GAEZ+_2015 global gridded crop harvest area, crop production, and crop yield – Metadata

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1. OVERVIEW

This dataset, GAEZ+_2015, provides global, gridded (5-arcminute resolution) irrigated and rainfed crop harvested areas, irrigated and rainfed crop production, and irrigated and rainfed crop yield for 26 different crops/crop categories (for crop list see Table 1). This new product is an update to 2015 of the Global Agro-Ecological Zones (GAEZ) Version 4 data of c.2010 crop harvested area (Fischer et al. 2012; note GAEZ v4.0 is not published, this citation is to v3.0). This product is based on national statistics and ignores changes in the spatial distribution of cropland. It was developed as an intermediate product for studies that rely on GAEZ data, providing more recent data on production, yield, and harvested areas. It is not meant to depict the spatial distribution of crops at the pixel level in 2015 accurately, and will become obsolete as soon as a more formal update of GAEZ becomes available that updates pixel level data using the GAEZ methodology.

2. METHODOLOGY:

This new product updates the 2010 GAEZ crop harvest area, crop production, and crop yield maps (Fischer et al., 2012), using national-scale data on the fractional change in crop harvested area and production from 2010 to 2015, based on statistics for 160 crops from FAOSTAT (http://www.fao.org/faostat/en/#data/QA).

2.1. Grid cell mapping to country name.

Each 5-minute land grid cell is assigned to a country, or partitioned fractionally between multiple countries, based on the Global Administrative Unit Layers (GAUL) of FAO (http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691)
Note: Antarctica is excluded from this analysis and product.

2.2. Crop harvested areas

For each country, we extracted the harvested area for each crop from the FAOSTAT database (http://www.fao.org/faostat/en/#data/QC; data downloaded April 2020). We averaged three years (2009-2011) of annual national crop harvested area data to represent 2010 national crop harvest area, and three years (2014-2016) of annual crop harvested area data to represent 2015 national crop harvest area.

2.3. Crop Production

For each country, we extracted the production for each crop from the FAOSTAT database (http://www.fao.org/faostat/en/#data/QC; data downloaded April 2020). We averaged three years (2009-2011) of annual national crop production data to represent 2010 national crop production, and

three years (2014-2016) of annual national crop production data to represent 2015 national crop production.

2.3. Change in Crop Harvested Area and Production, 2010 to 2015

For each country and crop, we used the results of §2.2 and §2.3 to compute the ratio of the 2015 harvested area to the 2010 harvested area, and the ratio of 2015 production to 2010 production. A ratio of 1.0 implied no change in crop harvested area, or crop production; a ratio greater (less) than 1.0 implied an increase (decrease) in crop harvested area or crop production for that crop in that country from 2010 to 2015.

2.4. Harmonizing the FAOSTAT crop list to the GAEZ crop list:

We followed the crop aggregation of GAEZ to aggregate the FAOSTAT crop list (160 unique crops in the 2020 download) to 26 crops in GAEZ (see Table 1). There was one exception to this: the GAEZ 2010 crop category '*Foddercrops'* was an aggregate of 17 crops (see Table 1) for which harvest area and production data are no longer reported on FAOSTAT. We assumed that the 2010 to 2015 fractional change in *Foddercrops* harvest area and production in each country was equal to fractional change in the national total cattle plus buffalo livestock numbers for that country. National livestock data were from FAOSTAT (data from http://www.fao.org/faostat/en/#data/QA; data downloaded 28 October 2019), and the 2010 to 2015 change in livestock numbers was calculated following the same methodology as for crop harvested area change (see next section). We also note that in some GAEZ documentation a there is a '*Fruits & Nuts*' crop category, but there were no 5-arcminute grids for 2010 for this category, so the crops were merged into *CropsNES* (see Table 1).

2.5. Generating the GAEZ+_2015 Crop Harvested Area and Production Datasets

2.5.1. Harvested Area

We used the GAEZ v4.0 global gridded (5-arcminute) 2010 crop harvest area product (Fischer et al., 2012) as our base layer. For each grid cell, we multiplied the crop harvested area in the 2010 product by the fractional change from 2010 to 2015 in harvested area for that crop and country (see §2.3 and §2.4 above). In cases where a grid cell shares its area between multiple countries, we used country area-fraction weighted-average for the calculation of the given crop, *m*, harvested area in this cell as

