September 2017
Version 1.0

NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) Global Food Security-support Analysis Data (GFSAD) @ 30-m for South Asia, Afghanistan and Iran: Cropland Extent Product (GFSAD30SAAFGIRCE)

User Guide

Document History

Document Version	Publication Date	Description
1.0	September, 2017	Original
1.1	October 2017	Modifications made according to USGS reviewers comments

Contents

1.0 Dataset Overview

The goal of the Global Food Security-support Analysis Data @ 30-m (GFSAD30) is to provide highest resolution, objective cropland datasets to assist and address global food and water security issues of the twenty-first century. The project proposed developing cropland products using time-series Landsat and Sentinel satellite sensor data, machine learning algorithms, and cloud computing. The project is funded by the National Aeronautics and Space Administration (NASA) with supplemental funding from the United States Geological Survey (USGS). The project is led by USGS and carried out in collaboration with NASA AMES, University of New Hampshire (UNH), California State University Monterey Bay (CSUMB), University of Wisconsin (UW), NASA GSFC, and Northern Arizona University (NAU). There were a number of International partners, including The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

This user guide provides guidelines of the GFSAD30 cropland extent product for the countries of South Asia, Afghanistan and Iran (GFSAD30SAAFGIRCE) at nominal 30m in 2015. The Coordinate Reference System (CRS) used for the GFSAD30SAAFGIRCE 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 as 10^o x 10^o tiles in GeoTIFF format. The year, resolution, tiling, and file name convention details are provided in section 2.0 of this document.

1.1 Background

Monitoring global croplands (GCs) is imperative for ensuring sustainable water and food security to the people of the world in the twenty-first century. However, the currently available cropland products suffer from major limitations such as: (a) Absence of precise spatial location of the cropped areas; (b) Coarse resolution nature of the map products with significant uncertainties in areas, locations, and detail; (c) Uncertainties in differentiating irrigated areas from rainfed areas; (d) Absence of crop types and cropping intensities; and (e) Absence of a dedicated web\data portal for the dissemination of cropland products. Therefore, our project aims to close these gaps through Global food security support-analysis data @ 30-m (GFSAD30).

Satellite-derived cropland extent maps at high spatial resolution are necessary for food and water security analysis. Therefore, GFSAD30SAAFGIRCE cropland extent products were produced at a resolution of 30-m for the countries of South Asia, Afghanistan and Iran for the nominal year 2015 using Landsat-8 time-series data. These data are part of a global data release; thereby each region will be made publically available. Global cropland extent maps, indicating cropland and non-cropland areas, provide working baseline data to develop high-level products such as crop watering method (irrigated or rainfed), cropping intensities (e.g., single, double, or continuous cropping), crop type mapping, cropland fallows, as well as assessment of cropland productivity (productivity per unit of land), and crop water productivity (productivity per unit of water or "crop per drop"). Uncertainties associated with cropland extent maps have a cascading effect on all higher-level cropland products.

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

For a very 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 GFSAD30SAAFGIRCE.

2.0 Dataset Characteristics

Global food security-support analysis data @ 30-m cropland extent for the countries of South Asia, Afghanistan and Iran (GFSAD30SAAFGIRCE) datasets and characteristics described below.

2.1 Global Food Security Support Analysis Data (GFSAD) 30-m V001

2.1.1 Collection Level

Short name	GFSAD30SAAFGIRCE
Temporal Granularity	Static
Temporal Extent	2015, nominal
Spatial Extent	South Asia, Afghanistan and Iran
File size	~800 MB
Coordinate System	Geographic
Datum	WGS84
File Format	GeoTIFF

2.1.2 Granule Level

Number of Layers	1
Columns/Rows	307053 x 272312
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	Crop Extent for South Asia, Afghanistan, and Iran	N/A	8-bit un-signed in-teger	N/A	0,1, 2	N/A

2.1.4 Data Layers Classification

Class Label	Class Name	Description
0	Water	Ocean and Water bodies
1	Non-Cropland	Non-Cropland areas
2	Cropland	Cropland and cropland fallows

2.1.4 Filename Convention

GFSAD30SSAAFGIRCE_2015_N40E50_001_20172612030105.tif
GFSAD30SAAFGIR = Product Short name
SA = South Asia
AFGIR = Afghanistan, Iran
CE = Crop Extent
30 = 30 m Spatial Resolution
2015 = Nominal Year
N40E50= 10 x 10 degree grid, starting at (N40, E50)
001 = Version
20172612030105 = Processing Date in YYYYJJJHHMMSS

3.0 Dataset Knowledge

The following questions addresses the user information regarding the **GFSAD30SSAAF-GIRCE** collection.

3.1 Frequently Asked Questions

What does the GFSAD30SSAAFGIRCE product contain?

