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Version 1.0

Global Food Security-support Analysis Data (GFSAD) Project

Landsat-derived Global Rainfed and Irrigated-Cropland Product @ 30-m (LGRIP30) of the World (GFSADLGRIP30WORLD)

User Guide

Document History

Document Version	Publication Date	Description
1.0	January, 2023	Original
1.1	February, 2023	Modification made according to USGS reviewer comments
1.2	February, 2023	Modifications made according to LPDACC reviewer comments

Contents

1.0 Dataset Overview

The goal of the Global Food Security-support Analysis Data (GFSAD) project is to provide global cropland datasets to assist and address global food and water security issues of the twenty-first century. The project is developing multiple global cropland products using time-series Landsat satellite data, machine learning algorithms, and cloud computing. The project was initially (2013-2018) funded by the National Aeronautics and Space Administration (NASA) with supplemental funding from the United States Geological Survey (USGS). Since 2018, USGS has continued to fund the work through National Land Imaging (NLI) and Land Change Science (LCS) programs of the Core Science Systems (CSS). The project is led by USGS and collaborators including NASA, USDA, and several international partners, including The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

This user guide provides guidelines of the GFSAD Landsat-derived Global Rainfed and Irrigated-Cropland Product (LGRIP30). The product is produced at a 30m spatial/pixel resolution of the World (GFSADLGRIP30WORLD) for the nominal year 2015 (note: Landsat-8 16-day data was used for 3 to 4 years from 2014-2017, but the product is referred to as nominal 2015). The Coordinate Reference System (CRS) used for the GFSADLGRIP30WORLD is a geographic coordinate system (GCS) based on the World Geodetic System 84 (WGS84) reference ellipsoid. The legend is presented in Section 2. Datasets are provided in 10^o x 10^o raster tiles and available as GeoTIFF files. The year, resolution, tiling, and file name convention details are provided in section 2.0 and its sub-section of this document.

1.1 Background

The United Nations Framework Convention on Climate Change's (UNFCCC) Conference of the Parties session 21 (COP21) held in Paris, France and the subsequent COP22 held in Marrakech, Morocco, set clear goals to achieve a zero-carbon economy sometime during 2050-2100. With agriculture food production contributing to as much as 29% (Vermeulen et al., 2012) of the total greenhouse gas emissions (GHG), including some of the most potent such as methane, which is 22 times- and N_2O which is 300 times that of CO_2, the role of agriculture in achieving zero carbon economy is critical. Added to these complexities are demographic changes which are predicted to exacerbate food insecurity. For example, in Africa, where food insecurity is greatest, population growth in the twenty-first century is projected to reach a massive 4 billion by 2100 from the current ~1.2 billion.

The global food and water security scenario in the twenty-first century will be an extraordinarily complex one. The United Nations projects that the population of the world will reach 9.7 billion by 2050 and nearly 11-12 billion by 2100 (UN DESA, 2015). In addition, global daily average calorie consumption is expected to rise from 2789 kcal\person\day in the year 2000 to 3130 kcal\person\day by the year 2050 (Bodirsky et al., 2015). These caloric estimates may rise even higher if traditionally low meat consuming nations start increasing meat consumption as a result of economic growth. Human dietary habits are diversifying considerably (e.g., rice or wheat only to a mix of rice, wheat, pulses, fruits, and vegetables). The concern about producing more food to serve a growing population is compounded by the facts that 30 to 50% of the food produced globally is wasted (IME, 2013).

Further, the world's most fertile agricultural lands have been lost to industry and urbanization. It is also widely expected by 2050 that a staggering 84% of the world's population will live in cities (UN DESA, 2015), abandoning vast stretches of rural croplands and associated livelihoods by traditional small-holder agriculturists in the developing world. As a result, urban\peri-urban agriculture is expected to multiply. Studies (Teluguntla et al, 2017, Thenkabail and Wu, 2014) have shown that a single worst drought year can result in massive cropland area losses by as much as 20% as well as reduction in crop productivity, leading to a significant impact on global food security.

Global **food and water security challenges are tightly intertwined**. Currently, worldwide, **~ 80% all human water use is for producing food**. In a changing climate, quantities of surface and groundwater are dwindling, and quality is degrading. Demand for alternative uses (e.g., industry, ecological) of water are increasing swiftly. Yet, in contrast, the need to provide adequate water for growing more food for rising populations is also increasing swiftly. Added to this complexity, is the need for water at different locations due to urban migration requiring new infrastructure to deliver water and establish new lands to grow crops.

