NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) Global Food Security-support Analysis Data (GFSAD) 1 km datasets

User Guide

Version 1.0

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Document History

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Contents

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1.0 Dataset Overview

This Global Food Security-support Analysis Data (GFSAD) at nominal 1 km result from a collaborative effort by the National Aeronautics and Space Administration (NASA) and the United States Geological Survey (USGS), to provide global cropland data that contributes towards global food security in the twenty-first century.

1.1   Background

Monitoring global croplands is imperative for ensuring sustainable water and food security for people of the world in the twenty-first century. Currently, available cropland products suffer from major limitations. These include: absence of precise spatial location of the cropped areas; coarse resolution nature of the map products with significant uncertainties in areas, locations, and detail; uncertainties in differentiating irrigated areas from rainfed areas; absence of crop types and cropping intensities; and absence of a dedicated web\data portal for the dissemination of cropland products. This project aims to address these gaps.

The GFSAD products at 1 km resolution include the Crop Dominance (CD) product (GFSAD1KCD) and Crop Mask (CM) product (GFSAD1KCM). The GFSAD1KCD and GFSAD1KCM are produced for nominal year 2010 and are produced for one time with input data ranging for years 2007 through 2012.

Both products were created with specific and differing purposes in mind and should be used for that purpose only and not be compared.

First, the Global Crop Extent (GCE) 1 km Crop Dominance (Thenkabail et al., 2012, Thenkabail et al., 2011, Thenkabail et al., 2009a, 2009b) provides cropland extent, irrigated vs. rainfed, and crop dominance. Note that the GCE 1 km Crop Dominance provides spatial distribution of the five major global cropland types (wheat, rice, corn, barley and soybeans; which occupy 60% of all global cropland areas) at nominal 1 km (GCE 1 km Crop Dominance). The map is produced by overlying the five dominant crops of the world produced by Ramankutty et al. (2008), Monfreda et al. (2008), and Portman et al. (2009) over the remote sensing derived global irrigated and rainfed cropland area map of the International Water Management Institute (IWMI; Thenkabail et al., 2009a, 2009b, 2011, Biradar et al., 2009). Input data used in these various products include remote sensing (e.g., AVHRR, SPOT vegetation, MODIS), crop type distribution, secondary (e.g., elevation), climate (e.g., 50-year precipitation, 20-year temperature), reference (e.g., sub-meter to 5-m imagery, ground data), and statistics (e.g., country statistics) data were used. Detailed methodology and other descriptions are presented in numerous publications (Thenkabail et al., 2012, Thenkabail, 2012, Thenkabail et al., 2011, Thenkabail et al., 2009a, 2009d, Biradar et al., 2009, Thenkabail and Lyon, 2009, Turral et al., 2009, Dheeravath et al., 2010, Velpuri et al., 2010, Thenakabail et al., 2009c, Thenkabail et al., 2009b, 2009c, Thenkabail et al., 2007a, 2007b, Thenkabail et al., 2006, Biggs et al., 2006, Gangalakunta et al., 2009, Li et al., 2009).

Second, GCE 1 km Multi-study Crop Mask provides cropland extent, irrigated vs. rainfed. Note that the spatial distribution of a disaggregated five class global cropland extent map derived at nominal 1 km based on four major studies: Thenkabail et al. (2009a, 2011), Pittman et al. (2010), Yu et al. (2013), and Friedl et al. (2010). Classes 1 to Class 5 are cropland classes that are dominated by irrigated and rainfed agriculture. Class 4 to and Class 5 have minor/very minor fractions of croplands. *Irrigation major*: areas irrigated by large reservoirs created by large and medium dams, barrages, and even large ground water pumping. *Irrigation minor*: areas irrigated by small reservoirs, irrigation tanks, open wells, and other minor irrigation. However, it is very hard to draw a strict boundary

between major and minor irrigations and in places, there can be significant mixing. For example, major irrigated areas such as the Ganges basin, California's central valley, Nile basin, and other major command areas (e.g, several major and medium reservoirs for the Krishna basin in India, numerous major and medium irrigation in China), are clearly distinguishable. Input data used in these various products include remote sensing (e.g., Landsat, MODIS, AVHRR, SPOT vegetation), secondary (e.g., elevation), climate (e.g., 50-year precipitation, 20-year temperature), reference (e.g., sub-meter to 5-m imagery, ground data), and statistics (e.g., country statistics) data were used.

