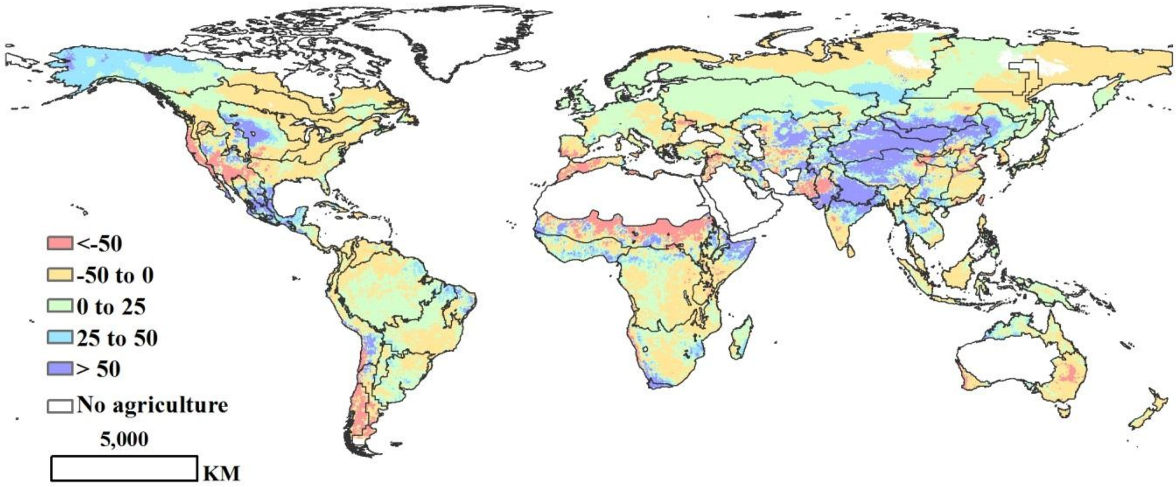
Other regions such as boreal North America, the Gulf of Guinea region in West Africa, Madagascar, Ukraine to Kazakhstan, western, south and southeast Asia (including Thailand, Cambodia, Laos, and Vietnam) present a slightly increased biomass. Southern Canada and most parts of the United States present a decreased biomass potential, as do the Sahel region, Horn of Africa, eastern Siberia, and the Lower Yangtze region in China.

The largest biomass percentage drop is observed in the Taiwan CPSZ (-53 percent), followed by the North American west coast (-49 percent). Other areas with marked drops in biomass include Huanghuaihai in China, parts of Oceania (New Zealand, Queensland to Victoria, Nullarbor-Darling), the Caribbean, the north-African mediterranean, and the southwestern Southern Cone in Latin America.

Figure 1.4. Biomass accumulation by Crop Production System Zone (a) and pixel (b), October 2013-January 2014 compared to the 12YA, difference expressed as percentage



(a)



(b)

Note: 12YA=The twelve-year average for the October-January periods between October 2001 and January 2013.