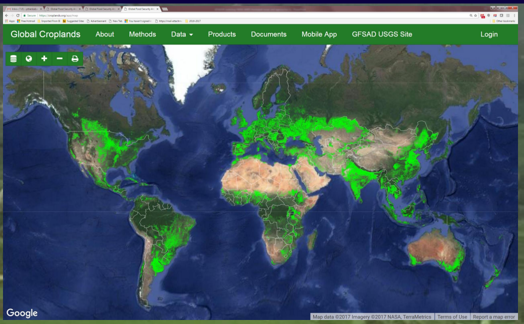
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Mapping the World's Croplands @ nominal 30-m from Multi-sensor Remote Sensing



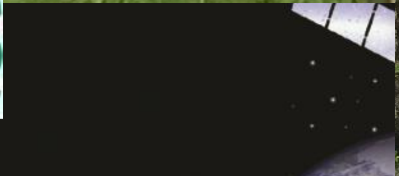
Dr. Prasad S.Thenkabail

Research Geographer @ the

U. S. Geological Survey (USGS)

February 7-9, 2017

Presented @ the GFSAD30 Workshop Help @ NASA AMES, CA



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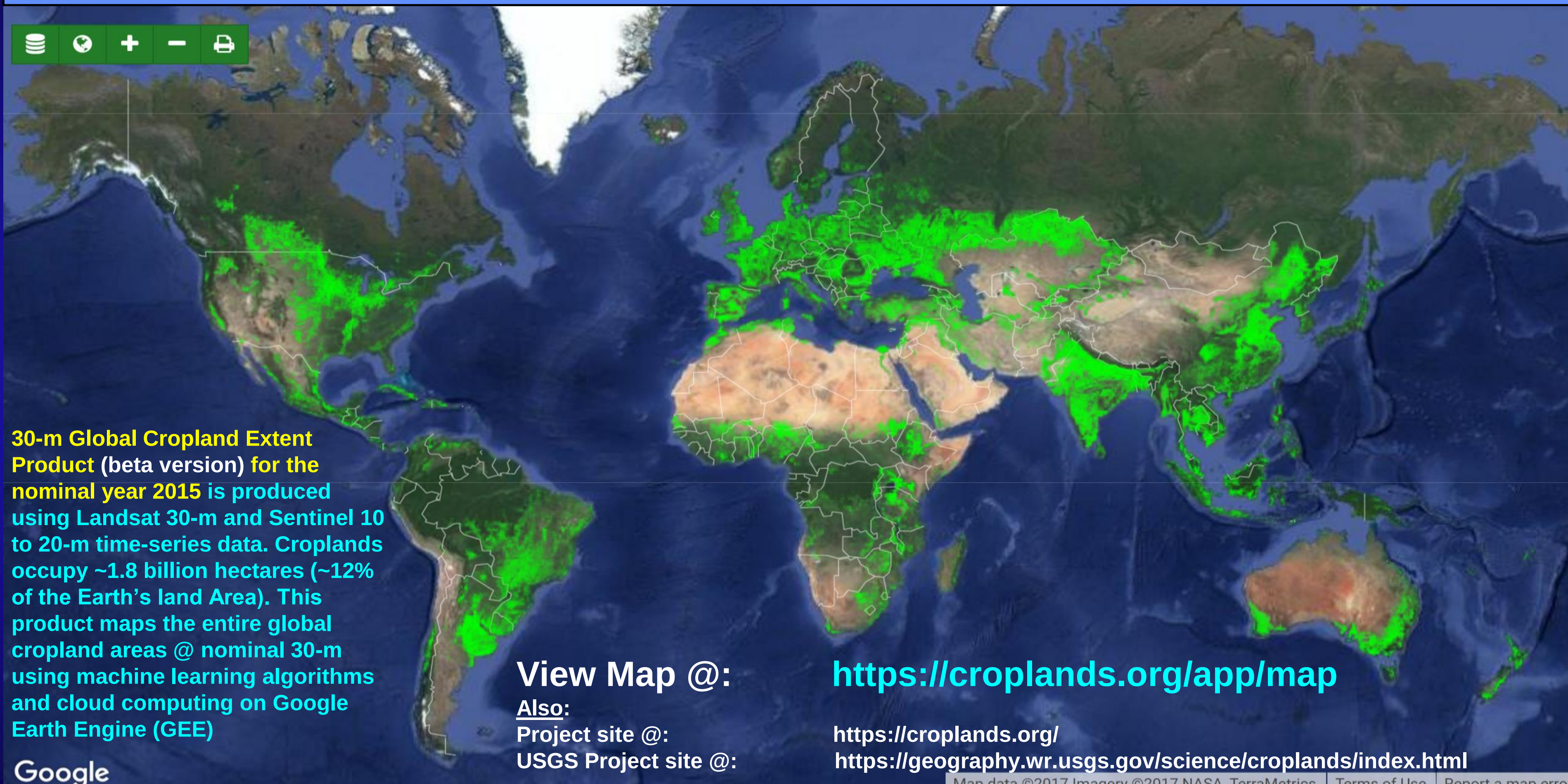
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Mapping the World's Croplands @ nominal 30-m from Multi-sensor Remote Sensing

World's First 30-m Global Cropland Extent Product (β Version)



30-m Global Cropland Extent Product (beta version) for the nominal year 2015 is produced using Landsat 30-m and Sentinel 10 to 20-m time-series data. Croplands occupy ~1.8 billion hectares (~12% of the Earth's land Area). This product maps the entire global cropland areas @ nominal 30-m using machine learning algorithms and cloud computing on Google Earth Engine (GEE)

View Map @: https://croplands.org/app/map

Also:

Project site @: https://croplands.org/

USGS Project site @: https://geography.wr.usgs.gov/science/croplands/index.html

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Acknowledgments: NASA grant number: NNH13AV82I through its ROSES MEaSUREs (Making Earth System Data Records for Use in Research Environments) initiative

Food for the Thought

"Agriculture is our wisest pursuit, because it will in the end contribute most to real wealth, good morals, and happiness"- Thomas Jefferson

"When the well is dry, we learn the worth of water"- Benjamin Franklin

"Food is the moral right of all who are born into this world" - Norman Borlaug

Agriculture ↕ Water ↕ Food Security

GFSAD30 Project: Background

1. Global Croplands

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

Cropland Area Expansion in Human History

Till the early 1900 AD only ~2% global land areas was under agriculture, in last 100 years we have added an additional 10%

Global Ecology and Biogeography, 20, 73–86, © 2010 Blackwell Publishing Ltd

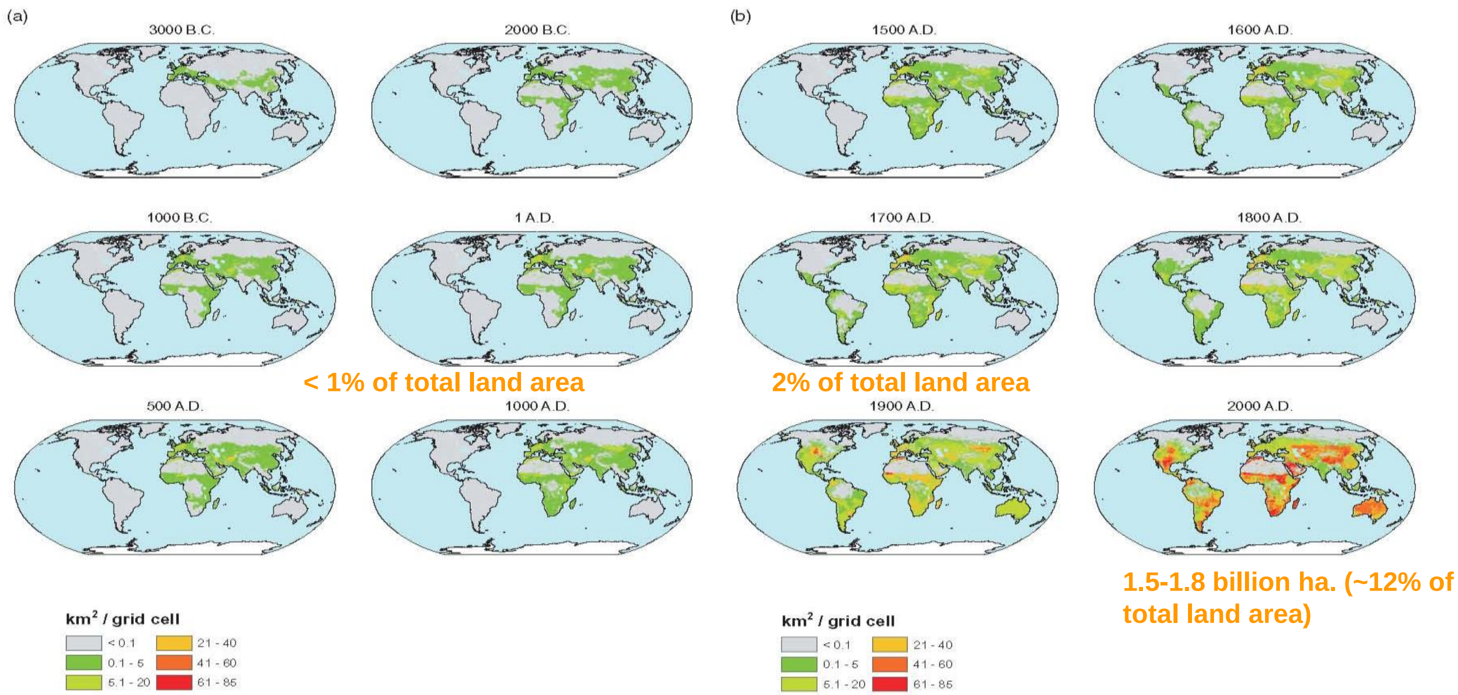

Figure 2 Historical pasture area (a) 3000 BC to AD 1000 and (b) AD 1500–2000.

HYDE 3.1 Holocene land use

Goldewijk et al., 2011

Settled agriculture = 23,000 years
Irrigated agriculture = 10,000 years

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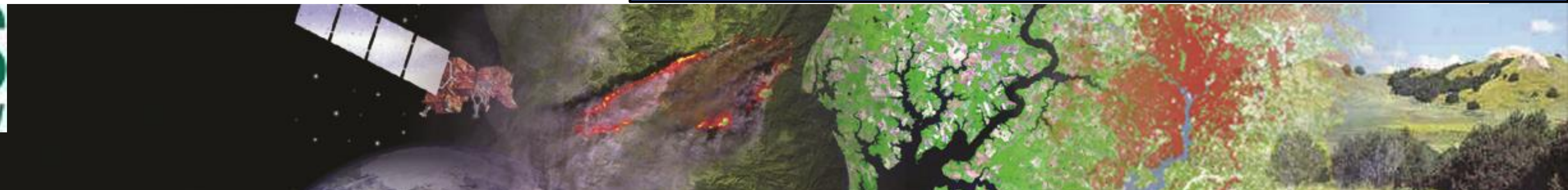