Figure 1. Crop Dominance (CD) product (GFSAD1KCD). Classes 1 to 3 are croplands that are irrigated. Classes 4 to 7 are croplands that are rainfed. Class 8 is overwhelmingly non-croplands, but have very small fractions of croplands (refer to Thenkabail et al., 2012). Each class has some combination of croplands dominating in them.
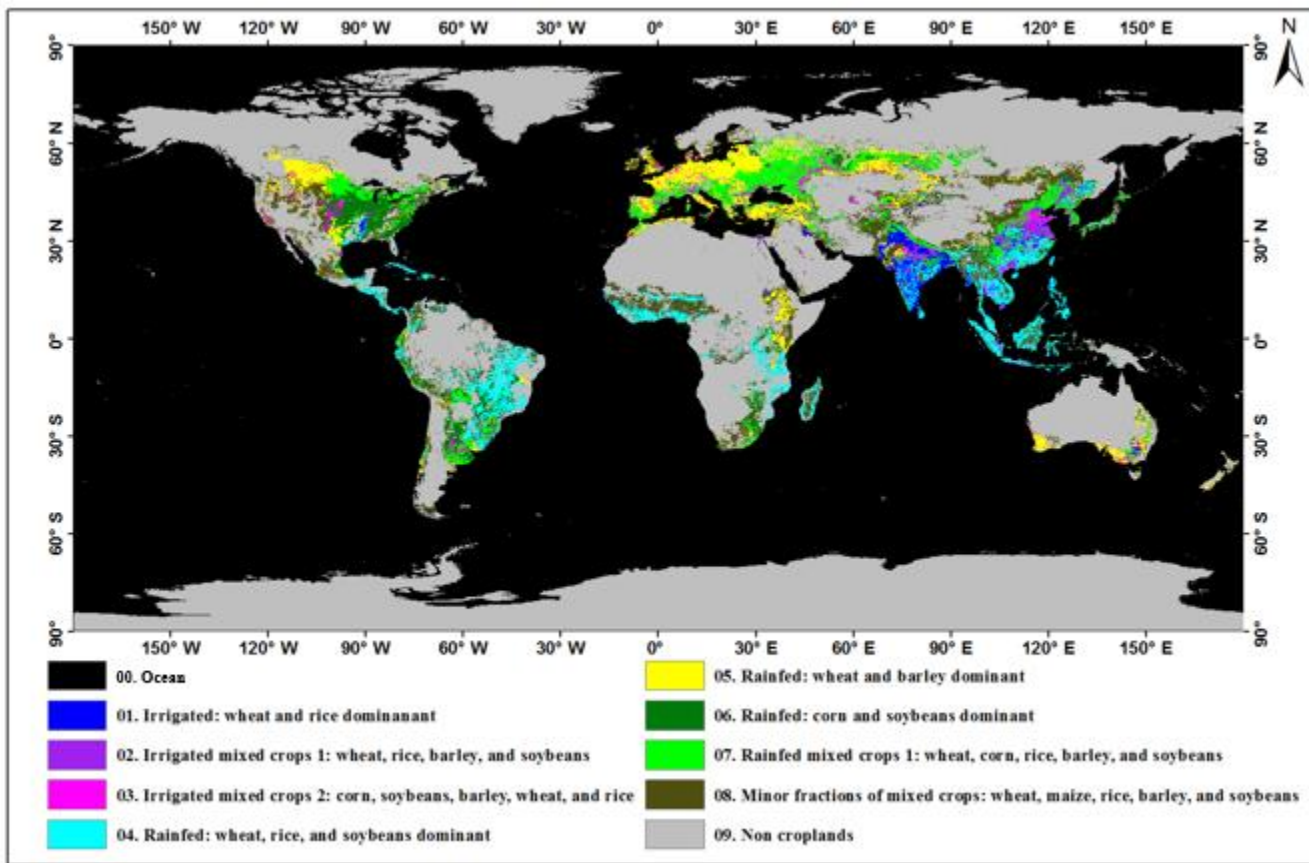