$$A^k_{H_{m,2015}} = A^k_{H_{m,2010}} \sum_{i=1}^{N} f^k_{m,i} F_{H,m,i}$$

where $A^k_{H_{m,2015}}$ and $A^k_{H_{m,2010}}$ are harvested area in a grid cell *k* of crop *m* for years 2015 and 2010 accordingly; $f^k_{m,i}$ is an area fraction of country *i* in the grid cell *k*; and $F_{H,m,i}$ is country-level crop *m* area change factor described above. In the common cases of a 5-arcminute grid cell not being shared between multiple countries (*N*=1), the equation simplifies to

$$A^k_{H_{m,2015}} = A^k_{H_{m,2010}} F_{H,m,i}$$

Note, a cell table of country fractions in the given cell ($f^k_{m,i}$) was based on the Global Administrative Unit Layers (GAUL) of FAO (http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691).

2.5.2. Production

The method for updating crop production from 2010 to 2015 was the same as for crop harvested area, except using the 2010 national crop areas, $A^k_{P_{m,2010}}$ and the crop production ratio $F_{P,m,i}$.

2.5.3. Special Case: Sudan

In the FAOSTAT data downloaded in Oct. 2019 and April 2020, crop harvest area and production and livestock data are reported for 'Sudan_former' in 2010, but for 'Sudan' and 'South_Sudan' in 2015. To compute the fractional changes for these grid cells, we split the 2010 data for Sudan into a virtual 'Northern Sudan' and 'Southern Sudan' using the data for the year 2012, which exists for both countries. We then used these generated 2010 data and applied the same methodology as described above to calculated changes in harvested areas in all grid cells in both countries.

2.5.4. Special Case: Small regions and islands

Some countries (generally small regions or islands) had no crop harvested area or crop production data reported in FAOSTAT. We assumed that there was no change in crop harvested area or crop production for the grid cells in these countries. Note that many may have had zero reported crop harvested area or crop production in the GAEZ database in 2010. These were (number following region is code in ADM0_CODE in the GAUL data):

Anguilla (9), Aruba (14), Ashmore_and_Cartier_Islands (16), Azores_Islands (74578), Baker_Island (22), Bassas_da_India (25), Bird_Island (32), Bouvet_Island (36), British_Indian_Ocean_Territory (38), Christmas_Island (54), Clipperton_Island (55), Cocos (Keeling)_Islands (56), Europa_Island (80), French_Southern_and_Antarctic_Territories (88), Glorioso_Island (96), Greenland (98), Guernsey (104), Heard_Island_and_McDonald_Islands (109), Howland_Island (112), Isle_of_Man (120), Jarvis_Island (127), Jersey (128), Johnston_Atoll (129), Juan_de_Nova_Island (131), Kingman_Reef (134), Kuril_islands (136), Madeira_Islands (151), Mayotte (161), Midway_Island (164), Navassa_Island (174), Netherlands_Antilles (176), Norfolk_Island (184), Northern_Mariana_Islands (185), Palmyra_Atoll (190), Paracel_Islands (193), Pitcairn (197), Saint_Helena (207), Scarborough_Reef (216), Senkaku_Islands (218), South_Georgia_and_the_South_Sandwich_Islands (228), Spratly_Islands (230), Svalbard_and_Jan_Mayen_Islands (234), Tromelin_Island (247), Turks_and_Caicos_Islands (251), United_States_Virgin_Islands (258), Wake_Island (265), Gibraltar (95), Holy_See (110), Liechtenstein (146).

2.5.3. Special Case: Disputed Areas

Some grid cells in the cell-table database are assigned to disputed areas, rather than to specific countries (the number following region is the ADM0_CODE in the GAUL data):

Abyei (102), Aksai_Chin (2), Arunachal_Pradesh (15), China/India (52), Hala'ib_Triangle (40760), Ilemi_Triangle (61013), Jammu_and_Kashmir (40781), Ma'tan_al-Sarra (40762), Falkland_Islands_(Malvinas) (81).

We assumed that there was no change in crop harvested area or crop production during 2010 – 2015 for these grid cells.

2.6. Irrigated and Rainfed Crops

GAEZ_2010 has separate grids for irrigated and rainfed crop harvest area, production and yield. FAOSTAT does not report separate data for irrigated and rainfed crops. At the time these GAEZ grids were updated to 2015 (i.e., in 2020) the FAO AQUASTAT database (http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en) did not have sufficient data to make defensible national updates to irrigation activity for all countries for 2010 to 2015. We therefore have assumed that all ratios of irrigated to rainfed crop harvest area and all ratios of irrigated to rainfed crop production were unchanged during 2010 to 2015, and applied the crop harvest area and crop production change factors discussed above to both the irrigated and rainfed GAEZ grids.

