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NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) Global Food Security-support Analysis Data (GFSAD) @ 30-m for Southeast and Northeast Asia Cropland Extent-Product (GFSAD30SEACE)

User Guide

USGS EROS
Sioux Falls, South Dakota

Document History

Document Version	Publication Date	Description
1.0	September, 2017	Original

Contents

1.0 Dataset Overview

The goal of the Global Food Security-support Analysis Data @ 30-m (GFSAD30) is to provide highest resolution, unbiased 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 satellite sensor data, machine learning algorithms, and cloud computing. National Aeronautics and Space Administration (NASA) is the primary funding source of this project, 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, University of Wisconsin Madison, NASA Goddard Space Flight Center, and the Northern Arizona University. There were a number of International partners including Asian Disaster Preparedness Center.

This user guide provides guidelines of the GFSAD30 cropland extent product for Southeast and Northeast Asia (SE&NE Asia) (GFSAD30SEACE). The Coordinate Reference System (CRS) used for the GFSAD30SEACE is a geographic coordinate system (GCS) based on the World Geodetic System 84 (WGS84) reference ellipsoid. The legend is presented in Section 2.

1.1 Background

Mapping cropland extent, as well as establishing location and area is essential for continuing food security. The availability of accurate maps is also required for development of all higher level cropland products. These products include crop watering method, cropping intensities, cropland fallows, crop type maps, and assessment of cropland and crop water productivity. A lack of certainty in the cropland extent map effects the certainty of all higher level cropland products. Unfortunately, reliable cropland extent maps that are of sufficiently high spatial resolution do not exist for the entire study area. The study area features many limitations, such as persistent cloud cover, aquaculture, and permanent croplands that are hard to distinguish from native forests. This project aims to address all these knowledge gaps.

Satellite-derived cropland extent mapped at high spatial resolution would be a monumental advancement for food and water security analysis. Thereby, GFSAD30SEA cropland extent product was produced @ nominal resolution of 30-m for SE&NE Asia for the nominal year 2015 using Landsat-7&8 time-series data, produced for nominal year 2015. Global cropland extent maps, indicating cropland and non-cropland areas, provides a working baseline data to develop high-level products such as crop watering method (irrigated or rainfed), cropping intensities (single, double, or continuous), 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. However, precise and accurate cropland extent maps do not exist for the entirety of SE&NE Asia. Cloud-based geo-spatial computing platforms and satellite image inventory offer opportunities for mapping croplands to meet the spatial and temporal requirements of broad applications. Such maps 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 have brought significant influence to LULC mapping and agriculture monitoring. Especially, the production of standard static maps of the past will be shifted to dynamic creation maps from massively large volumes of big data, crowd-souring of training and validation samples, and implementing machine learning algorithms on the cloud to serve better specific applications.

For a very detailed description of the satellite and reference data, processing scheme, approaches, methods, results, and conclusions please refer ATBD of GFSAD30SEACE.

2.0 Dataset Characteristics

Global food security-support analysis data @ 30-m cropland extent for the Southeast and Northeast Asia (GFSAD30SEACE) datasets and characteristics are described below.

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

2.1.1 Collection Level

Short name	GFSAD30SEACE
Temporal Granularity	Static
Temporal Extent	2015, nominal
Spatial Extent	Southeast and Northeast Asia
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 Southeast and Northeast Asia	N/A	8-bit unsigned integer	N/A	0,1,2	N/A

2.1.4 Data Layers Classification

Class Label	Class Name	Description
0	Water	Water bodies/no-data
1	Non-Cropland	Non-Cropland areas
2	Cropland	Cropland and Fallow-land

2.1.5 Filename Convention

GFSAD30SEACE_2015_N20E10_001_2017052200520.tif
GFSAD30SEACE = Product Short name
30 = 30 m Spatial Resolution
SEA = Southeast Asia
CE = Crop Extent
2015 = Nominal Year
N20E10 = 10 x 10 degree grid, starting at (N20, E10)
001 = Version
2017052200520 = Processing Date in YYYYJJJHHMMSS

3.0 Dataset Knowledge

The following questions addresses the user information regarding the GFSAD30SEACE collection.

3.1 Frequently Asked Questions

What is the accuracy of the GFSAD30CEAF product?
The independent accuracy assessment team systematically tested each of the 7 refined agro-ecological zones or RAEZs (Figure 2) for accuracies. For the entirety of SE and NE Asia, the overall accuracy was 88.6% with producer's accuracy of 81.6% (errors of omissions of 18.4%) and user's accuracy of 76.7% (errors of commissions of 23.3%) for the cropland class. For each of the 7 RAEZs individually, the range of the (Table 4): (a) overall accuracies were 83.2-96.4%, (b) producer's accuracies were 67.2-97.2%, and (c) user's accuracies were 58.8-85.7%.