■ 00. Ocean	▢ 05. Rainfed: wheat and barley dominant
■ 01. Irrigated: wheat and rice dominanant	■ 06. Rainfed: corn and soybeans dominant
■ 02. Irrigated mixed crops 1: wheat, rice, barley, and soybeans	■ 07. Rainfed mixed crops 1: wheat, corn, rice, barley, and soybeans
■ 03. Irrigated mixed crops 2: corn, soybeans, barley, wheat, and rice	■ 08. Minor fractions of mixed crops: wheat, maize, rice, barley, and soybeans
■ 04. Rainfed: wheat, rice, and soybeans dominant	▢ 09. Non croplands

Figure 1 Crop Dominance

Figure 2. Crop Mask (CM) product (GFSAD1KCM). A disaggregated five class global cropland extent map derived at nominal 1 km based on four major studies: Thenkabail et al. (2009a, 2011), Pittman et al. (2010), Yu et al. (2013), and Friedl et al. (2010). Classes 1–5 are cropland classes that are dominated by irrigated and rain-fed agriculture. However, Class 4 and Class 5 have ONLY minor or very minor fractions of croplands.
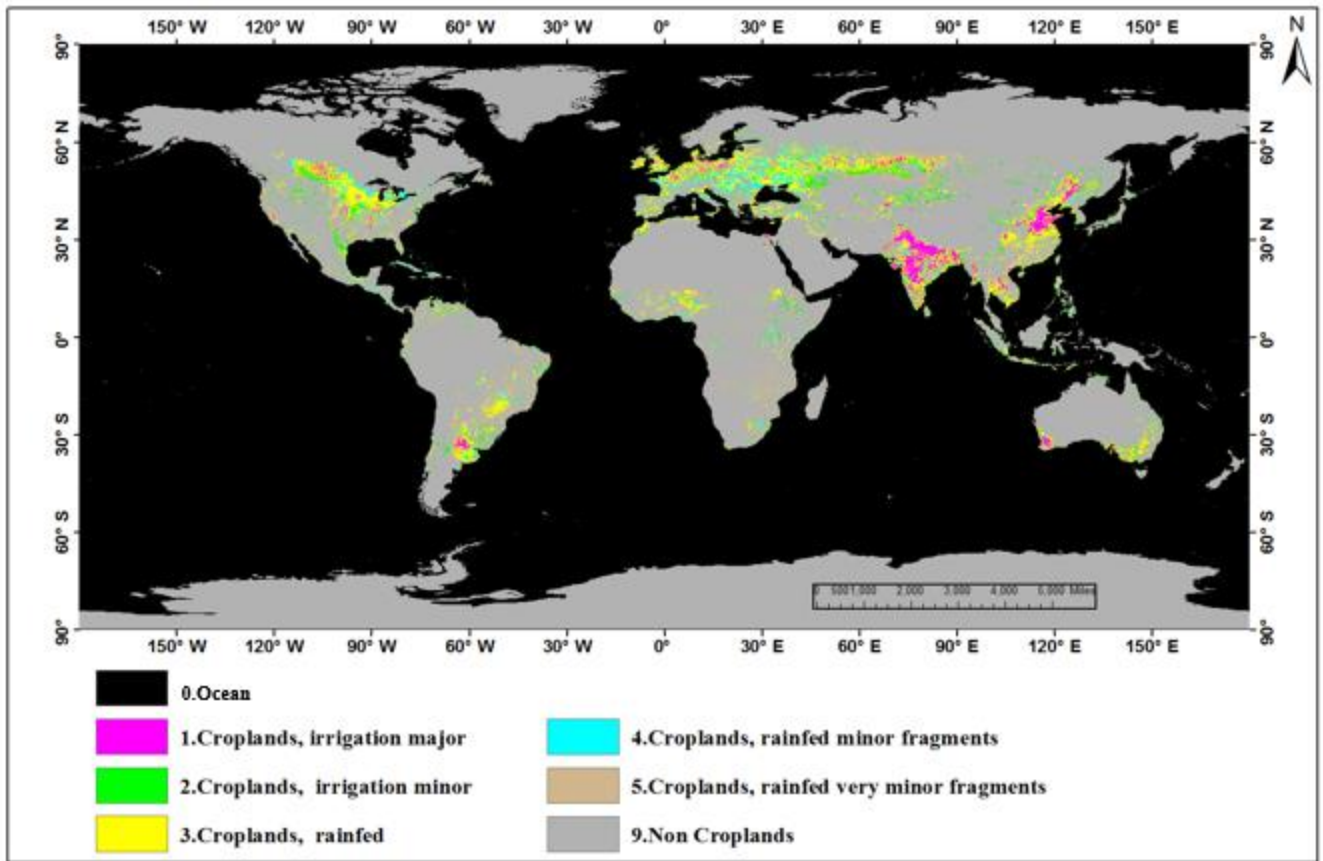
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Figure 2 Crop Mask