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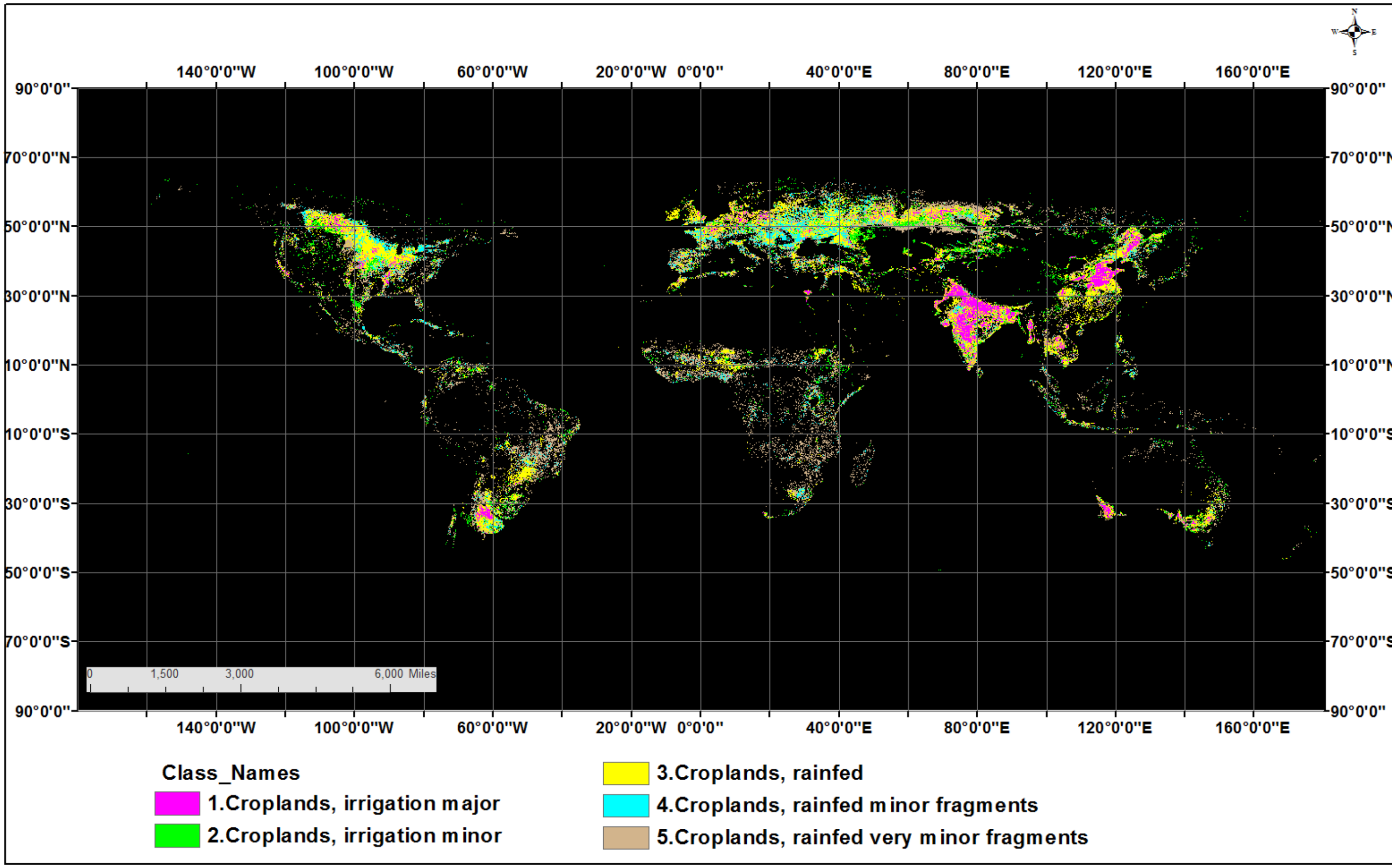
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Cropland Area: Best Synthesis, Current Status as of Nominal Year 2015



~1.8 billion hectares of croplands as of 2015, with 34% irrigated and 66% rainfed

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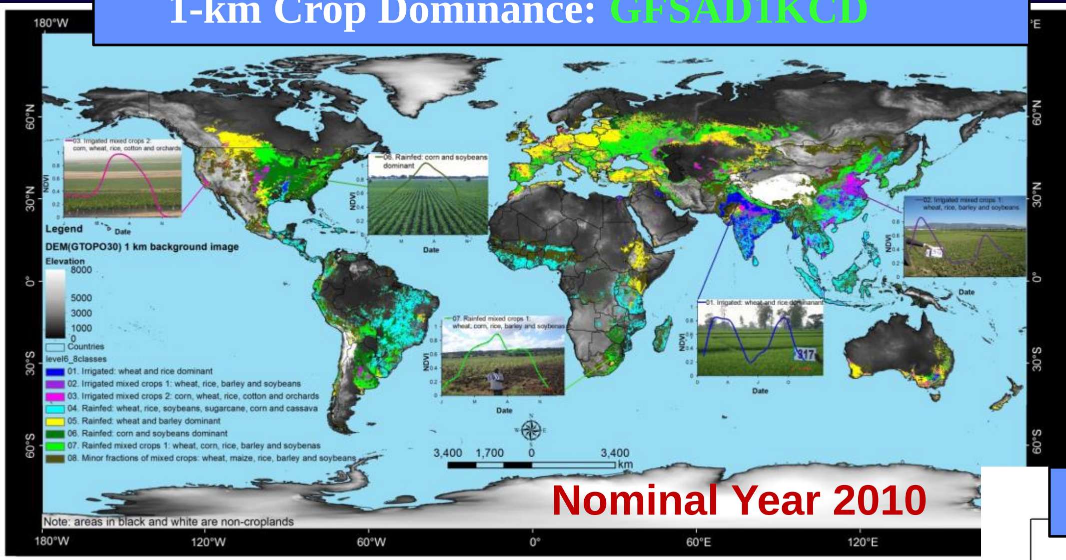
Teluguntla, P., Thenkabail, P.S., Xiong, J., Gumma, M.K., Giri, C., Milesi, C., Ozdogan, M., Congalton, R., Tilton, J., Sankey, T.R., Massey, R., Phalke, A., and Yadav, K. 2015. Global Food Security Support Analysis Data at Nominal 1 km (GFSAD1km) Derived from Remote Sensing in Support of Food Security 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.

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Global Croplands @ 1-km: Best Synthesis for Nominal Year 2010

1-km Crop Dominance: GFSAD1KCD



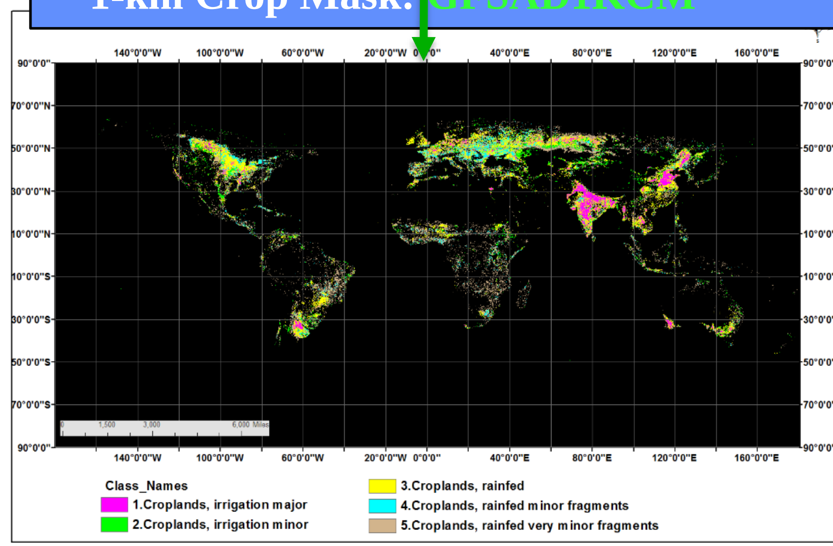
1. Thenkabail P.S., Knox J.W., Ozdogan, M., Gumma, M.K., Congalton, R.G., Wu, Z., Milesi, C., Finkral, A., Marshall, M., Mariotto, I., You, S. Giri, C. and Nagler, P. 2012. Assessing future risks to agricultural productivity, water resources and food security: how can remote sensing help?. Photogrammetric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

Product released @:
https://e4ftl01.cr.usgs.gov/provisional/MEaSUREs/GFSAD/GFSADCD1KM/

2. 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 (GFSAD1km) 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.

Product released @:
https://e4ftl01.cr.usgs.gov/provisional/MEaSUREs/GFSAD/GFSADCM1KM/

1-km Crop Mask: GFSAD1KCM



Nominal Year 2010

Visit Page:
https://geography.wr.usgs.gov/science/croplands/products.html

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U.S. Geological Survey
U.S. Department of Interior

Note: Globally, there is ~1.8 billion hectares of croplands as of nominal Years 2010, with 34% irrigated and 66% rainfed

DATA ACCESS through LP DAAC

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

1. **The GFSAD1KCD dataset landing page including data access and further information can be found at:**
2. **The GFSAD1KCM dataset landing page including data access and further information can be found at:**

Data Pool:
https://e4ftl01.cr.usgs.gov/GFSAD/
Reverb|ECHO:
https://e4ftl01.cr.usgs.gov/GFSAD/
NASA Earthdata Search Client:
https://search.earthdata.nasa.gov/search?q=GFSAD&ok=GFSAD

ALSO:

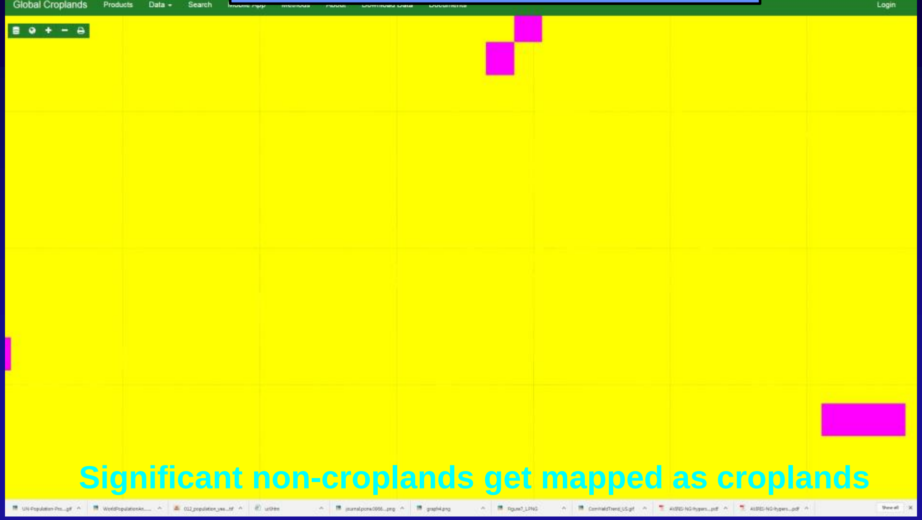
GFSAD data visualization and information can also be found at Global Croplands:
globalcroplands.org

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

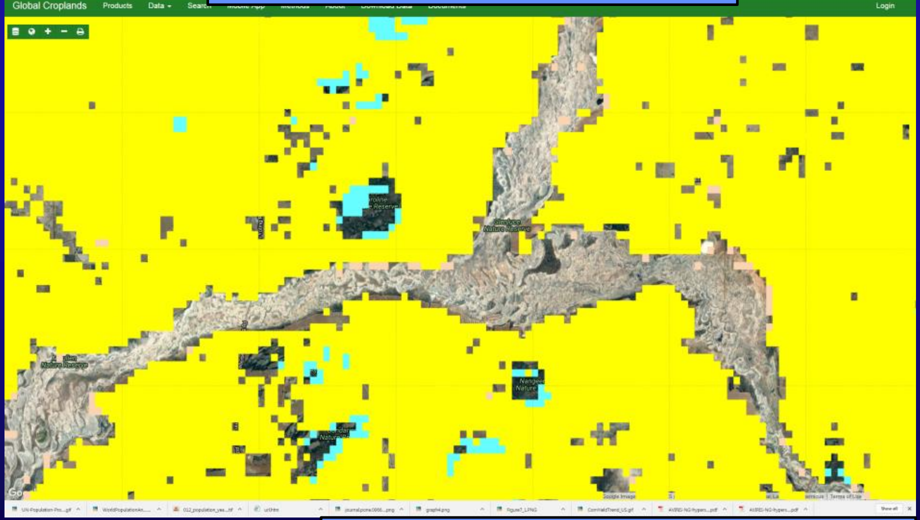
Uncertainties in Cropland Mapping Across Resolutions (e.g., A Micro area in Australia)