2.7. Generating the GAEZ+_2015 Crop Yield Dataset

FAOSTAT yield data for all countries and crops, 2009-2100 and 2014-2016, are calculated from production and area, not directly reported yield values (http://www.fao.org/faostat/en/#data/QA). We computed the 2015 crop yield grids by doing a grid cell by grid cell division of crop production by crop

harvested area, for all crops, both irrigated and rainfed. For each crop, *m*, and grid cell, *k*, crop yield in 2015 was computed as the ratio of crop production in 2015 to crop harvested area in 2015.

$$A^k_{Y_{m,2015}} = \frac{A^k_{P_{m,2015}}}{A^k_{H_{m,2015}}}$$

Note that for many grid cells and many crops, the GAEZ+_2015 harvested area is zero. In these cases, the GAEZ+_2015 yield is reported as -3.39999999999999996e+38.

2.8 Generating total harvest area, total production and mean yield products

Total harvested area per crop by grid cell was computed as the grid cell sums of irrigated harvest area plus rainfed harvest area for that crop. Total production per crop by grid cell was computed as the grid cell sums of irrigated production plus rainfed production for that crop. Mean yield per crop by grid cell was computed as the ratio for each grid cell of total production divided by total harvest area for that crop.

3. RESULTING PRODUCTS

This new data product consists of 234 data files in geotiff format. For each of the 26 GAEZ crops or crop categories in Table 1, there is one rainfed harvested area file, one irrigated harvested area file, one total harvested area file, one rainfed production file, one irrigated production file, one total production file, one rainfed yield file, one irrigated yield file, and one mean yield file. Each file is a global product, gridded at 5-arcminute resolution.

Technical details

File format: geotiff

File name format: *GAEZAct2015_Variable_Cropname_Management.tif*

+ *Variable: HarvArea* or *Production* or Y*ield.*
+ *Cropname*: see column 1 in Table 1 below.
+ *Management: Irrigated* or *Rainfed* or *Total* or *Mean.*

Date Produced: May 2020.

GIS layer info: Extent: X: -180 to +180, Y: -90 to +90;
Resolution: 0.083333 decimal degrees (5 arcminutes);
Projection: CRS "+proj=longlat".

Units:

- Crop Harvest Area: 1000 ha (10^7 m^2) per 5-arcminute grid cell
- Crop Production: 1000 tonnes (10^6 kg) per 5-arcminute grid cell
- Crop Yield: tonnes per ha (10^{-1} kg m^{-2})

'no data': Oceans, open-water, Antarctica in the tif files have the no-data value of -3.39999999999999996e+38.

REFERENCES

Fischer G, Nachtergaele FO, Prieler S, Teixeira E, Toth G, van Velthuizen H, Verelst L, & Wiberg D (IIASA/FAO). 2012. *Global Agro-ecological Zones (GAEZ v3.0)*. IIASA, Laxenburg, Austria and FAO, Rome, Italy. Available at http://pure.iiasa.ac.at/id/eprint/13290/.