2.0 Dataset Characteristics

GFSAD 1 km datasets and characteristics are described below.

2.1 Global Food Security Support Analysis Data (GFSAD) Crop Dominance 2010 Global 1 km V001

2.1.1 Collection Level

Short name	GFSAD1KCD
Temporal Granularity	Static
Temporal Extent	2010, nominal
Spatial Extent	Global
File size	~28 MB
Coordinate System	Geographic
Datum	WGS84
File Format	GeoTIFF

2.1.2 Granule Level

Number of Layers	1
Columns/Rows	40430 x 20160
Pixel Size	~1 km

2.1.3 Data Layers

Layer	Data Type	No Data	Classes
Crop Dominance	Byte	0	1 to 9

2.1.4 Data Layers Classification

Class Label	Class Name	Description
1	Irrigated	Wheat and Rice
2	Irrigated Mixed Crops 1	Wheat, Rice, Barley, Soybeans
3	Irrigated Mixed Crops 2	Wheat, Rice, Cotton, Orchards
4	Rainfed	Wheat, Rice, Soybeans, Sugarcane, Corn, Cassava
5	Rainfed	Wheat, Barley
6	Rainfed	Corn, Soybeans

7	Rainfed Mixed Crops	Wheat, Corn, Rice, Barley, Soybeans
8	Fractions of Mixed Crops	Wheat, Maize, Rice, Barley, Soybeans
9	Non-Cropland	Non-Cropland areas

2.1.5   Filename Convention

GFSAD1KCD.2010.001.2016348142525.tif
GFSAD = Project
1K = 1 km Resolution
CD = Crop Dominance
2010 = Year
001 = Version
2016348142525 = Processing Date in YYYYJJJHHMMSS (JJJ = Julian Date)

2.2   Global Food Security Support Analysis Data (GFSAD) Crop Mask 2010 Global 1 km V001

2.2.1   Collection Level

Short name	GFSAD1KCM
Temporal Granularity	Static
Temporal Extent	2010, nominal
Spatial Extent	Global
File size	~34 MB
Coordinate System	Geographic
Datum	WGS84
File Format	GeoTIFF