Sub-meter to 5-m image

1-km

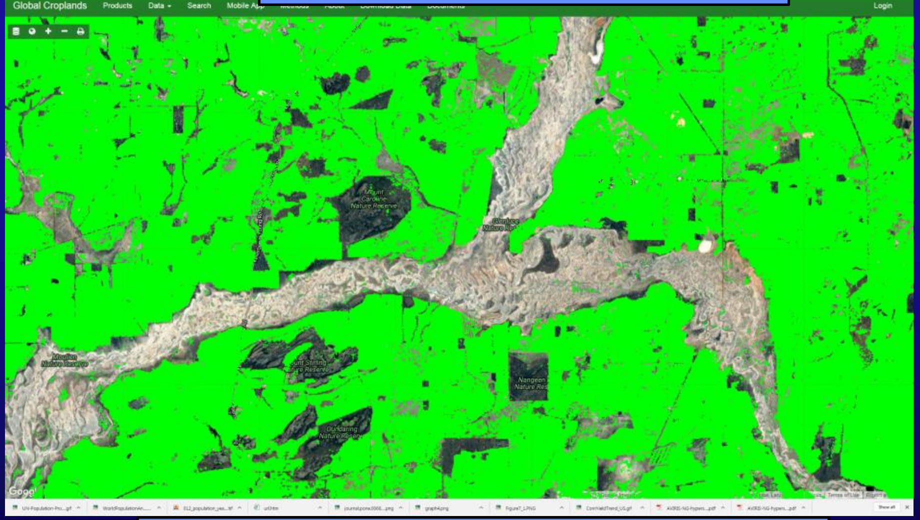


250-m



Some of the minor non-cropland fractions get separated from croplands

30-m



Most of minor non-cropland fractions get separated from croplands

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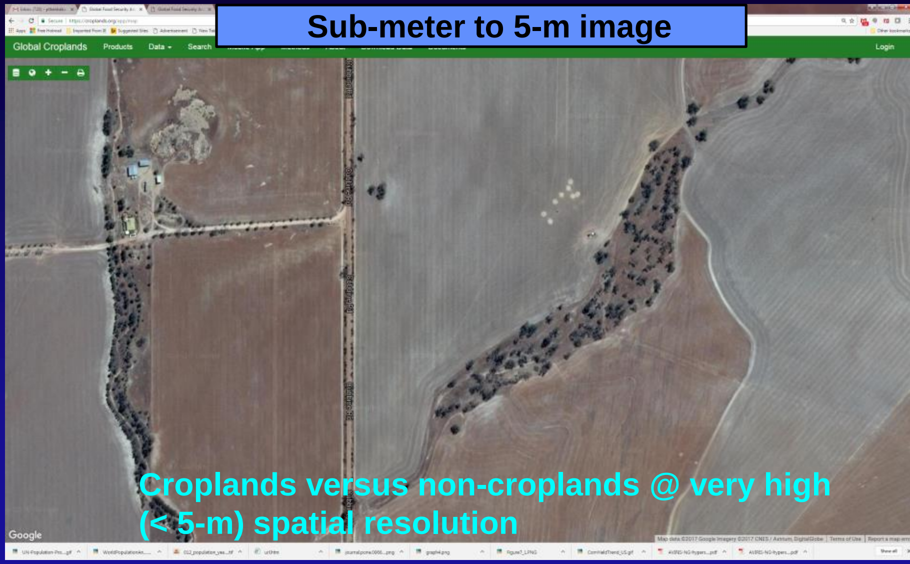
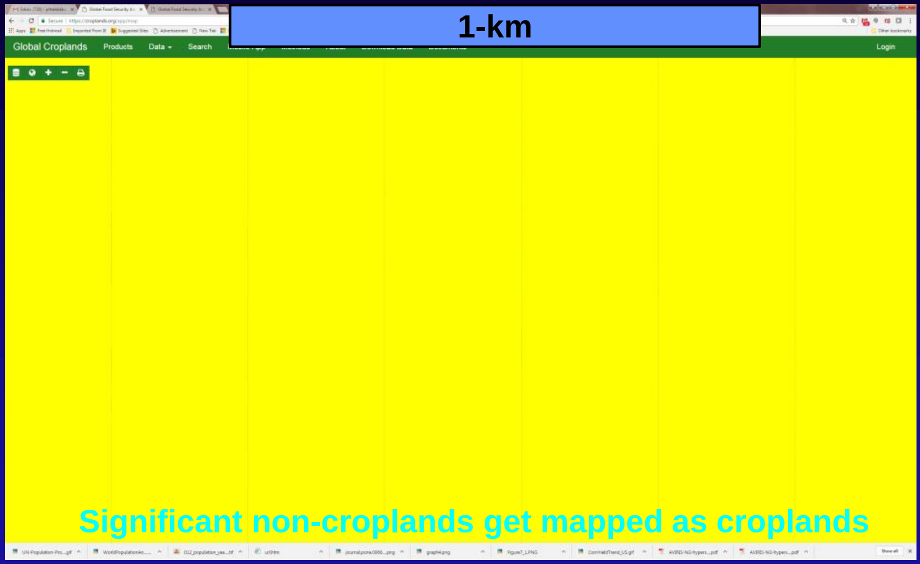
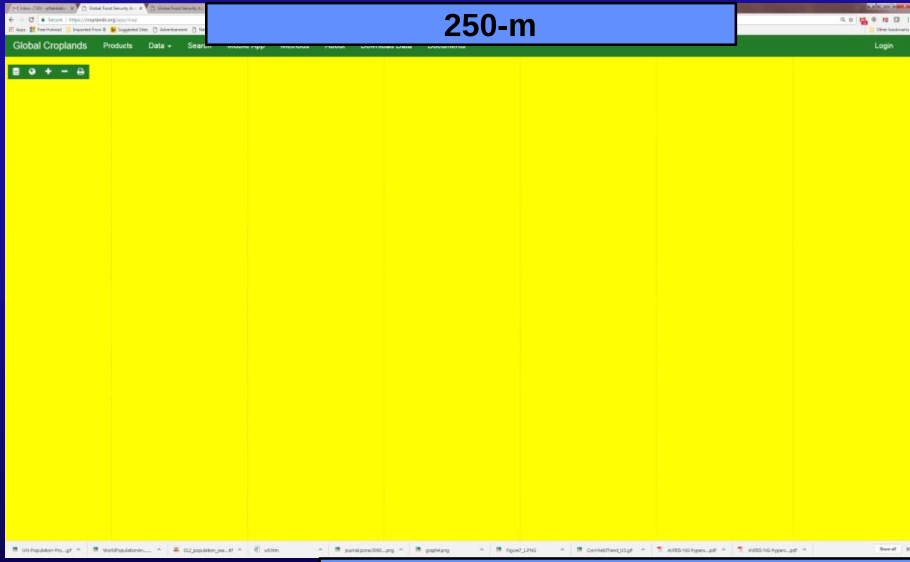
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

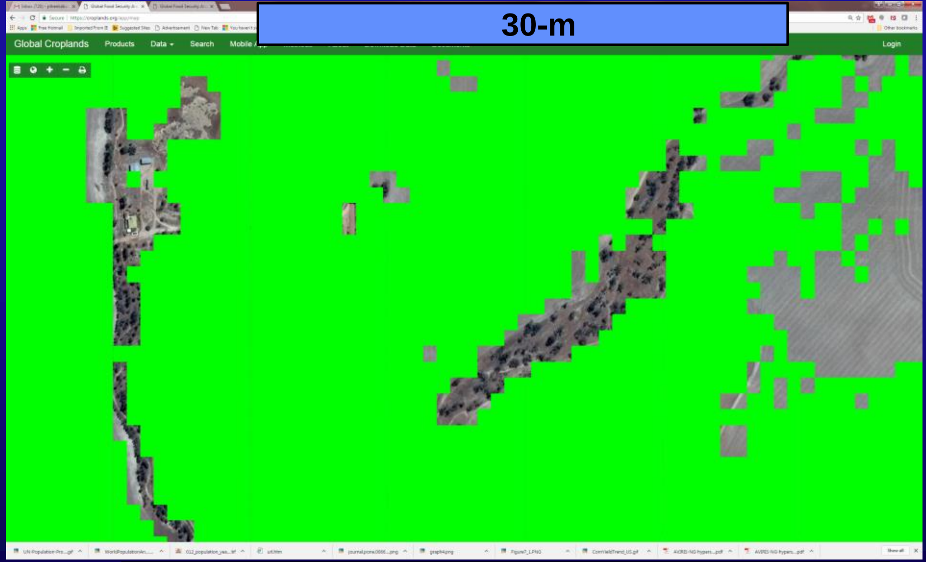
Uncertainties in Cropland Mapping Across Resolutions (e.g., A Micro area in Australia)







Some of the minor non-cropland fractions get separated from croplands



Most of minor non-cropland fractions get separated from croplands

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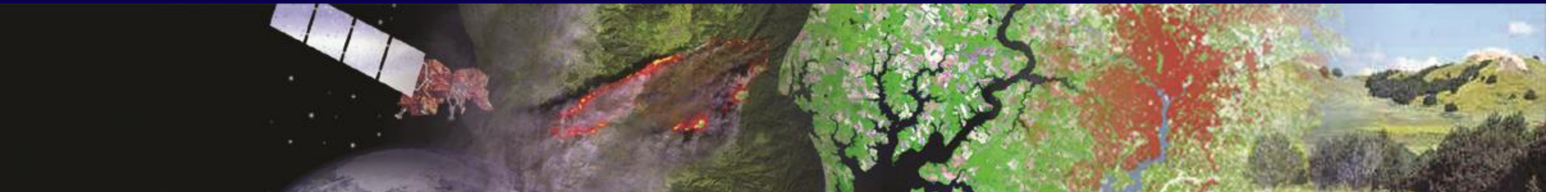
U.S. Department of Interior

GFSAD30 Project: Background
2. Global Crop Yield and Productivity

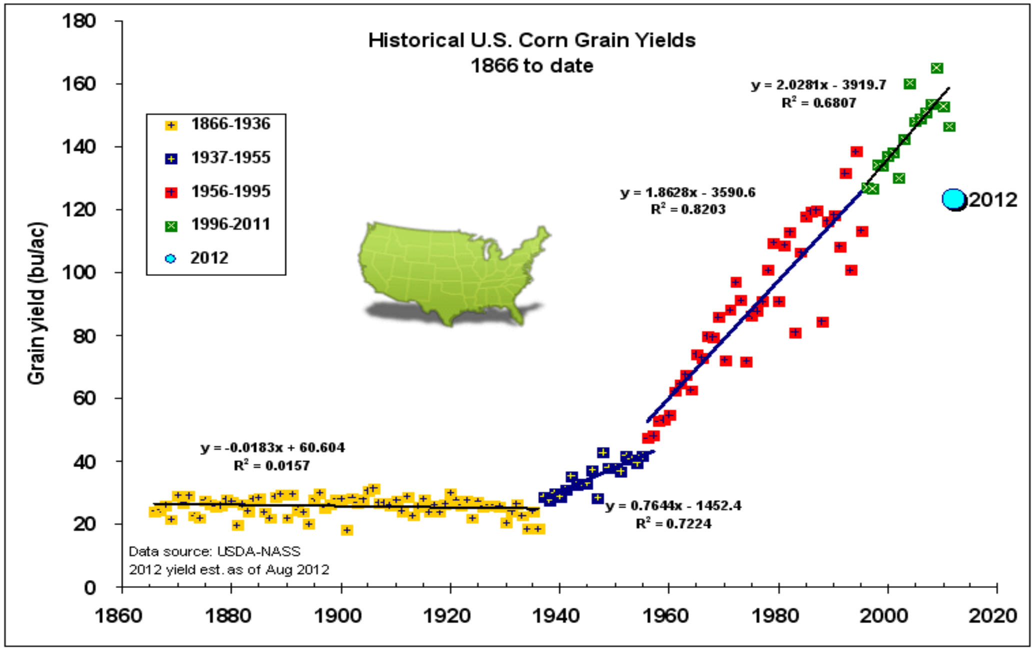
http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