Table 4. Independent assessment of overall-, producer-, and user-accuracies of Croplands for 7 zones of Southeast & Northeast Asia. TNCA = Total Net Cropland Area of SE&NE Asia

Zone 1: Mainland SE Asia: 47.6 % of TNCA

	Cropland	Non cropland	Row total	Commission error
Cropland	**80**	20	100	20.0%
Non cropland	16	**134**	150	10.7%
Column total	96	154	**250**	
Omission error	16.7%	13.0%		
Producer accuracy	83.3%	87.0%		
User accuracy	80.0%	89.3%		
Overall accuracy				**85.6%**

Zone 2: Philippines: 7.2 % of TNCA

	Cropland	Non cropland	Row total	Commission error
Cropland	**41**	7	48	14.6%
Non cropland	15	**187**	202	7.4%
Column total	56	194	**250**	
Omission error	26.8%	3.6%		
Producer accuracy	73.2%	96.4%		
User accuracy	85.4%	92.6%		
Overall accuracy				**91.2%**

Zone 3: Sumatra & Malaysia: 14.5 % of TNCA

	Cropland	Non cropland	Row total	Commission error
Cropland	**45**	20	65	30.8%
Non cropland	22	**163**	185	11.9%
Column total	67	183	**250**	
Omission error	32.8%	10.9%		
Producer accuracy	67.2%	89.1%		
User accuracy	69.2%	88.1%		
Overall accuracy				**83.2%**

Zone 4: Java & Bali: 4.7 % of TNCA

	Cropland	Non cropland	Row total	Commission error
Cropland	**89**	27	116	23.3%
Non cropland	13	**121**	134	9.7%
Column total	102	148	**250**	
Omission error	12.7%	18.2%		
Producer accuracy	87.3%	81.8%		
User accuracy	76.7%	90.3%		
Overall accuracy				**84.0%**

Zone 5: Borneo: 14.4 % of TNCA

	Cropland	Non cropland	Row total	Commission error
Cropland	**69**	26	95	27.4%
Non cropland	2	**153**	155	1.3%
Column total	71	179	**250**	
Omission error	2.8%	14.5%		
Producer accuracy	97.2%	85.5%		
User accuracy	72.6%	98.7%		
Overall accuracy				**88.8%**

Zone 6: Japan & Korea: 6.7 % of TNCA

	Cropland	Non cropland	Row total	Commission error
Cropland	**42**	7	49	14.3%
Non cropland	15	**186**	201	7.5%
Column total	57	193	**250**	
Omission error	26.3%	3.6%		
Producer accuracy	73.7%	96.4%		
User accuracy	85.7%	92.5%		
Overall accuracy				**91.2%**

Zone 7: Pacific Island Nations: 4.9 % of TNCA

	Cropland	Non cropland	Row total	Commission error
Cropland	**10**	7	17	41.2%
Non cropland	2	**231**	233	0.9%
Column total	12	238	**250**	
Omission error	16.7%	2.9%		
Producer accuracy	83.3%	97.1%		
User accuracy	58.8%	99.1%		
Overall accuracy				**96.4%**

Total: Entire Study Area: 100 % of TCA

	Cropland	Non cropland	Row total	Commission error
Cropland	**376**	114	490	23.3%
Non cropland	85	**1175**	1260	6.7%
Column total	461	1289	**1750**	
Omission error	18.4%	8.8%		
Producer accuracy	81.6%	91.2%		
User accuracy	76.7%	93.3%		
Overall accuracy				**88.6%**

What do GFSAD30SEACE product contain?

They provide cropland extent product for the Southeast and Northeast Asia at nominal 30-m. It covers all 18 countries.

NOTE: Certain small islands in the Pacific are not classified and therefore data for these areas are not provided.

What's 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 also includes areas equipped for cropping but may not be cropped in a particular season or year. These are cropland fallow. So, cropland extent includes all planted crops plus cropland fallows. Non-croplands include all other land cover classes other than croplands and cropland fallows.

How to access the dataset?

All the GFSAD30 products is downloadable through the Land Processes Distributed Active Archive Center (LP DAAC). GFSAD30SEACE, divided into 10x10 grids, is among them.

4.0 Dataset Access (Applicable Data Tools)

The GFSAD30SEACE dataset is available through the LP DAAC Data Pool and NASA Earthdata Search. GFSAD data visualization and information can also be found at Global Croplands Website.

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

6.0 Citations

6.1 GFSAD30SEACE

Oliphant, A.J., Thenkabail, P.S., Teluguntla, P., Xiong, J., Congalton, R.G., Yadav, K., Massey, R., Gumma, M.K., 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 Southeast Asia 30 m V001* [Data set]. NASA EOSDIS Land Processes DAAC. doi: 10.5067/MEaSUREs/GFSAD/GFSAD30SEACE.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 Open Access Journal. Remote Sens. 2014, 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 - CAT# K22125. Print ISBN: 978-1-4822-1786-5; eBook ISBN: 978-1-4822-1787-2. 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. doi:10.1016/j.jag.2008.11.002. January, 2009.

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. http://dx.doi.org/10.1016/j.isprsjprs.2009.08.004. 65(1): 42-59.

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 (48 pages in color). 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.).