2.2.2   Granule Level

Number of Layers	2
Columns/Rows	40457 x 20188
Pixel Size	~1 km

2.2.3   Data Layers

Layer	Data Type	No Data	Classes
Crop Mask	Byte	0	1 to 5, 9

2.2.4   Data Layers Classification

Class Label	Class Name	Description
1	Croplands, Irrigation	Irrigation Major
2	Croplands, Irrigation	Irrigation Minor
3	Croplands, Rainfed	Rainfed
4	Croplands, Rainfed	Rainfed, Minor Fragments
5	Croplands, Rainfed	Rainfed, Very Minor Fragments
9	Non-Cropland	Non-Cropland areas

2.2.5   Filename Convention

GFSAD1KCM.2010.001.2016348142550.tif
GFSAD = Project
1K = 1 km Resolution
CM = Crop Mask
2010 = Year
001 = Version
2016348142550 = Processing Date in YYYYJJJHHMMSS (JJJ = Julian Date)

3.0 Dataset Knowledge

The following questions address user information regarding the GFSAD 1 km collection.

3.1   Frequently Asked Questions

What do GFSAD 1 km Crop Dominance and GFSAD 1 km Crop Mask products contain?

They provide cropland information for the entire world at nominal 1 km. Both products have cropland extent. They also provide information on watering methods (irrigated versus rainfed). GFSAD 1 km Crop Dominance product also provides crop dominance.

How are in GFSAD 1 km Crop Dominance and GFSAD 1 km Multi-study Crop Mask calculated?

Both products are created with specific purpose and should be used for that purpose only (they should not be compared).

First, the GFSAD 1 km Crop Dominance provides cropland extent, irrigated vs. rainfed, and crop dominance. Note that the GFSAD1 km Crop Dominance provides spatial distribution of the five major global cropland types (wheat, rice, corn, barley and soybeans; which occupy 60% of all global cropland areas) at nominal 1 km (GFSAD 1 km Crop Dominance). The map is produced by overlying the five dominant crops of the world produced by Ramankutty et al. (2008), Monfreda et al. (2008),

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and Portman et al. (2009) over the remote sensing derived global irrigated and rainfed cropland area map of the International Water Management Institute (IWMI; Thenkabail et al., 2009a, 2009b, 2011).

Second, GFSAD 1 km Multi-study Crop Mask provides cropland extent, irrigated vs. rainfed. Note that the spatial distribution of a disaggregated five class global cropland extent map derived at nominal 1 km based on four major studies: Thenkabail et al. (2009a, 2011), Pittman et al. (2010), Yu et al. (2013), and Friedl et al. (2010). Classes 1 to Class 5 are cropland classes, that are dominated by irrigated and rainfed agriculture. Class 4 to and Class 5 have minor/very minor fractions of croplands.

Can we get cropping intensity from these products?

Yes!. All you need to do is use the time-series Normalized Difference Vegetation Index (NDVI) corresponding to this data and generate the same. For example, for the entire world corresponding to these products you can use time-series NDVI datasets such as the AVHRR monthly NDVI time-series from 1982-2000 to generate intensity. A simple example is to take a pixel (e.g. in class 1) and use the time-series NDVI data such as AVHRR monthly NDVI data to derive intensity. A user can request us a mega file data cube of 20 year AVHRR NDVI time-series available with us for the purpose or use GIMMS data which is for 33 years monthly NDVI time series. Similarly you can generate intensity of croplands using any other time-series data (e.g., Moderate Resolution Imaging Spectroradiometer (MODIS) 250 m monthly NDVI data from 2000-present).

The Crop Dominance layer contains information on the spatial distribution of the five major global cropland types (1. wheat; 2. rice; 3. corn; 4. barley; 5. soybeans). In class 8 of this product (Crop Dominance) maize is included as a crop type. What is the explanation for the discrepancy?

True that the focus of crop dominance product was five crops: 1. wheat; 2. rice; 3. corn; 4. barley; 5. soybeans. Please understand that all 8 classes of this product, including class 8, only provide crop dominance. No class provides crop type as that is simply not possible at this resolution.