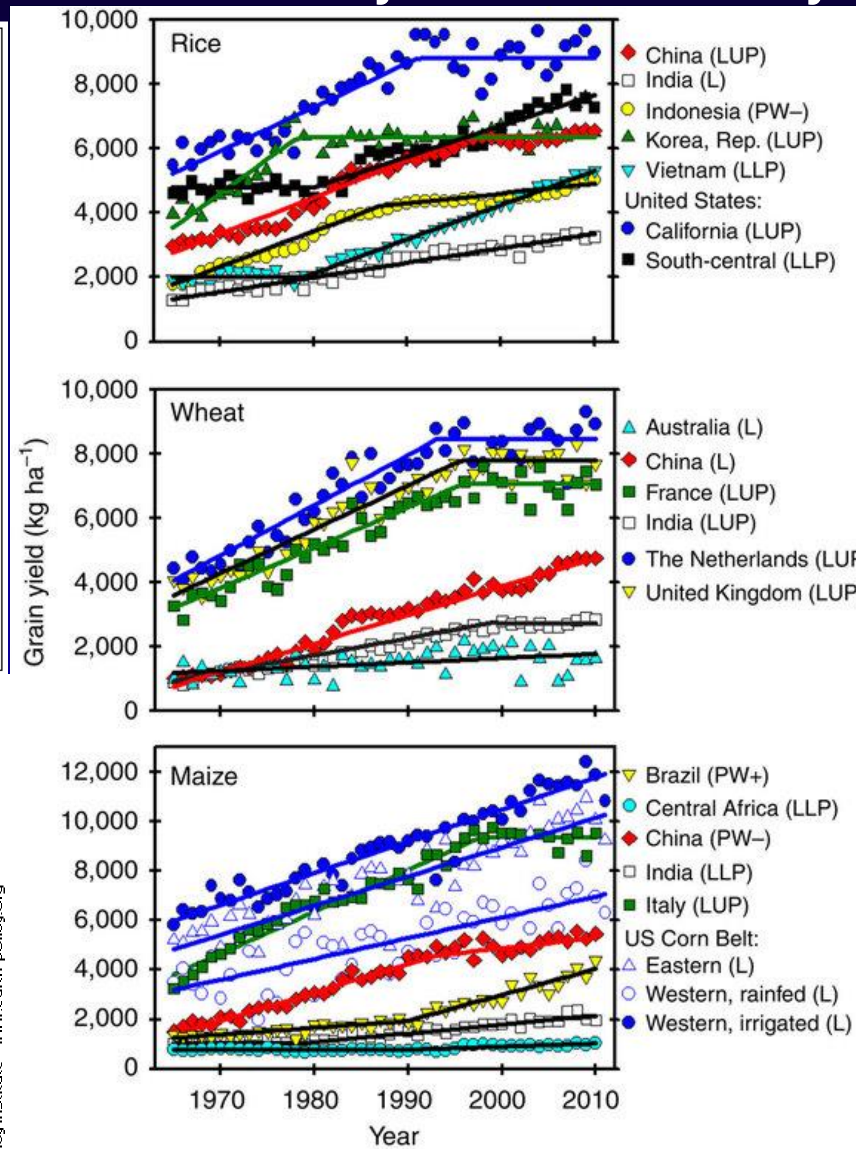


U.S. Geological Survey
U.S. Department of Interior

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Crop Yield Stagnation is Causing Concern for Food Security in the 21st Century

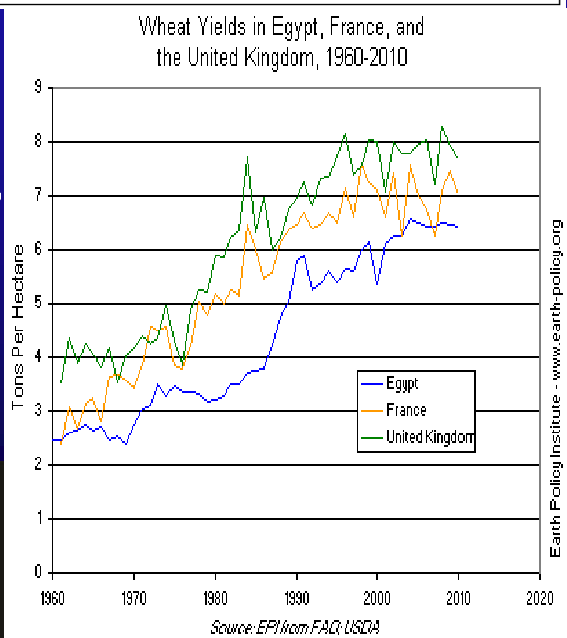




Crop Yield Increases along with increases in

1. **cropland areas,**
2. **irrigated areas,**
3. **technology (e.g., genomics, combine, tillers), and**
4. **inputs (e.g., fertilizers, herbicides)……..**

resulted in "green Revolution" and Food security in last 70 years



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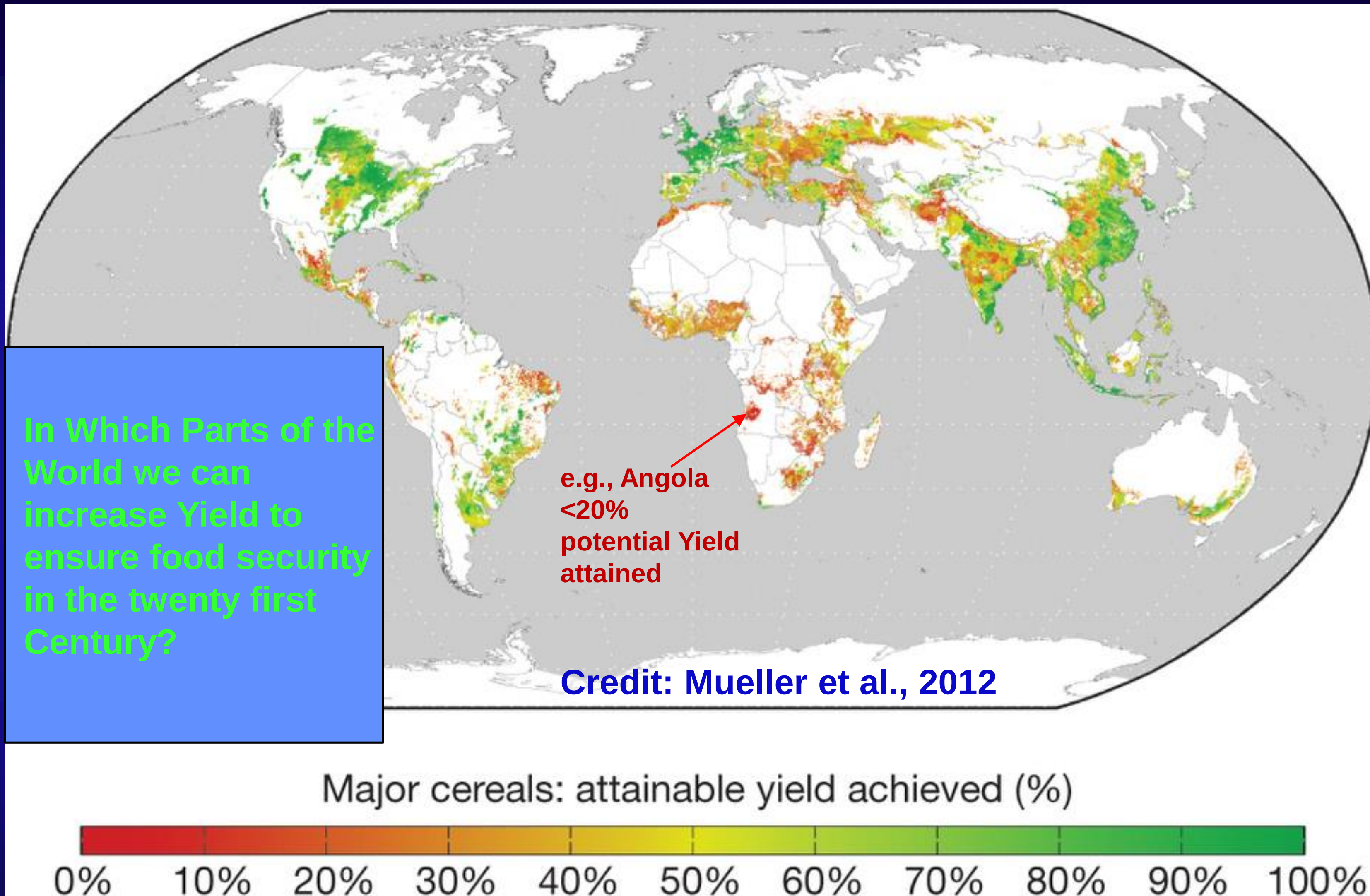
U.S. Department of Interior

Source: Grassini, P. *et al.* Distinguishing between yield advances and yield plateaus in historical crop production trends. *Nat. Commun.* 4:2918 doi: 10.1038/ncomms3918 (2013).

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Yield Gap: Most parts of Very Productive Agricultural Areas of the World Have Attained Full Yield Potential

In Which Parts of the World we can increase Yield to ensure food security in the twenty first Century?



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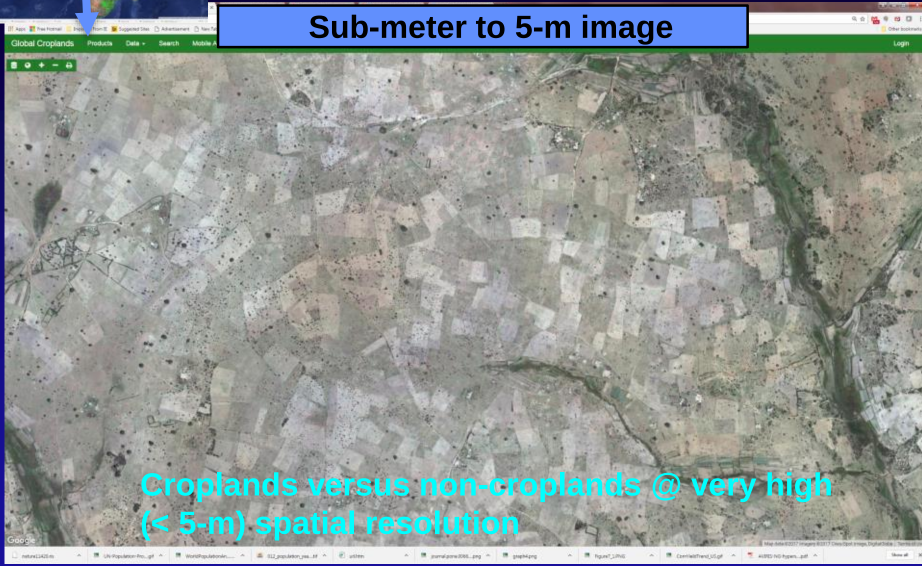
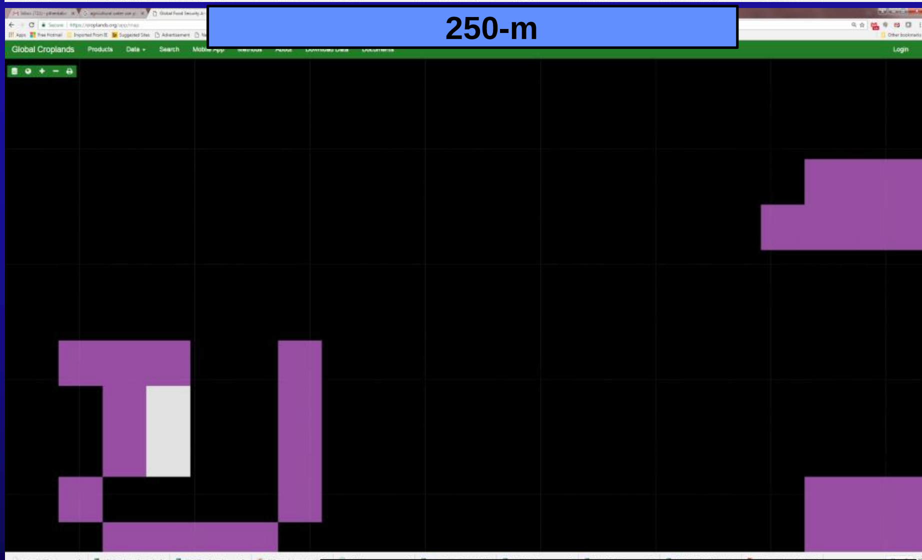
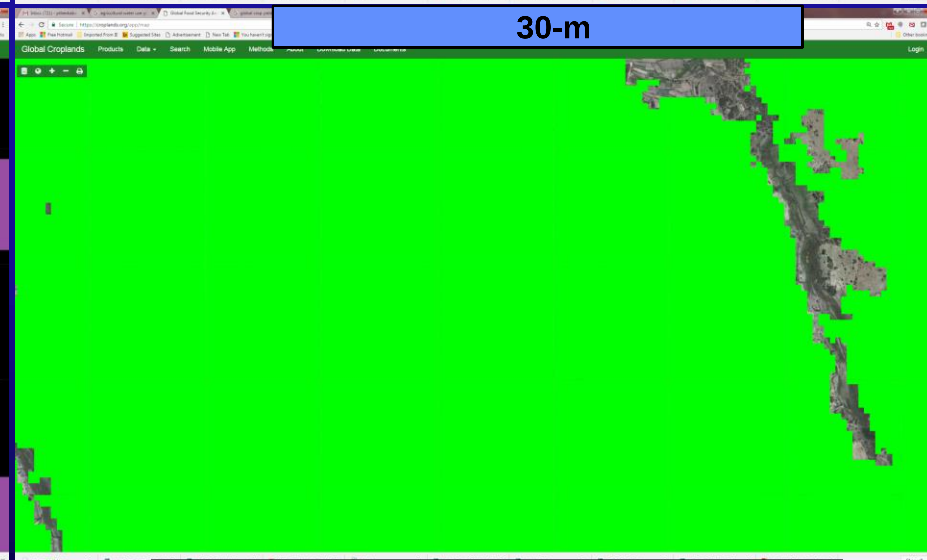
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Uncertainties in Cropland Mapping Across Resolutions (e.g., a Micro Area in Angola)







Almost all croplands missing!