They provide cropland extent product for the countries of South Asia, Afghanistan and Iran at nominal 30-m.

What is the accuracy of the GFSAD30SAAFGIRCE product?

For the entire study region with all 6 zones combined, the overall accuracies were 84.5% with producer's accuracy of 74.8% (errors of omissions of 25.2%) and user's accuracy of 82.0% (errors of commissions of 18%) (Table 6) for cropland class. These results mean, there is 25.2% missing croplands and 18% non-croplands mapped as croplands. These errors of omissions and commissions, somewhat balance themselves, but the goal must be to increase producer's accuracies and reduce user's accuracies. When considering all 6 zones, the overall accuracies ranged between 76% -96%, producer's accuracies ranged between 71-85% except for zone 2 (33.3%) and zone 6 (48.4%); and user's accuracies ranged between 56-86% (Table 5). Zones that included a larger proportion of croplands had high overall, user's, and producer's accuracies. These results clearly imply the high level of confidence in differentiating croplands from non-croplands for the South Asia region.

Zone#1		Reference Data: Crop	Reference Data: No-Crop	Total	User Accuracy
Map Data	Crop	42	32	74	56.76%
	No-Crop	17	159	176	90.34%
Total		59	191	250	
Producer Accuracy		71.19%	83.25%		**80.40%**

Zone#2		Reference Data: Crop	Reference Data: No-Crop	Total	User Accuracy
Map Data	Crop	4	3	7	57.14%
	No-Crop	8	235	243	96.71%
Total		12	238	250	
Producer Accuracy		33.33%	98.74%		**95.60%**

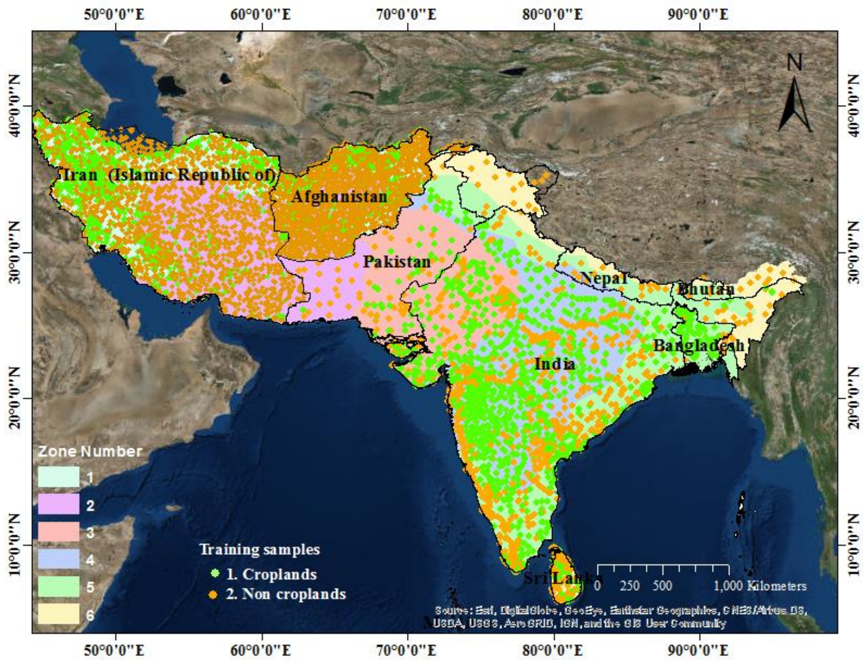
Zone#3		Reference Data: Crop	Reference Data: No-Crop	Total	User Accuracy
Map Data	Crop	111	19	130	85.38%
	No-Crop	40	80	120	66.67%
Total		151	99	250	
Producer Accuracy		73.51%	80.81%		**76.40%**

Zone#4		Reference Data: Crop	Reference Data: No-Crop	Total	User Accuracy
Map Data	Crop	140	18	158	88.61%
	No-Crop	24	67	91	73.63%
Total		164	85	249	
Producer Accuracy		85.37%	78.82%		**83.13%**

Zone#5		Reference Data: Crop	Reference Data: No-Crop	Total	User Accuracy
Map Data	Crop	104	17	121	85.95%
	No-Crop	36	92	128	71.88%
Total		140	109	249	
Producer Accuracy		74.29%	84.40%		**78.71%**

Zone#6		Reference Data: Crop	Reference Data: No-Crop	Total	User Accuracy
Map Data	Crop	15	3	18	83.33%
	No-Crop	16	216	232	93.10%
Total		31	219	250	
Producer Accuracy		48.39%	98.63%		**92.40%**

Combined		Reference Data: Crop	Reference Data: No-Crop	Total	User Accuracy
Map Data	Crop	418	92	510	81.96%
	No-Crop	141	849	990	85.76%
Total		559	941	1,500	
Producer Accuracy		74.78%	90.22%		**84.47%**



What is the definition of the crop extent?
For the entire Global Food Security-Support Analysis Data project at 30-m (GFSAD30) project, cropland extent was defined as: "*lands cultivated with plants harvested for food, feed, and fiber, include 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.