4.0 Dataset Access (Applicable Data Tools)

The GFSAD1KCD and GFSAD1KCM datasets are available through the Land Processes Distributed Active Archive Center (LP DAAC).

The GFSAD1KCD dataset landing page including data access and further information can be found at lpdaac.usgs.gov under Dataset Discovery / Enter Term GFSAD1KCD.

The GFSAD1KCM dataset landing page including data access and further information can be found at lpdaac.usgs.gov udner Dataset Discovery / Enter Term GFSAD1KCM.

GFSAD data visualization and information can also be found at Global Croplands: globalcroplands.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
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For the Principal Investigators, feel free to write to:

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Jun Xiong at jxiong@usgs.gov

More details about the GFSAD project and products can be found at: globalcroplands.org

6.0 Citations

6.1   GFSAD1KCD

DOI: 10.5067/MEaSUREs/GFSAD/GFSAD1KCD.001

P. Thenkabail, P. Teluguntla, J Xiong, A. Oliphant, R. Massey (2016). NASA MEaSUREs Global Food Security Support Analysis Data (GFSAD) Crop Dominance 2010 Global 1 km V001. NASA EOSDIS Land Processes DAAC. Retrieved from https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD1KCD.001

If a GFSAD 1 KM product generated graphic or browse image is used, please insert the text "GFSAD1KCD" somewhere that is clearly visible.

6.2   GFSAD1KCM

DOI: 10.5067/MEaSUREs/GFSAD/GFSAD1KCM.001

P. Thenkabail, P. Teluguntla, J Xiong, A. Oliphant, R. Massey (2016). NASA MEaSUREs Global Food Security Support Analysis Data (GFSAD) Crop Mask 2010 Global 1 km V001. NASA EOSDIS Land Processes DAAC. Retrieved from https://doi.org/10.5067/MEaSUREs/GFSAD/GFSAD1KCM.001

If a GFSAD 1 km product generated graphic or browse image is used, please insert the text "GFSAD1KCM" somewhere that is clearly visible.

7.0 Publications

7.1   Peer-reviewed publications

Biggs, T., Thenkabail, P.S., Krishna, M., GangadharaRao, P., and Turral, H., 2006. Vegetation phenology and irrigated area mapping using combined MODIS time-series, ground surveys, and agricultural census data in Krishna River Basin, India. International Journal of Remote Sensing. 27(19):4245-4266.

Biradar, C.M., Thenkabail, P.S., Noojipady, P., Yuanjie, L., Dheeravath, V., Velpuri, M., Turral, H., Gumma, M.K., Reddy, O.G.P., Xueliang, L. C., Schull, M.A., Alankara, R.D., Gunasinghe, S., Mohideen, S., Xiao, X. 2009. A global map of rainfed cropland areas (GMRCA) at the end of last millennium using remote sensing. International Journal of Applied Earth Observation and Geoinformation. 11(2). 114-129. doi:10.1016/j.jag.2008.11.002. January, 2009.

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Thenkabail, P.S. 2012. Special Issue Foreword. Global Croplands special issue for the August 2012 special issue for Photogrammetric Engineering and Remote Sensing. PE&RS. 78(8): 787-788. Thenkabail, P.S. 2012. Guest Editor for Global Croplands Special Issue. Photogrammetric Engineering and Remote Sensing. PE&RS. 78(8).

Thenkabail, P.S., Biradar C.M., Noojipady, P., Cai, X.L., Dheeravath, V., Li, Y.J., Velpuri, M., Gumma, M., Pandey., S. 2007a. Sub-pixel irrigated area calculation methods. *Sensors Journal (special issue:* Remote Sensing of Natural Resources and the Environment (Remote Sensing SensorsEdited by Assefa M. Melesse)*. 7:2519-2538.* http://www.mdpi.org/sensors/papers/s7112519.pdf.