Almost all croplands captured

GFSAD30 Project: Background

3. Global Cropland Water Use

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Croplands use Massive Quantities of Water; ~80% of all Human Water Use Worlwide

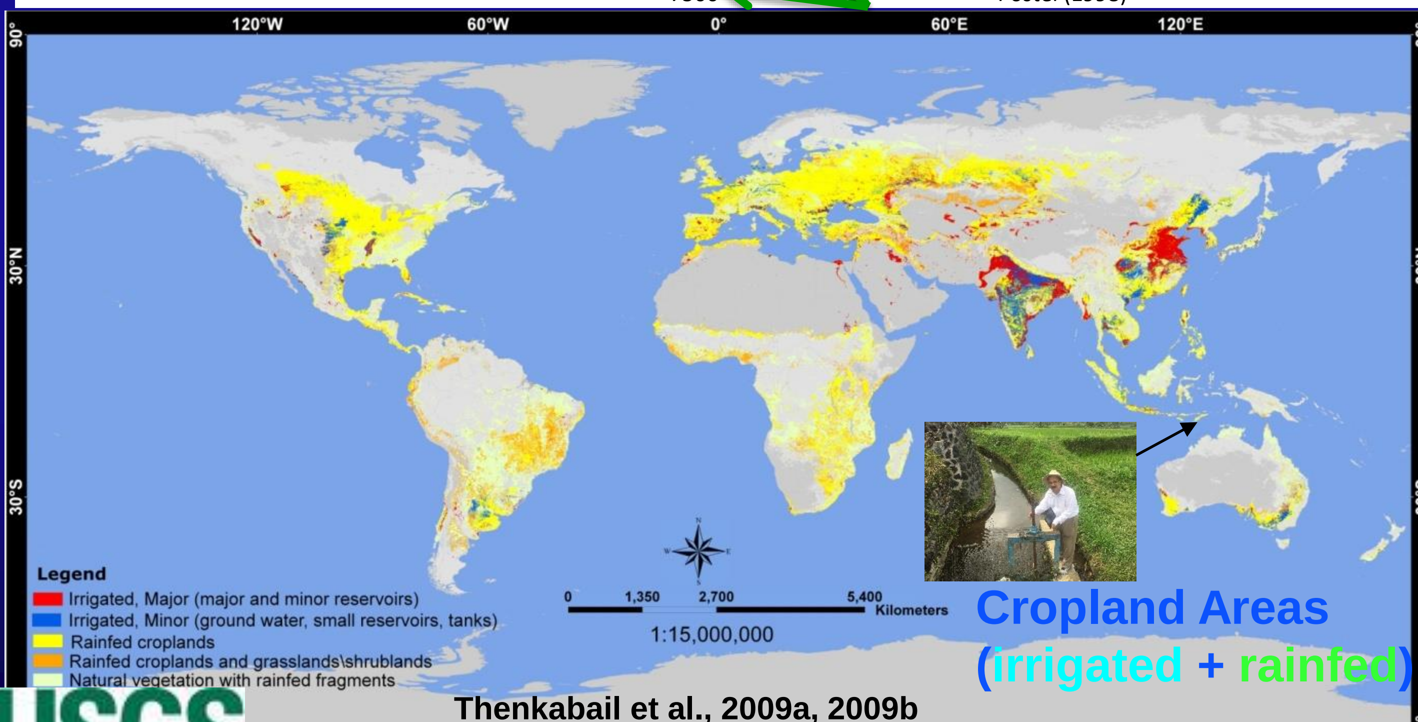
Table 2. Global blue water and green water use by agricultural crops for roughly at end of the last millennium.

Blue water use By Irrigated crops km³/yr	Green water use by irrigated crops km³/yr	Green water use by Rainfed crops km³/yr	Total water use by irrigated and rainfed crops km³/yr	Reference
1180	919	4586	6685	Siebert and Döll (2009)
1800	-	5000	6800	Falkenmark and Rockström (2006)
			7500	Postel (1998)

global
Green + Blue
water use

How much water does 1.8 billion hectares of total cropland areas use?

….but these estimates will change if we consider uncertainties in irrigated areas…….



Thenkabail et al., 2009a, 2009b

Blue water (from lakes, reservoirs, rivers, ground water) use by irrigated croplands
+
Green Water (from soil moisture) use by rainfed croplands

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Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

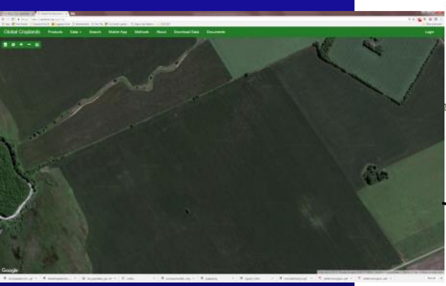
Rainfed Croplands use Massive Quantities of Water; ~80% of all Human Water Use Worlwide

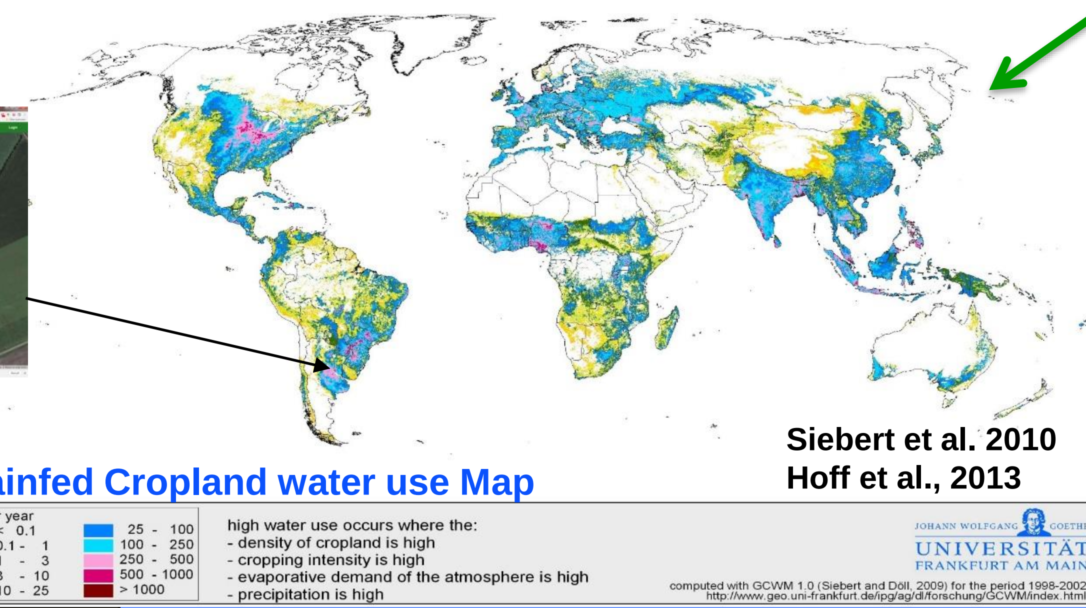
Table 2. Global blue water and green water use by agricultural crops for roughly at end of the last millennium.

Blue water use By Irrigated crops km^3/yr	Green water use by irrigated crops km^3/yr	Green water use by Rainfed crops km^3/yr	Total water use by irrigated and rainfed crops km^3/yr	Reference
1180	919	4586	6685	Siebert and Döll (2009)
1800	-	5000	6800	Falkenmark and Rockström (2006)
			7500	Postel (1998)

Green water use

Total consumptive green water use of crops
(mm per year averaged over total grid cell area)





How much water does 1.4 billion hectares of rainfed croplands use?

Green Water (from soil moisture) use by rainfed croplands

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U.S. Department of Interior

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Irrigated Croplands use Massive Quantities of Water; ~80% of all Human Water Use Worlwide

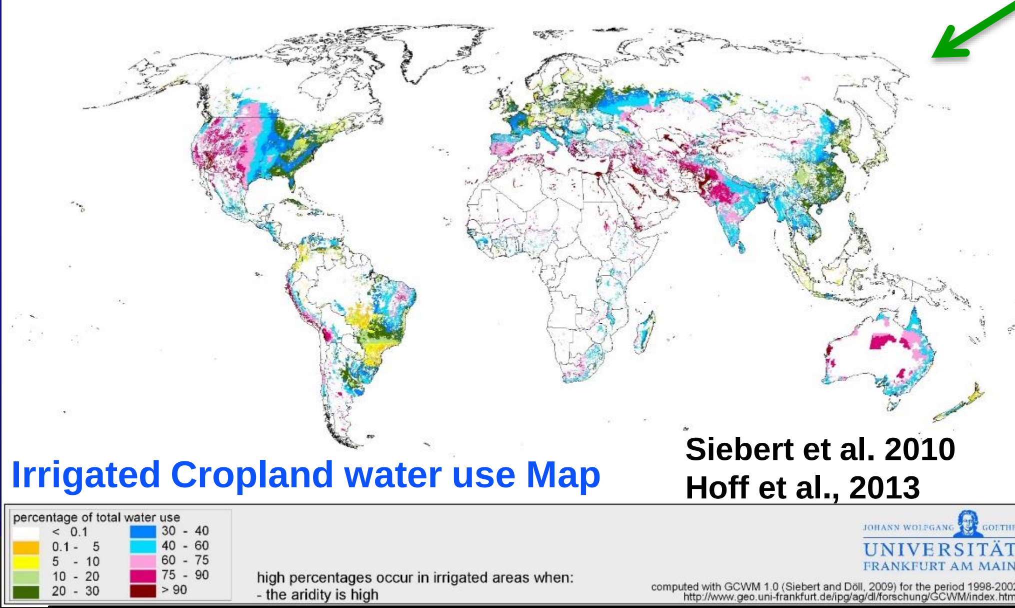
Table 2. Global blue water and green water use by agricultural crops for roughly at end of the last millennium.

Blue water use By Irrigated crops km^3/yr	Green water use by irrigated crops km^3/yr	Green water use by Rainfed crops km^3/yr	Total water use by irrigated and rainfed crops km^3/yr	Reference
1180	919	4586	6685	Siebert and Döll (2009)
1800	-	5000	6800	Falkenmark and Rockström (2006)
			7500	Postel (1998)

Water use by irrigated crops by artificial irrigation (e.g., from lakes, reservoirs, rivers, ground water)

Water use by irrigated crops by Rainfall falling over irrigated areas

Blue consumptive water use of irrigated crops
(percentage of total consumptive water use of irrigated crops)



Irrigated Cropland water use Map

Siebert et al. 2010
Hoff et al., 2013

How much water does 400 Mha irrigated croplands use?

Blue water (from lakes, reservoirs, rivers, ground water) use by irrigated croplands

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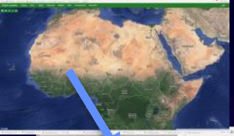
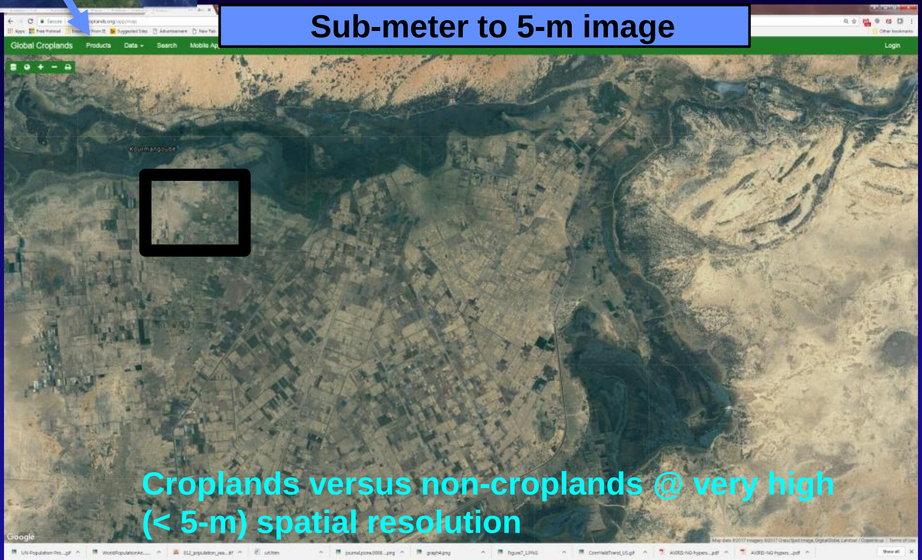
U.S. Department of Interior



Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

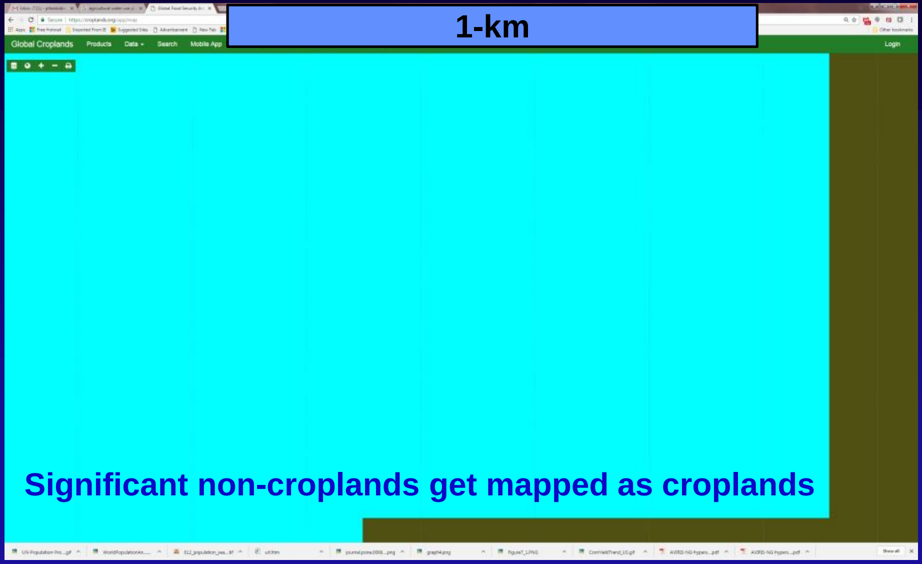
Uncertainties in Cropland Mapping Across Resolutions (e.g., A Micro area in Africa)

Sub-meter to 5-m image



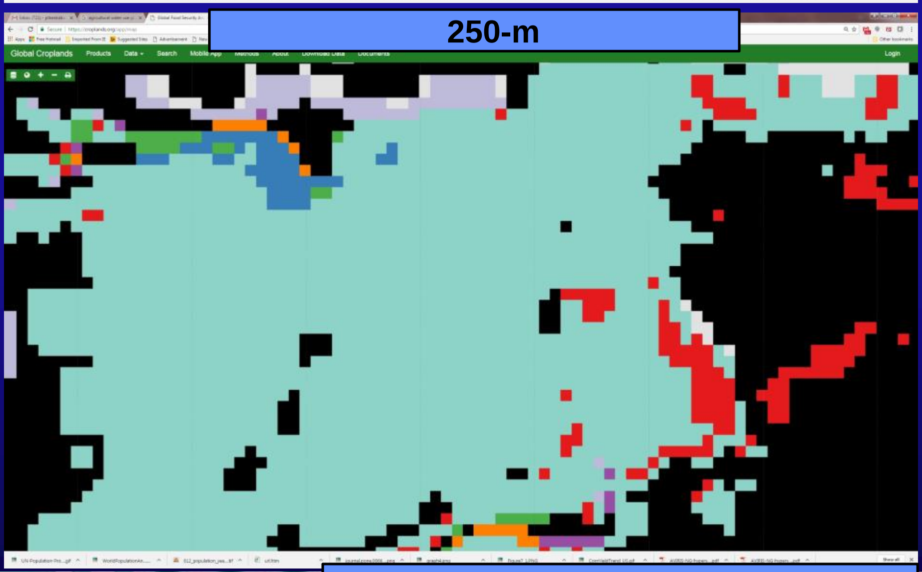
Croplands versus non-croplands @ very high (< 5-m) spatial resolution

1-km



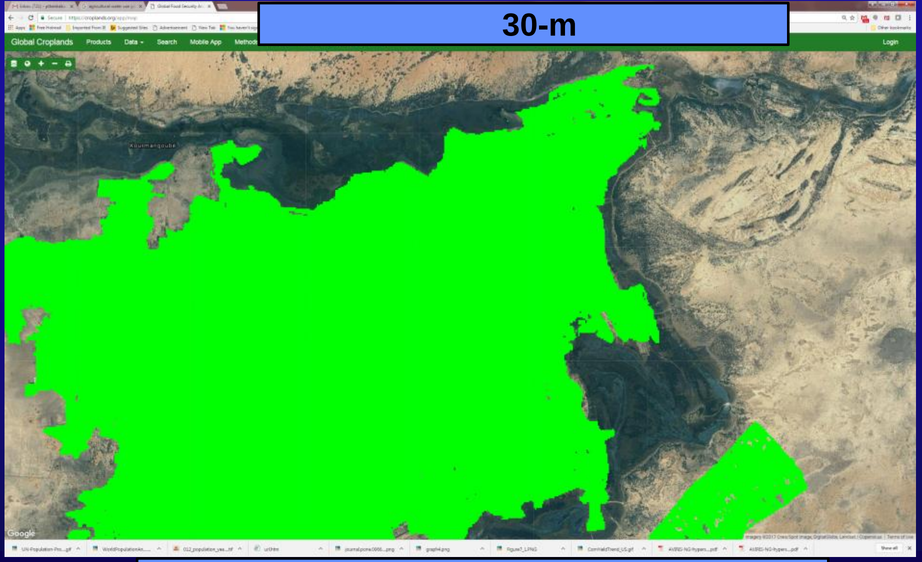
Significant non-croplands get mapped as croplands

250-m



Does better than 1-km, but still maps certain non-croplands as croplands

30-m



Captures almost all croplands perfectly; separates all non-croplands as non-croplands

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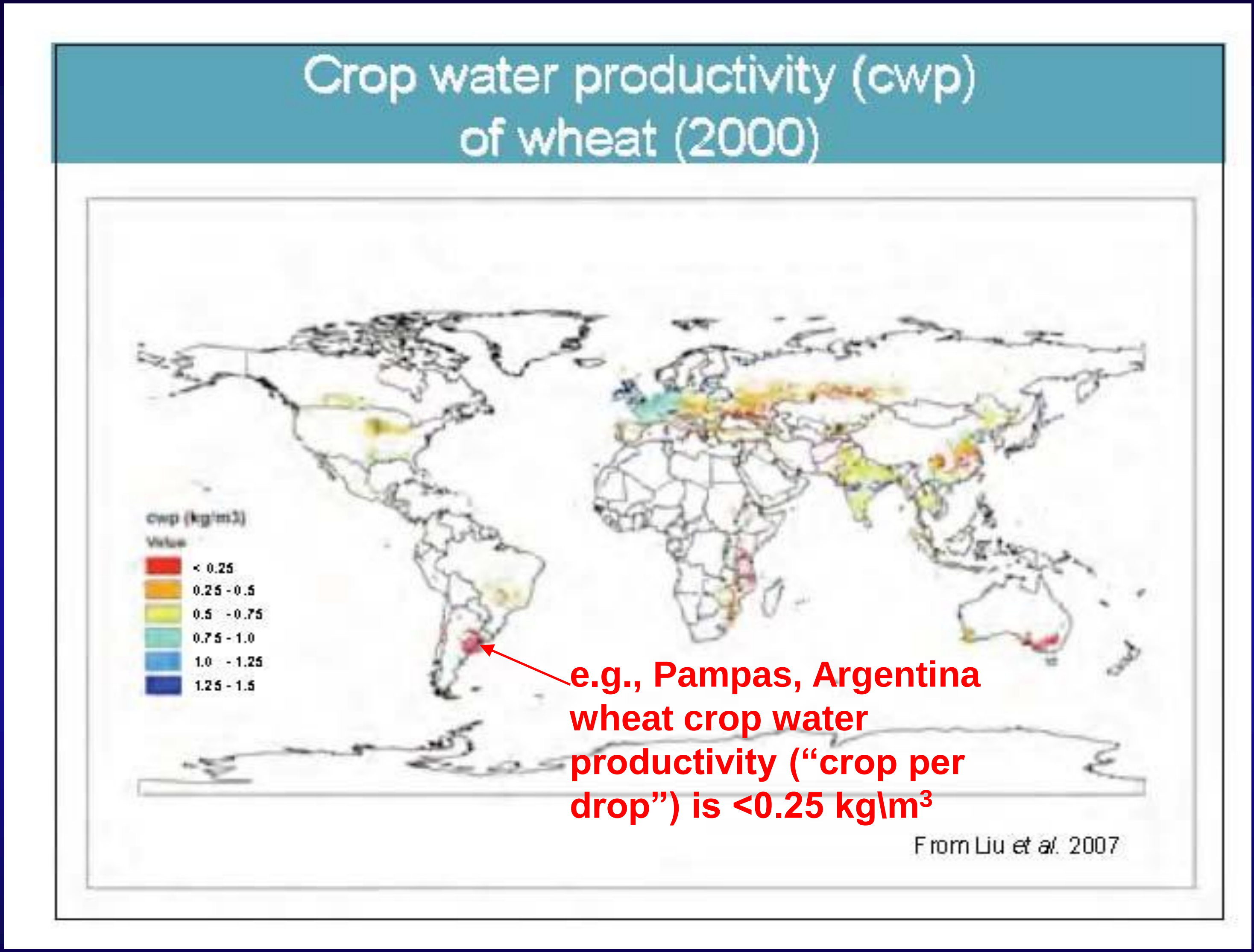
GFSAD30 Project: Background
4. Global Cropland Water Productivity

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

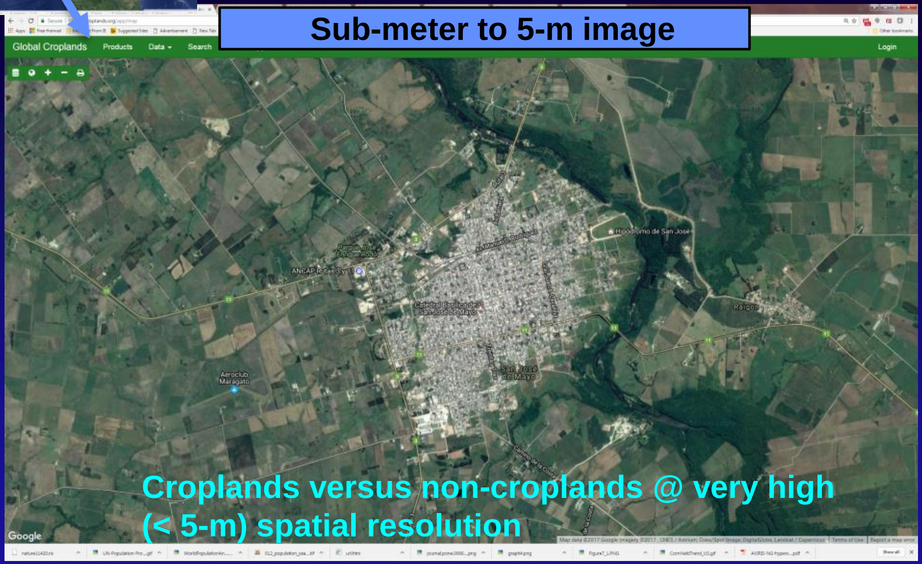
Improving Crop Water Productivity (crop per drop) of Wheat crop

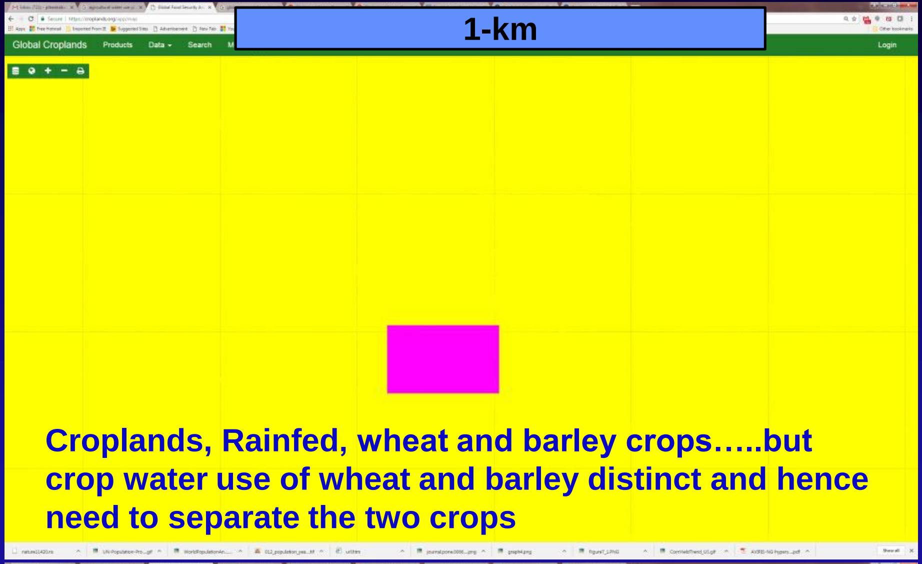
Wheat occupies about 22% of the 1.8 billion hectares of croplands. It is a staple crop across the world. Improving crop water productivity (“crop per drop”) of wheat will be huge contribution towards ensuring food security in the 21st Century