The GFSAD LGRIP30 product uses the Global Cropland Extent Product at 30m (GCEP30) (Thenkabail et al., 2021) as baseline for further analysis to separate irrigated areas from rainfed areas. In addition, some of the croplands missing in the GCEP30 were identified and categorized as irrigated or rainfed in the GFSADLGRIP30WORLD.

Cloud-based geo-spatial computing platforms and satellite image inventory offer opportunities for producing maps of cropland extent and area that meet the spatial and temporal requirements of broad applications. Such maps can be a significant improvement compared to existing products, which tend to have coarser resolution, are often not representative of regions with highly dynamic change and have a fixed set of cover classes. Cloud-based computing platforms such as Google Earth Engine and new earth-observing satellites like Landsat 8 have brought significant improvements to LULC mapping and agriculture monitoring. Specifically, the production of standard static maps of the past will be shifted to dynamic creation maps from massively large volumes of big data, crowd sourcing of training and validation samples, and implementing machine-learning algorithms on the cloud to serve more specific applications.

For a detailed description of the satellite and reference data, processing scheme, approaches, methods, results, and conclusions please refer to the algorithm theoretical basis document (ATBD) of GFSADLGRIP30WORLD.

2.0 Dataset Characteristics

The GFSAD Landsat-derived Global Rainfed and Irrigated-Cropland Product at nominal 30m of the World (GFSADLGRIP30 datasets and characteristics are described below.

2.1 The GFSAD Landsat-derived Global Rainfed and Irrigated-Cropland Product at nominal 30m of the World (GFSADLGRIP30WORLD) V001

2.1.1 Collection Level

Short name	GFSADLGRIP30WORLD
Temporal Granularity	Static
Temporal Extent	2015, nominal
Spatial Extent	Global
File size	~200 GB
Coordinate System	Geographic
Datum	WGS84
File Format	GeoTIFF

2.1.2 Granule Level

Number of Layers	1
Columns/Rows	37114 x 37114
Pixel Size	~30 m

2.1.3 Data Layer Characteristics

SDS Layer Name	Description	Units	Data Type	Fill Value	Valid Range	Scale Factor
Band 1	Landsat-derived Global Rainfed and Irrigated-Cropland Product at nominal 30m of the World (LGRIP30)	N/A	8-bit unsigned integer	N/A	0,1,2, 3	N/A

2.1.3 Data Layers Classification

Class Label	Class Name	Description
0	Water	Ocean and Water bodies
1	Non-croplands	Land with other land use
2	Irrigated croplands	Agricultural croplands that are irrigated
3	Rainfed croplands	Agricultural croplands that are rainfed

2.1.4 Filename Convention

GFSADLGRIP30WORLD-2015-S10E120-001-20230092030105.tif
GFSAD LGRIP30 = Product Short name
Resolution = 30m
GFSAD = Global Food Security Support Analysis Data
LGRIP30WORLD = Landsat-derived Global Rainfed and Irrigated-Cropland Product at nominal 30m of the World
2015 = Nominal Year
S10E120 = 10^0 x 10^0 grid, starting at (S10, E120)
001 = Version
20230092030105 = Processing Date in YYYYJJJHHMMSS.S