How to access the dataset?
All the GFSAD30 products will be downloadable through the Land Processes Distributed Active Archive Center (LP DAAC). The GFSAD30SAAFGIRCE product divided into 10x10 grids, are among them.
You can also visualize this data @ https://croplands.org by going to the "products" drop-down menu.

Is the data available on the Google Earth Engine?
No. Not at this time. In the future, we may make this available on GEE. For this, contact the PI (Prasad S. Thenkabail)

4.0 Dataset Access (Applicable Data Tools)

The **GFSAD30SAAFGIRCE** dataset is available through the LP DAAC Data Pool and NASA Earthdata Search. GFSAD data visualization and information 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 or

For specific to 30-m cropland extent product of South Asia, Afghanistan and Iran, contact:
Prasad S. Thenkabail at pthenkabail@usgs.gov
Pardhasaradhi Teluguntla at pteluguntla@usgs.gov
Murali Krishna Gumma at m.gumma@cgiar.org
Adam Oliphant at aoliphant@usgs.gov
More details about the GFSAD30 project and products can be found at:
globalcroplands.org

6.0 Citations

6.1 GFSAD30SAAFGIRCE

Gumma, M.K., Thenkabail, P.S., Teluguntla, P., Oliphant, A.J., Xiong, J., Congalton, R.G., Yadav, K., Phalke, A., Smith, C. (2017). *NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) Global Food Security-support Analysis Data (GFSAD) Cropland Extent 2015 South Asia, Afghanistan, Iran 30 m V001* [Data set]. NASA EOSDIS Land Processes DAAC. doi: 10.5067/MEaSUREs/GFSAD/GFSAD30SAAFGIRCE.001

7.0 Publications

The following publications are related to the development of the above croplands products:

1. Peer-reviewed publications relevant to this study

Oliphant, A., Thenkabail, P., Teluguntla, P., Xiong, J. Congalton, R., Yadav, K., 2017. Mapping cropland Extent of South East Asia using time-series Landsat 30-m data using Random Forest on Google Earth Engine (GEE) Cloud Computing. In Preparation.

Xiong, J., Thenkabail, P. S., James C. T., Gumma, M. K., Teluguntla, P., Congalton, R. G., Poehnelt, J., Kamini Yadav., et al. (2017). A Nominal 30-m Cropland Extent of Continental Africa Using Sentinel-2 data and Landsat-8 by Integrating Random Forest (SVM) and Hierarchical Segmentation Approach on Google Earth Engine. In press.

Xiong, J., Thenkabail, P. S., Gumma, M. K., Teluguntla, P., Poehnelt, J., Congalton, R. G., et al. (2017). Automated cropland mapping of continental Africa using Google Earth Engine cloud computing. ISPRS Journal of Photogrammetry and Remote Sensing, 126, 225–244.

Teluguntla, P., Thenkabail, P.S., Oliphant, A., Xiong, J., Gumma, M., Congalton, R., and Yadav, K. (2017). 30-m Cropland Extent and Areas of Australia, New Zealand, and China for the Year 2015 Derived using Landsat-8 Time-Series Data for three years (2013-2015) using Random Forest Algorithm on Google Earth Engine Cloud Platform. In preparation.

2. Peer-reviewed publications within GFSAD project

Congalton, R.G., Gu, J., Yadav, K., Thenkabail, P.S., and Ozdogan, M. 2014. Global Land Cover Mapping: A Review and Uncertainty Analysis. Remote Sensing,, 6: 12070-12093; http://dx.doi.org/10.3390/rs61212070.

Congalton, R.G, 2015. Assessing Positional and Thematic Accuracies of Maps Generated from Remotely Sensed Data. Chapter 29, In Thenkabail, P.S., (Editor-in-Chief), 2015. "Remote Sensing Handbook" Volume I: Volume I: Data Characterization, Classification, and Accuracies: Advances of Last 50 Years and a Vision for the Future. Taylor and Francis Inc.\CRC Press, Boca Raton, London, New York. Pp. 900+. In Thenkabail, P.S., (Editor-in-Chief), 2015. "Remote Sensing Handbook" Volume I:**): Remotely Sensed Data Characterization, Classification, and Accuracies**. Taylor and Francis Inc.\CRC Press, Boca Raton, London, New York. ISBN 9781482217865. Pp. 678.