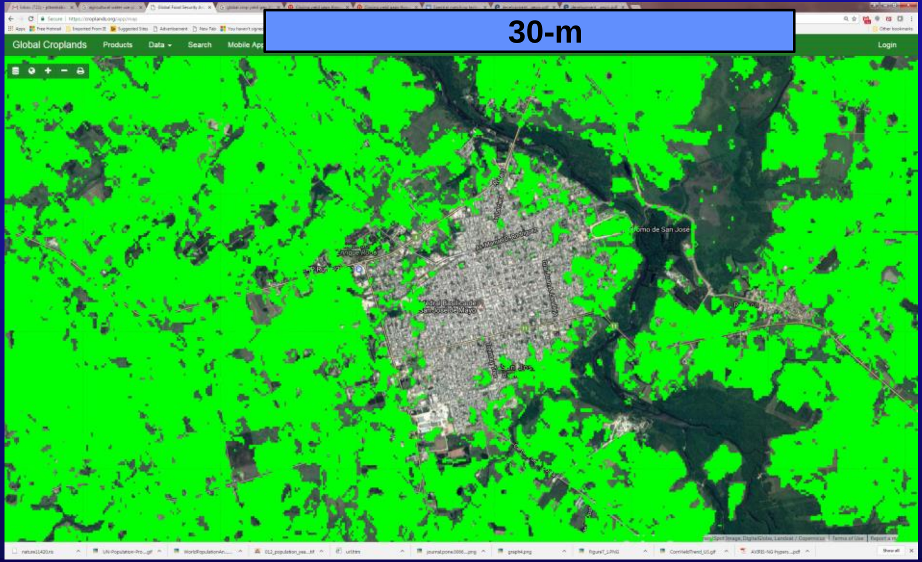


Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Uncertainties in Crop Type Mapping Across Resolutions (e.g., A Micro area in Argentina)







Crop water productivity ("crop per drop") is best studied by taking each crop. Coarse resolution remote sensing does not allow crop type separation with desired accuracies. Finer (30-m or less) resolution data, that also have good temporal coverage will be ideal for separating crop types.

Captures almost all croplands perfectly; However, need to separate wheat from barley (attempt not made yet)

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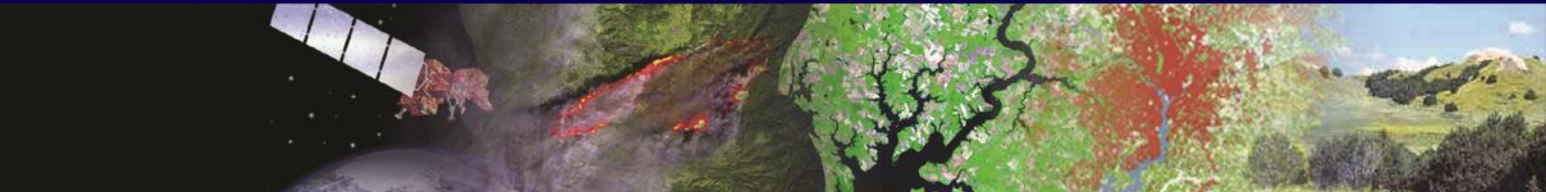
GFSAD30 Project: Background

5. Global Population Growth and Food Security

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/



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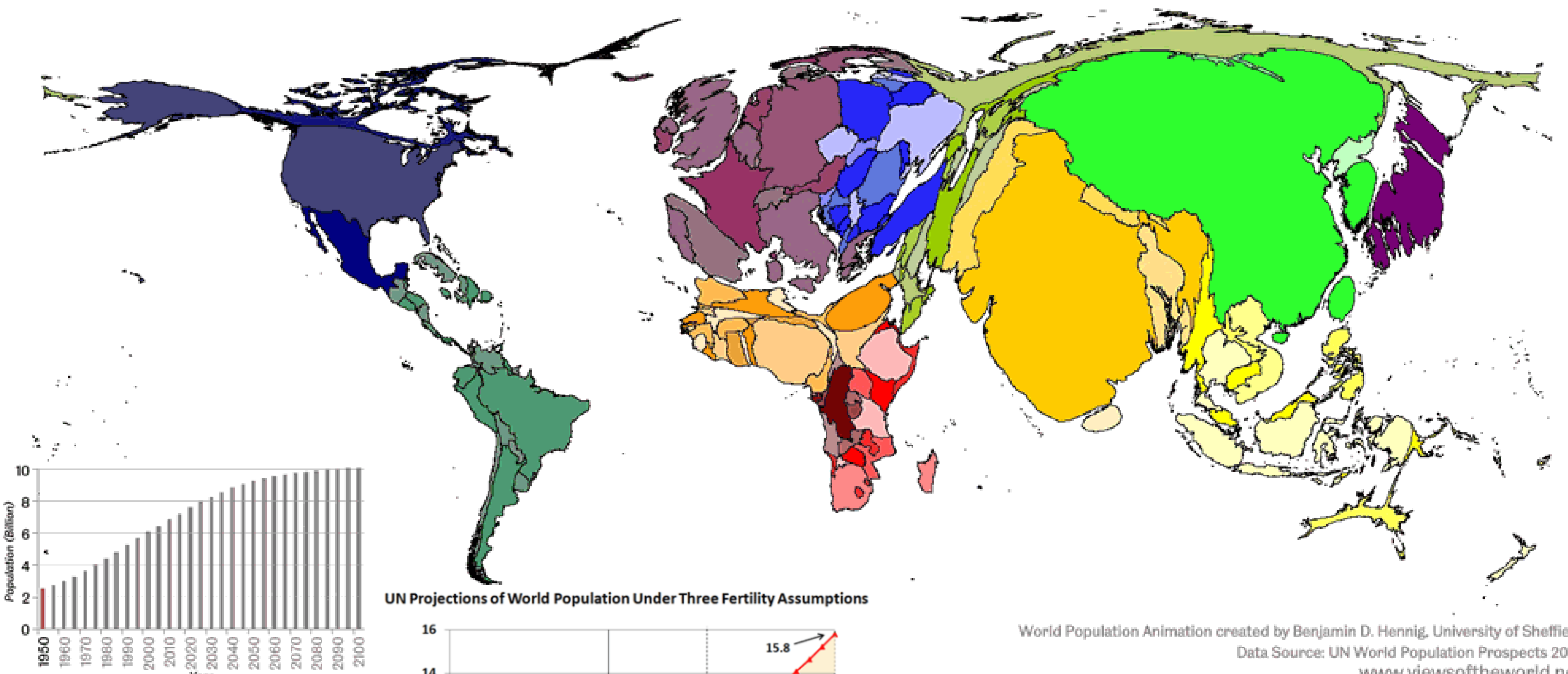
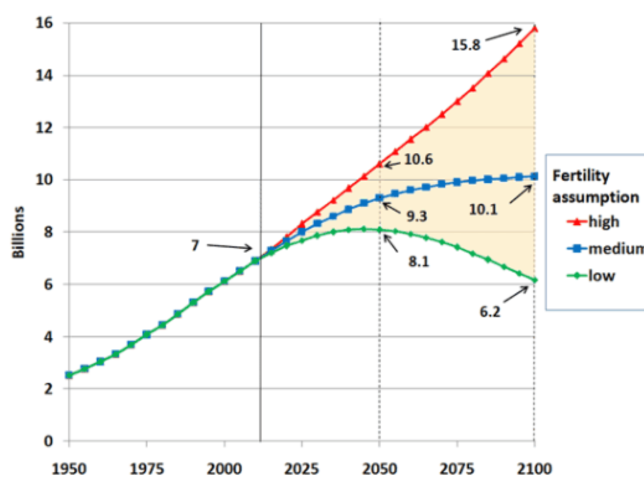
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Population Growth-Croplands-Crop Water Use-Crop Water Productivity-Food Security

World Population 1950



UN Projections of World Population Under Three Fertility Assumptions



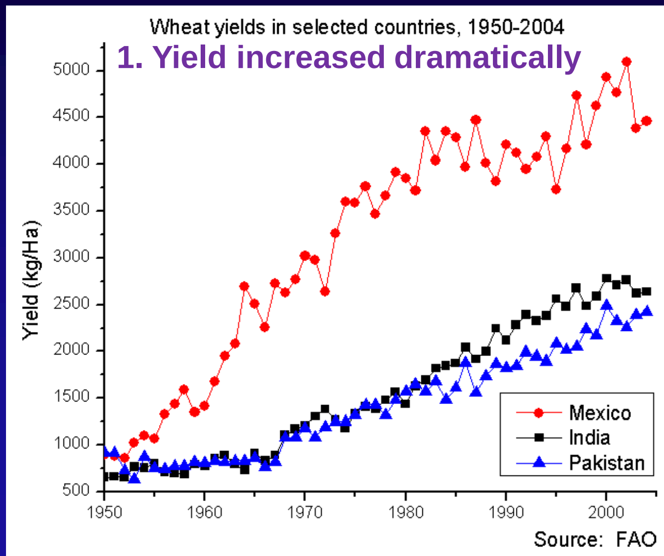
World Population Animation created by Benjamin D. Hennig, University of Sheffield
Data Source: UN World Population Prospects 2010
www.viewsoftheworld.net

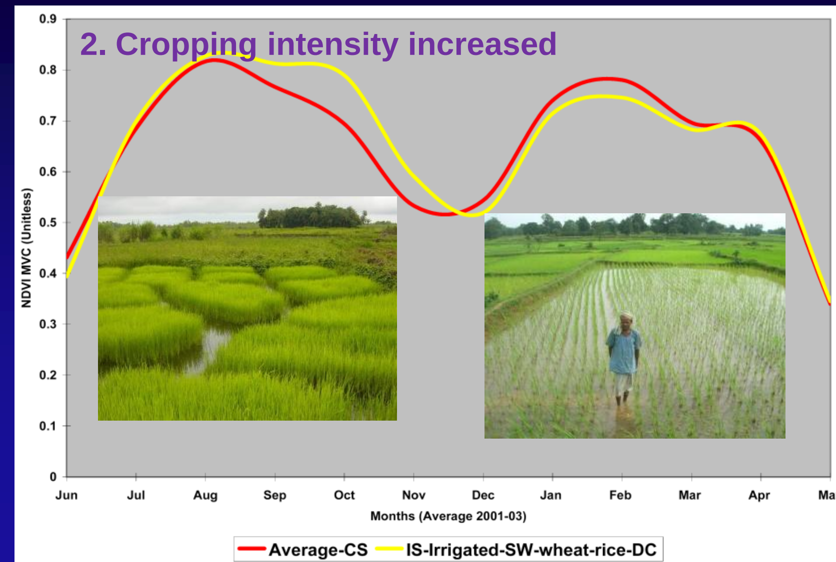
How do we feed a population of 10 billion by 2050 or 12 billion by 2100?.....How does accurate and objective information on croplands help us assess crop productivity, Crop water use, crop water productivity, and food security?……GFSAD30 project is targeted to provide Objective Cropland Information in Support of addressing issues pertaining to global food security

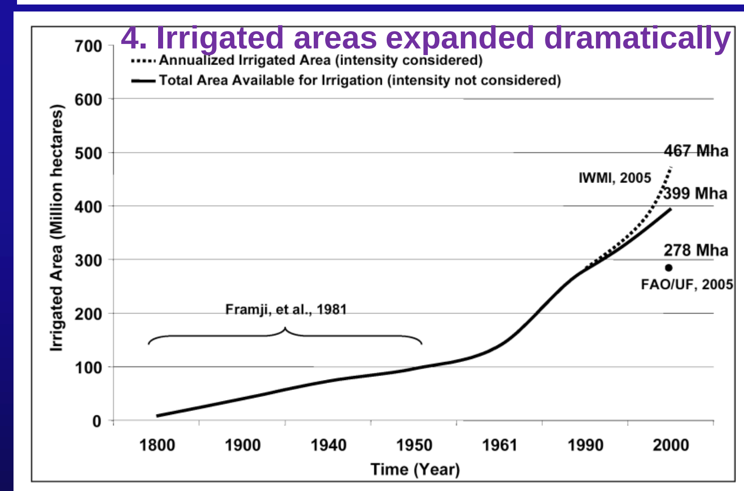
U.S. Geological Survey
U.S. Department of Interior