Thenkabail, P.S., Biradar C.M., Noojipady, P., Dheeravath, V., Li, Y.J., Velpuri, M., Gumma, M., Reddy, G.P.O., Turral, H., Cai, X. L., Vithanage, J., Schull, M., and Dutta, R. 2009a. Global irrigated area map (GIAM), derived from remote sensing, for the end of the last millennium. International Journal of Remote Sensing. 30(14): 3679-3733. July, 20, 2009.

Thenkabail, P.S., Biradar, C.M., Turral, H., Noojipady, P., Li, Y.J., Vithanage, J., Dheeravath, V., Velpuri, M., Schull M., Cai, X. L., , Dutta, R. 2006. An Irrigated Area Map of the World (1999) derived from Remote Sensing. Research Report # 105. International Water Management Institute. Pp. 74. Also, see under documents in: http://www.iwmigiam.org.

Thenkabail, P. S.; Dheeravath, V.; Biradar, C. M.; Gangalakunta, O. P.; Noojipady, P.; Gurappa, C.; Velpuri, M.; Gumma, M.; Li, Y. 2009b. Irrigated Area Maps and Statistics of India Using Remote Sensing and National Statistics. Journal Remote Sensing. 1:50-67. http://www.mdpi.com/2072-4292/1/2/50.

Thenkabail, P.S., GangadharaRao, P., Biggs, T., Krishna, M., and Turral, H., 2007b. Spectral Matching Techniques to Determine Historical Land use/Land cover (LULC) and Irrigated Areas using Time-series AVHRR Pathfinder Datasets in the Krishna River Basin, India. Photogrammetric Engineering and Remote Sensing. 73(9): 1029-1040. (Second Place Recipients of the 2008 John I. Davidson ASPRS President's Award for Practical papers).

Thenkabail P.S., Hanjra M.A., Dheeravath V., Gumma M. A. 2010. A Holistic View of Global Croplands and Their Water Use for Ensuring Global Food Security in the 21st Century through Advanced Remote Sensing and Non-remote Sensing Approaches. Remote Sensing open access journal. 2(1):211-261. doi:10.3390/rs2010211. http://www.mdpi.com/2072-4292/2/1/211

Thenkabail P.S., Knox J.W., Ozdogan, M., Gumma, M.K., Congalton, R.G., Wu, Z., Milesi, C., Finkral, A., Marshall, M., Mariotto, I., You, S. Giri, C. and Nagler, P. 2012. Assessing future risks to agricultural productivity, water resources and food security: how can remote sensing help? Photogrammetric Engineering and Remote Sensing, August 2012 Special Issue on Global Croplands: Highlight Article. 78(8): 773-782.

Thenkabail, P.S., Schull, M., Turral, H. 2005. Ganges and Indus River Basin Land Use/Land Cover (LULC) and Irrigated Area Mapping using Continuous Streams of MODIS Data. Remote Sensing of Environment. Remote Sensing of Environment, 95(3): 317-341.

Velpuri, M., Thenkabail, P.S., Gumma, M.K., Biradar, C.B., Dheeravath, V., Noojipady, P., Yuanjie, L., 2009. Influence of Resolution or Scale in Irrigated Area Mapping and Area Estimations. Photogrammetric Engineering and Remote Sensing (PE&RS). 75(12): December 2009 issue.

7.2   Books and Book Chapters

Biradar, C.M., Thenkabail. P.S., Noojipady, P., Li, Y.J., Dheeravath, V., Velpuri, M., Turral, H., Cai, X.L., Gumma, M., Gangalakunta, O.R.P., Schull, M., Alankara, R.D., Gunasinghe, S., and Xiao, X. 2009. Book Chapter 15: Global map of rainfed cropland areas (GMRCA) and stastistics using remote sensing. Pp. 357-392. In the book entitled: "Remote Sensing of Global Croplands for Food Security" (CRC Press- Taylor and Francis group, Boca Raton, London, New York. Pp. 475. Published in June, 2009. (Editors: Thenkabail. P., Lyon, G.J., Biradar, C.M., and Turral, H.).