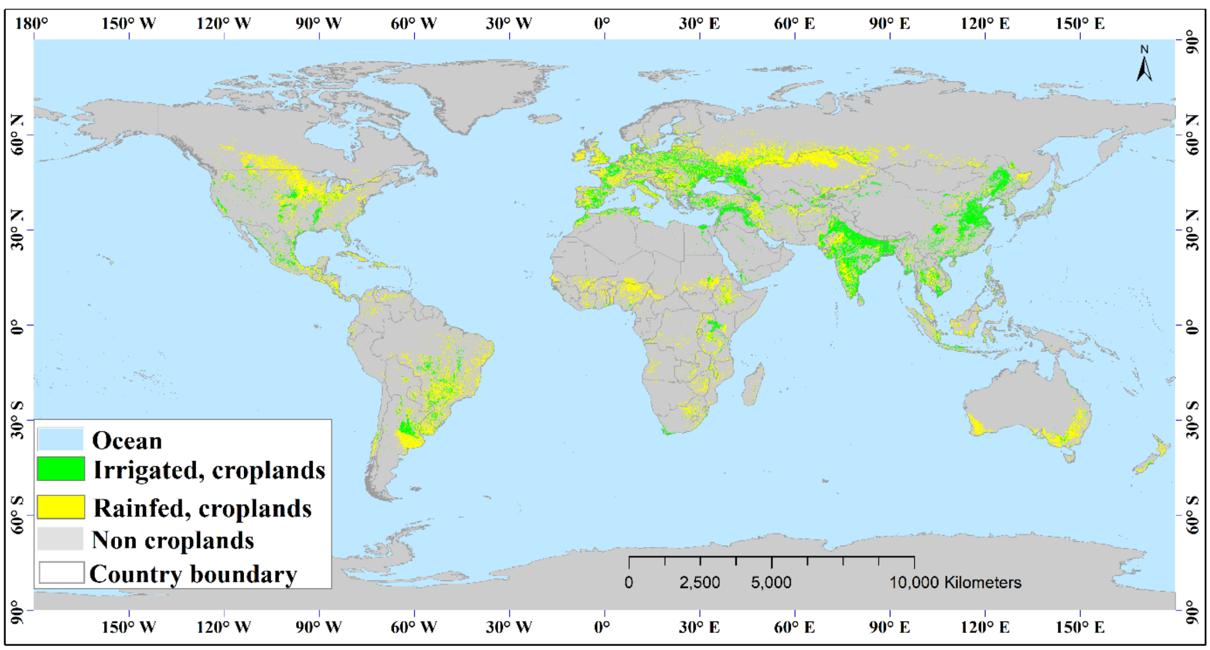

Figure 1. Landsat-derived Global Rainfed and Irrigated-Cropland Product at nominal 30m of the World

3.0 Dataset Knowledge

The following questions address the user information regarding the GFSADLGRIP30WORLD collection.

3.1 Frequently Asked Questions

What is the accuracy of the GFSAD LGRIP30GFSADLGRIP30WORLD **product?**

1. For the entire world, the overall accuracy was 86.5% (table below) with: A. producer's accuracy of 86.7% (omission error 13.3%) and user's accuracy of 84.3% (commission error 15.7%) for the irrigated area class; and B. producer's accuracy of 86.3% (omission error 13.7%) and user's accuracy of 88.4% (commission error 11.6%) for the rainfed area class.
2. Accuracies (overall, user's and producer's) were also determined for each of the 13 zones (Table 2).

Table 1. Global accuracy assessment error matrix showing the overall accuracies, user's accuracies, and producer's accuracies. Number of validation samples, N = 10477.

	Reference Data			
Class	Irrigated	Rainfed	Row total	Commission error
Irrigated	**4171**	774	4945	15.7%
Rainfed	639	**4893**	5532	11.6%
Column total	4810	5667	**10477**	
Omission error	13.3%	13.7%		
Producer accuracy	86.7%	86.3%		
User accuracy	84.3%	88.4%		
Overall accuracy				**86.5%**