Gumma, M.K., Thenkabail, P.S.,Teluguntla, P., Rao, M.N., Mohammed, I.A., and Whitbread, A.M. 2016. Mapping rice-fallow cropland areas for short-season grain legumes intensification in South Asia using MODIS 250 m time-series data. International Journal of Digital Earth, http://dx.doi.org/10.1080/17538947.2016.1168489

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, 198: 490-503, https://doi.org/10.1016/j.rse.2017.06.033.

Phalke, A. R., Ozdogan, M., Thenkabail, P. S., Congalton, R. G., Yadav, K., & Massey, R. et al. (2017). A Nominal 30-m Cropland Extent and Areas of Europe, Middle-east, Russia and Central Asia for the Year 2015 by Landsat Data using Random Forest Algorithms on Google Earth Engine Cloud. (in preparation).

Teluguntla, P., Thenkabail, P.S., Xiong, J., Gumma, M.K., Congalton, R.G., Oliphant, A., Poehnelt, J., Yadav, K., Rao, M., and Massey, R. 2017. Spectral matching techniques (SMTs) and automated cropland classification algorithms (ACCAs) for mapping croplands of Australia using MODIS 250-m time-series (2000–2015) data, International Journal of Digital Earth. , http://dx.doi.org/10.1080/17538947.2016.1267269.

Teluguntla, P., Thenkabail, P., Xiong, J., Gumma, M.K., Giri, C., Milesi, C., Ozdogan, M., Congalton, R., Yadav, K., 2015. CHAPTER 6 - Global Food Security Support Analysis Data at Nominal 1 km (GFSAD1km) Derived from Remote Sensing in Support of Food Security in the Twenty-First Century: Current Achievements and Future Possibilities, in: Thenkabail, P.S. (Ed.), Remote Sensing Handbook (Volume II): Land Resources Monitoring, Modeling, and Mapping with Remote Sensing. CRC Press, Boca Raton, London, New York., Pp. 131-160.Link

Xiong, J., Thenkabail, P.S., Tilton, J.C., Gumma, M.K., Teluguntla, P., Oliphant, A., Congalton, R.G., Yadav, K. 2017. A Nominal 30-m Cropland Extent and Areas of Continental Africa for the Year 2015 by Integrating Sentinel-2 and Landsat-8 Data using Random Forest, Support Vector Machines and Hierarchical Segmentation Algorithms on Google Earth Engine Cloud. Remote Sensing Open Access Journal (in review).

Xiong, J., Thenkabail, P.S., Gumma, M.K., Teluguntla, P., Poehnelt, J., Congalton, R.G., Yadav, K., Thau, D. 2017. Automated cropland mapping of continental Africa using Google Earth Engine cloud computing, ISPRS Journal of Photogrammetry and Remote Sensing, 126: 225-244, https://doi.org/10.1016/j.isprsjprs.2017.01.019.

3. Web sites and Data portals:

https://croplands.org (30-m global croplands visualization tool)
http://geography.wr.usgs.gov/science/croplands/index.html (GFSAD30 web portal and dissemination)
http://geography.wr.usgs.gov/science/croplands/products.html#LPDAAC (dissemination on LP DAAC)
http://geography.wr.usgs.gov/science/croplands/products.html (global croplands on Google Earth Engine)
https://croplands.org (crowdsourcing global croplands data)

4. Other relevant past publications prior to GFSAD project

Biggs, T., Thenkabail, P.S., Krishna, M., GangadharaRao Rao, 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. http://dx.doi.org/10.1016/j.jag.2008.11.002.

Dheeravath, V., Thenkabail, P.S., Chandrakantha, G, Noojipady, P., Biradar, C.B., Turral. H., Gumma, M.1, Reddy, G.P.O., Velpuri, M. 2010. Irrigated areas of India derived using MODIS 500m data for years 2001-2003. ISPRS Journal of Photogrammetry and Remote Sensing. 65(1): 42-59. http://dx.doi.org/10.1016/j.isprsjprs.2009.08.004.

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.K. 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.

5. Books and Book Chapters

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. Press, Boca Raton, London, New York. ISBN 9781482217957 - CAT# K22130. Pp. 131-160

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.).

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.).

Thenkabail. P., Lyon, G.J., Turral, H., and Biradar, C.M. (Editors) 2009d. Book entitled: "Remote Sensing of Global Croplands for Food Security" (CRC Press- Taylor and Francis group, Boca Raton, London, New York. Pp. 556 Published in June, 2009. Reviews of this book: http://www.crcpress.com/product/isbn/9781420090093
http://gfmt.blogspot.com/2011/05/review-remote-sensing-of-global.html

Thenkabail, P.S. and Lyon, J.G. 2009. Book Chapter 20: Remote sensing of global croplands for food security: way forward. Pp. 461-466. 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.).

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.).