TABLE 1. GAEZ and FAOSTAT crop harmonization

GAEZ crop category	FAOSTAT crop (production domain crop_code)
Wheat	Wheat (15)
Rice	Rice_paddy (27)
Maize	Maize (56)
Sorghum	Sorghum (83)
Millet	Millet (79)
Barley	Barley (44)
Othercereals	Rye (71), Oats (75), Buckwheat (89), Quinoa (92), Fonio (94), Triticale (97), Canary_seed (101), Grain_mixed (103), Cereals_nes (108)
PotatoAndSweetpotato	Potatoes (116), Sweet_potatoes (122)
Cassava	Cassava (125)
Yamsandotherroots	Yautia (cocoyam) (135), Taro (cocoyam) (136), Yams (137), Roots_and_tubers_nes (149)
Sugarbeet	Sugar_beet (157)
Sugarcane	Sugar_cane (156)
Pulses	Beans_dry (176), Broad_beans_dry (181), Peas_dry (187), Chick_peas (191), Cow_peas_dry (195), Pigeon_peas (197), Lentils (201), Bambara_beans (203), Pulses_nes (211)
Soybean	Soybeans (236)
Rapeseed	Rapeseed (270)
Sunflower	Sunflower_seed (267)
Groundnut	Groundnuts_with_shell (242)
Oilpalmfruit	Oil_Palm_Fruit (254)
Olives	Olives (260)
Cotton	Seed_Cotton (328)
Tobacco	Tobacco_unmanufactured (826)
Banana	Bananas (486), Plantains (489)
Stimulants	Coffee_green (656), Cocoa_beans (661), Tea (667), Maté (671)
Vegetables	Cabbages (358), Artichokes (366), Asparagus (367), Lettuce_and_chicory (372), Spinach (373), Cassave_Leaves (378), Tomatoes (388), Cauliflowers_and_broccoli (393), Pumpkins_squash_gourds (394), Cucumbers_and_gherkins (397), Eggplants (aubergines) (399), Chillies_peppers_green (401), Onions_shallots_green (402), Onions_dry (403), Garlic (406), Leeks (407), Beans_green (414), Peas_green (417), Vegetables_legum._nes (420), String_beans (423), Carrots_and_turnips (426), Okra (430), Maize_green (446), Mushrooms_and_truffles (449), Chicory_roots (459), Carobs (461), Vegetables_fresh_nes (463), Chillies_and_peppers_dry (689)
CropsNES *	Brazil_nuts_with_shell (216), Cashew_nuts_with_shell (217), Chestnut (220), Almonds_with_shell (221), Walnuts_with_shell (222), Pistachios (223), Kola_nuts (224), Hazelnuts_with_shell (225), Areca_nuts (226), Nuts_nes (234), Coconuts (249), Karite_nuts (sheanuts) (263), Tung_nuts (275), Melonseed (299), Kapok_Fruit (310), Oranges (490), Tangerines (495), Lemons_and_limes (497), Grapefruit_(incl._pomelos) (507), Fruit_citrus_nes (512), Apples (515), Pears (521), Quinces (523), Apricots (526), Cherries_sour (530), Cherries (531), Peaches_and_nectarines (534), Plums_and_sloes (536), Fruit_stone_nes (541), Fruit_pome_nes (542), Strawberries (544), Raspberries (547), Gooseberries (549), Currants (550), Blueberries (552), Cranberries (554), Berries_nes (558), Grapes (560), Watermelons (567), Melons_other (568), Figs (569), Mangoes_guavas (571), Avocados (572), Pineapples (574), Dates (577), Persimmons (587), Cashewapple (591), Kiwi_fruit (592), Papayas (600), Fruit_tropical_fresh_nes (603), Fruit_fresh_nes (619), Sugar_crops_nes (161), Vetches (205), Lupins (210), Castor_oil_seed (265), Jojoba_Seeds (277), Safflower_seed (280), Sesame_seed (289), Mustard_seed (292), Poppy_seed (296), Tallowtree_Seeds (305), Linseed (333), Hempseed (336), Oilseeds_nes (339), Hops (677), Pepper (piper_spp.) (687), Vanilla (692), Cinnamon (canella) (693), Cloves (698), Nutmeg_mace_cardamoms (702), Anise_badian_fennel (711), Ginger (720), Spices_nes (723), Peppermint (748), Pyrethrum_dried (754), Flax_fibre_and_tow (773), Hemp_tow_waste (777), Jute (780), Bastfibres_other (782), Ramie (788), Sisal (789), Agave_fibres_nes (800), Manila_fibre_(abaca) (809), Fibre_crops_nes (821)
Foddercrops **	*Cabbages_for_fodder (644), Pumpkins_for_fodder (645), Turnips_for_fodder (646), Beets_for_fodder (647), Carrots_for_fodder (648), Swedes_for_fodder (649), Vegetables_&_roots_fodder (655), Forage_&_Silage_crops (n.a.), Forage_products (651), Forage_&_silage,_maize (636), Forage_&_silage,_sorghum (637), Forage_&_silage,_rye_grass (638), Forage_&_silage,_grasses_nes (639), Forage_&_silage,_clover (640), Forage_&_silage,_alfalfa (641), Forage_&_silage,_green_oilsd (642), Forage_&_silage,_legumes (643)*

** Includes Fruits & Nuts.*

*** The FAOSTAT fodder and silage crops no longer have reported harvested area in FAOSTAT. The area change for the GAEZ Foddercrop aggregate, which includes both fodder and silage crops, was instead based on bovine livestock population changes 2010 -> 2015, reported by country by FAOSTAT (see text).*