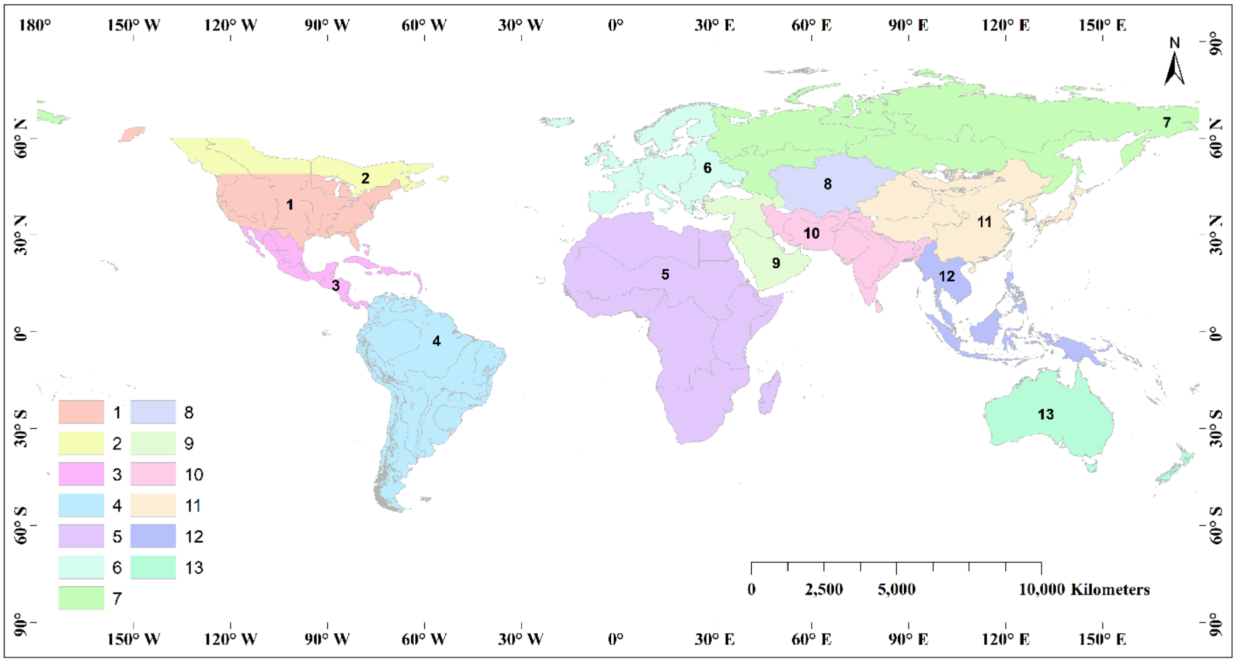

Figure 2. The 13 broad zones in which separate analysis was conducted to produce the Landsat-derived global rainfed and irrigated area product @ 30m (LGRIP30) product.

Table 2. Accuracies of the LGRIP30 product for each of the 13 zones in Figure 2.

		Producers Accuracy		**Users Accuracy**		**Overall accuracy**
Zone#	**Zone**	**Irrigated**	**Rainfed**	**Irrigated**	**Rainfed**	
#	**Name**	**%**	**%**	**%**	**%**	**%**
1	United States of America	84.6	85.2	77.0	90.4	85.0
2	Canada	82.5	97.5	89.7	95.5	94.4
3	Central America	77.9	87.8	85.5	81.1	83.0
4	South America	80.3	87.3	86.1	81.9	83.8
5	Africa	87.3	86.4	78.9	92.1	86.7
6	Europe	82.4	87.0	83.7	85.9	84.9
7	Russia	78.9	94.2	80.4	93.7	90.7
8	Central Asia	92.2	95.7	93.0	95.2	94.4
9	Middle east & West Asia	92.2	80.0	94.1	75.0	89.5
10	South Asia	93.7	77.4	86.1	89.0	87.1
11	China, Japan, & Korea	95.0	74.6	89.4	86.9	88.7
12	Southeast Asia	83.2	75.3	76.9	82.0	79.2
13	Australia &New Zealand	82.1	98.5	94.3	94.7	94.6
	Global	**86.7**	**86.3**	**84.3**	**88.4**	**86.5**

What do the GFSADLGRIP30WORLD product contain?
It is a Landsat-derived 30m global rainfed and irrigated area product (GFSAD-LGRIP30WORLD) or simply referred to as LGRIP30 for the nominal year 2015. This product is produced using every 16-day Landsat-8 time-series satellite sensor data for the time period 2014-2017 but called a nominal 2015 product.

What is the definition of the irrigated and rainfed cropland extent?
Irrigated cropland areas are defined as all cropland areas that have at least one artificial irrigation during the crop growing period. Artificial irrigation includes surface or groundwater irrigation and can come from a wide range of mechanisms. Groundwater irrigation includes water sourced from shallow or deep open wells or from tube-wells. The surface water irrigation includes large, medium, and small reservoirs. These reservoirs are created through large, medium, and small dams or tanks or naturally formed lakes. Water from these reservoirs is typically delivered through open canals, pipes, or pumping. Irrigation water also comes from run of the river systems where water for agricultural fields is delivered through river diversions by creating barrages (e.g., diversion dams), weirs, or simply from pumping water directly from the rivers. All of these are artificial irrigation systems. Natural irrigation systems include deltas, wetlands, and lowlands like inland valleys where water for crops come through flooding, recharge, and baseflow.

Rainfed cropland areas are defined as all cropland areas that are purely dependent of direct precipitation (rainfall or snowfall and its subsequent melt creating moisture) on the farm fields that provide adequate moisture\water for plant growth and productivity throughout the crop growing season. These cropland areas are overwhelmingly located in upland landscapes.