Gangalakunta, O.R.P., Dheeravath, V., Thenkabail, P.S., Chandrakantha, G., Biradar, C.M., Noojipady, P., Velpuri, M., and Kumar, M.A. 2009. Book Chapter 5: Irrigated areas of India derived from satellite sensors and national statistics: A way forward from GIAM experience. Pp. 139-176. In the book entitled: "Remote Sensing of Global Croplands for Food Security" (CRC Press- Taylor and Francis group, Boca Raton, London, New York. Pp. 475. Published in June, 2009. (Editors: Thenkabail. P., Lyon, G.J., Biradar, C.M., and Turral, H.).

Li, Y.J., Thenkabail, P.S., Biradar, C.M., Noojipady, P., Dheeravath, V., Velpuri, M., Gangalakunta, O.R., Cai, X.L. 2009. Book Chapter 2: A history of irrigated areas of the world. Pp. 13-40. In the book entitled: "Remote Sensing of Global Croplands for Food Security" (CRC Press- Taylor and Francis group, Boca Raton, London, New York. Pp. 475. Published in June, 2009. (Editors: Thenkabail. P., Lyon, G.J., Biradar, C.M., and Turral, H.).

Teluguntla, P., Thenkabail, P.S., Xiong, J., Gumma, M.K., Giri, C., Milesi, C., Ozdogan, M., Congalton, R., Tilton, J., Sankey, T.R., Massey, R., Phalke, A., and Yadav, K. 2015. Global Food Security Support Analysis Data at Nominal 1 km (GFSAD1 km) Derived from Remote Sensing in Support of Food Security in the Twenty-First Century: Current Achievements and Future Possibilities, Chapter 6. In Thenkabail, P.S., (Editor-in-Chief), 2015. "Remote Sensing Handbook" (Volume II): Land Resources Monitoring, Modeling, and Mapping with Remote Sensing. Taylor and Francis Inc.\CRC Press, Boca Raton, London, New York. ISBN 9781482217957 - CAT# K22130. Pp. 131-160.

Thenkabail, P.S., Lyon, G.J., and Huete, A. 2011. Book Chapter # 1: Advances in Hyperspectral Remote Sensing of Vegetation. In Book entitled: "Remote Sensing of Global Croplands for Food Security" (CRC Press- Taylor and Francis group, Boca Raton, London, New York. Edited by Thenkabail, P.S., Lyon, G.J., and Huete, A. Pp. 3-38.

Thenkabail. P.S., Biradar, C.M., Noojipady, P., Dheeravath, V., Gumma, M., Li, Y.J., Velpuri, M., Gangalakunta, O.R.P. 2009c. Book Chapter 3: Global irrigated area maps (GIAM) and statistics using remote sensing. Pp. 41-120. In the book entitled: "Remote Sensing of Global Croplands for Food Security" (CRC Press- Taylor and Francis group, Boca Raton, London, New York. Pp. 475. Published in June, 2009. (Editors: Thenkabail. P., Lyon, G.J., Biradar, C.M., and Turral, H.).

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Reviews of this book: http://www.crcpress.com/product/isbn/9781420090093
http://gfmt.blogspot.com/2011/05/review-remote-sensing-of-global.html

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Turral, H., Thenkabail, P.S., Lyon, J.G., and Biradar, C.M. 2009. Book Chapter 1: Context, need: The need and scope for mapping global irrigated and rain-fed areas. Pp. 3-12. In the book entitled: "Remote Sensing of Global Croplands for Food Security" (CRC Press- Taylor and Francis group, Boca Raton, London, New York. Pp. 475. Published in June, 2009. (Editors: Thenkabail. P., Lyon, G.J., Biradar, C.M., and Turral, H.).