One must note that the baseline cropland extent (that includes both irrigated and rainfed croplands) was used from the global cropland extent product at 30m or GCEP30 ((Thenkabail et al., 2021), which is part of the GFSAD30 project. The GCEP30 product formed the baseline for LGRIP30. For the entire GFSAD30 project, cropland extent was defined as: "*lands cultivated with plants harvested for food, feed, and fiber, including both seasonal crops (e.g., wheat, rice, corn, soybeans, cotton) and continuous plantations (e.g., coffee, tea, rubber, cocoa, oil palms). Cropland fallows are lands uncultivated during a season or a year but are farmlands and are equipped for cultivation, including plantations (e.g., orchards, vineyards, coffee, tea, rubber)*" (Teluguntla et al., 2015). Cropland extent includes all planted crops and fallowed lands. Non-croplands include all other land cover classes other than croplands and cropland fallows. However, in establishing LGRIP30, we added cropland areas missing from the GCEP30 map product.

How to access the dataset?
All GFSAD30 products will be downloadable through LP DAAC Data Pool and NASA Earthdata Search, including the **GFSADLGRIP30WORLD** product. The product is divided into 10x10 degree tiles for download but can also be visualized at www.croplands.org by going to the "products" drop-down menu.

Is the data available through Google Earth Engine (GEE)?
No. not currently. LP DAAC is the only source of the LGRIP30 product. In future, we may make the data available through GEE (please contact PI of the project: Prasad S. Thenkabail)

4.0 Dataset Access (Applicable Data Tools)

The **GFSADLGRIP30WORLD** dataset is available to download through the Land Processes Distributed Active Archive Center (LP DAAC). GFSADLGRIP30WORLD data visualization and information are also made available at our Global Croplands Website: https://croplands.org

5.0 Contact Information

LP DAAC User Services
U.S. Geological Survey (USGS)
Center for Earth Resources Observation and Science (EROS)
47914 252nd Street
Sioux Falls, SD 57198-0001

Phone Number: 605-594-6116
Toll Free: 866-573-3222 (866-LPE-DAAC)
Fax: 605-594-6963
Email: lpdaac@usgs.gov
Web: https://lpdaac.usgs.gov

For the Principal Investigators, feel free to write to:
Prasad S. Thenkabail at pthenkabail@usgs.gov

For the GFSAD Landsat-derived Global Rainfed and Irrigated-Cropland Product at nominal 30m of the World (GFSADLGRIP30WORLD), please contact:
Pardhasaradhi Teluguntla at pteluguntla@usgs.gov
Prasad S. Thenkabail at pthenkabail@usgs.gov
Adam Oliphant at aloiphant@usgs.gov

More details about the GFSAD30 project and products can be found at:
www.globalcroplands.org
www.usgs.gov/wgsc/gfsad30

6.0 Citations

6.1 GFSADLGRIP30WORLD

Teluguntla, P., Thenkabail, P., Oliphant, A., Gumma, M., Aneece, I., Foley, D., and Mccormick, R. (2023). The GFSAD Landsat-derived Global Rainfed and Irrigated-Cropland Product at nominal 30m of the World (GFSADLGRIP30WORLD). NASA EOSDIS Land Processes DAAC. IP-148728. DOI: https://doi.org/10.5067/Community/LGRIP/LGRIP30.001

Publications

7.1 Peer-reviewed publications relevant to this study

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https://lpdaac.usgs.gov/news/release-of-gfsad-30-meter-cropland-extent-products/ IP-119164.
Digital Object Identifier (DOI) of accompanying data release:
https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30AFCE.001
https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30AUNZCNMOCE.001
https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30EUCEARUMECE.001
https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30NACE.001
https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30SAAFGIRCE.001
https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30SACE.001
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https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD30VAL.001

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Link to this article: http://dx.doi.org/10.1016/j.isprsjprs.2017.01.019

Massey, R., Sankey, T.T., Congalton, R.G., Yadav, K., Thenkabail, P.S., Ozdogan, M., Sánchez Meador, A.J. 2017. MODIS phenology-derived, multi-year distribution of conterminous U.S. crop types, Remote Sensing of Environment, Volume 198, 1 September 2017, Pages 490-503, ISSN 0034-4257, https://doi.org/10.1016/j.rse.2017.06.033 , IP-081309.

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7.3 Web sites and Data portals:

www.usgs.gov/wgsc/gfsad30
www.croplands.org
https://lpdaac.usgs.gov/news/release-of-gfsad-30-meter-cropland-extent-products/
https://lpdaac.usgs.gov/products/gfsad1kcdv001/
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7.4 Other relevant past publications prior to GFSAD project

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