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

How Food Security was Ensured during the Green Revolution Era (1950-2010)



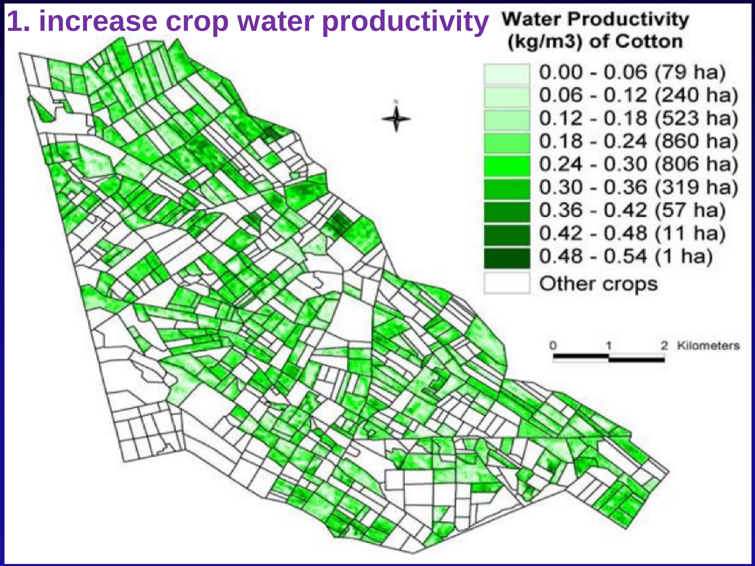


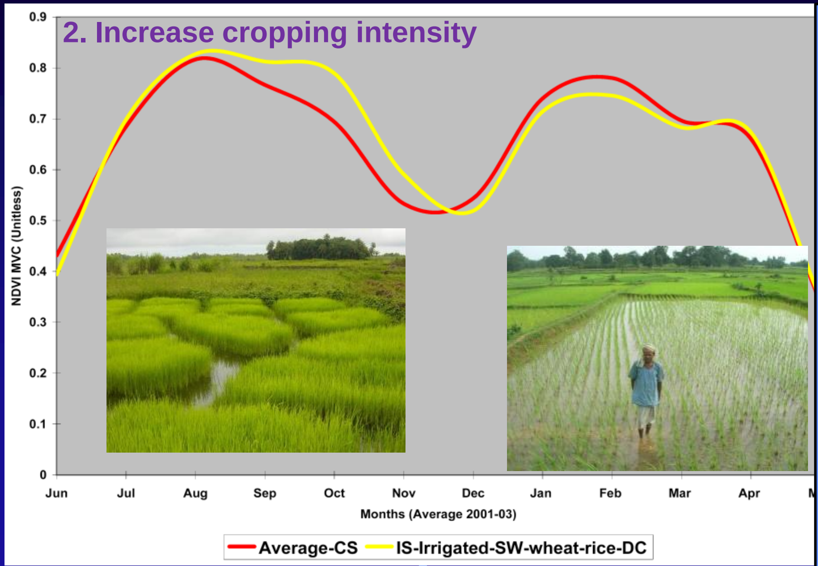


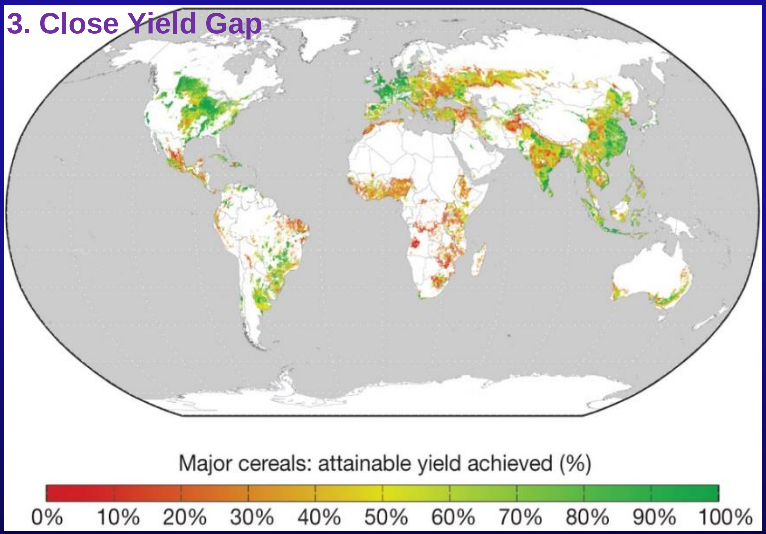
….also cropland management involving herbicides, pesticides, fertilizers, drainage……. combination of these factors lead to green revolution

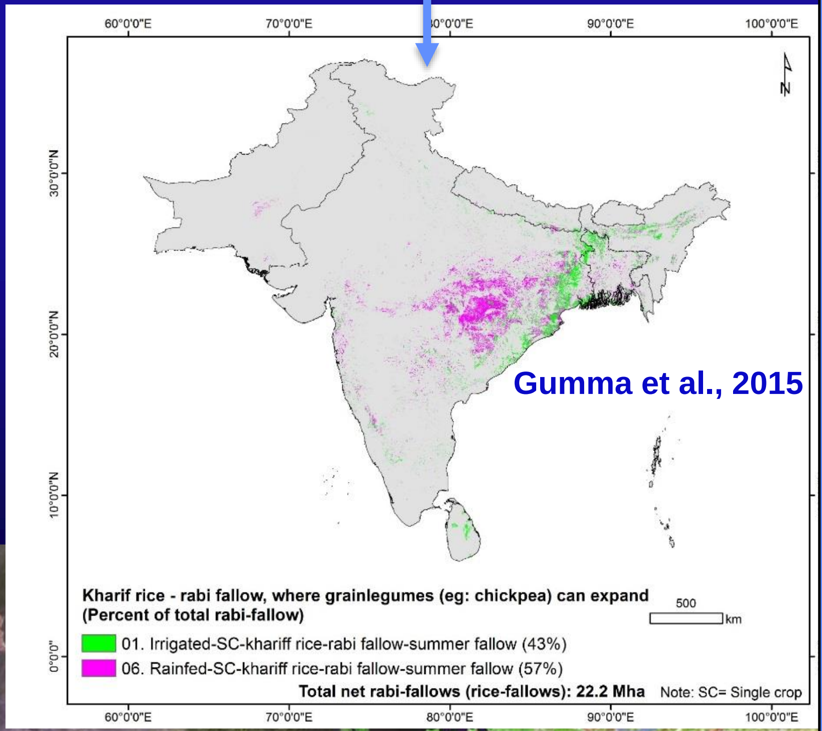
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

How Food Security will be Ensured during the 21st Century









Gumma et al. (2015) showed that there is 22.2 Mha of Rice Fallows (where during Kharif season rice is grown, but rabi season overwhelming proportion is fallow)……in this 22.2 Mha, there is an opportunity to grow a second crop such as Chickpea that is of short season (< 3 month) and low water consuming

science for a changing world

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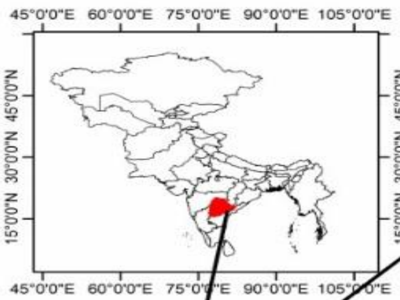
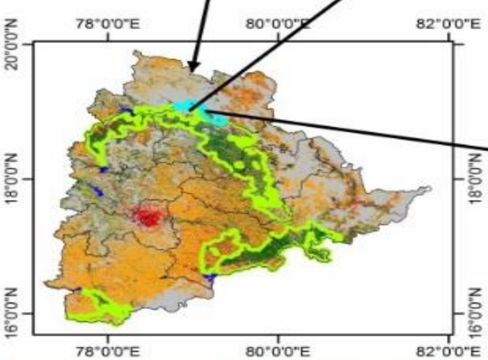
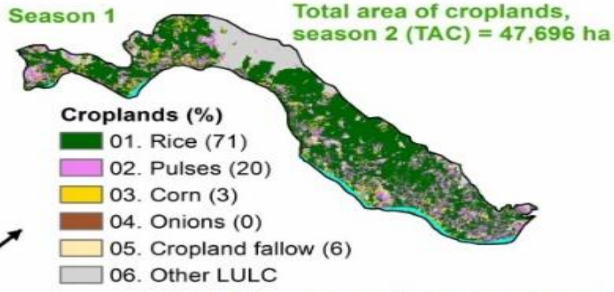
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

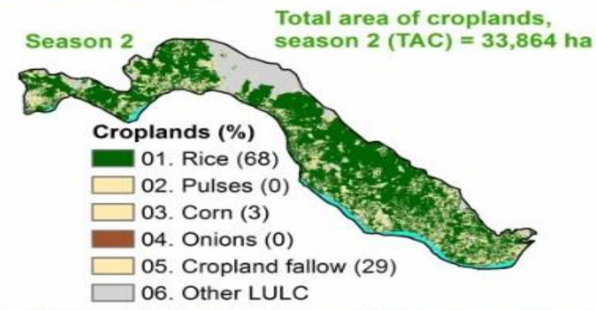
How Food Security will be Ensured during the 21st Century



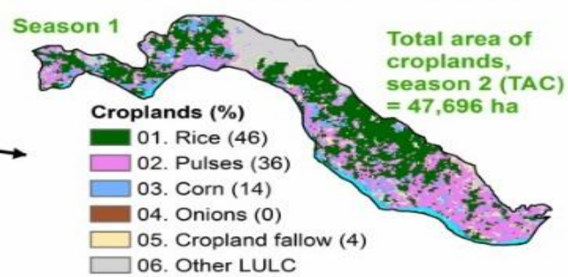


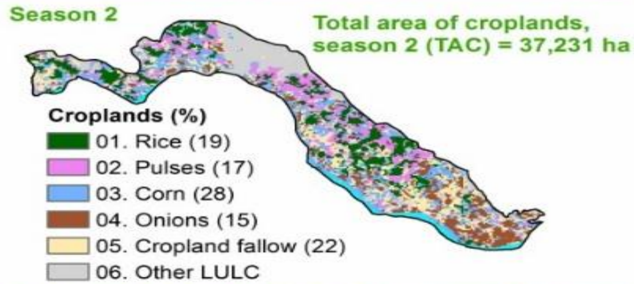
Baseline Scenario @ present





New Scenario with Improved water Productivity and less water consuming crops





A. In existing cropping scenario high water consuming crop like rice dominates. Also water productivity of rice is poor.

B. So, we propose agriculture that is:

1. water-smart (replacing less water consuming, short duration crops like pulses in some rice areas, especially during season 2);
2. Nutrition rich (e.g., pulses);
3. Increased water productivity (improved "crop per drop" through better management);
4. Climate-smart (e.g., growing less water consuming second crop); and
5. Economic-smart (e.g., ensure farmers are not dependent on one crop markets)

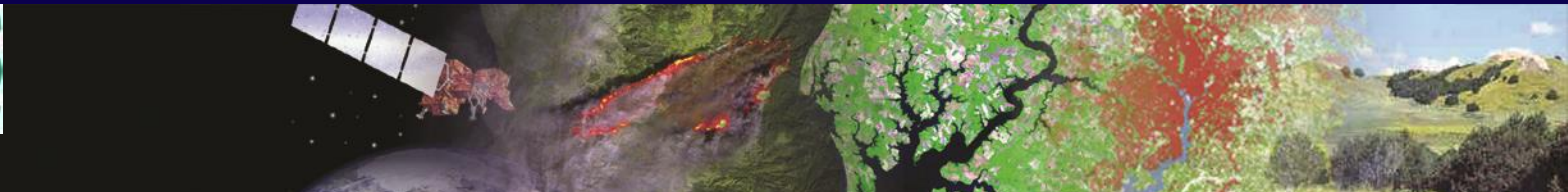
......resulting in a saving of 120 billion liters of water in just 56,606 hectares resulting in "new water" that is used for creating new "water banks" [above-ground (surface water) and below-ground (ground water)].

Table A. Kaddam water use in: (A) baseline scenario, and (B) New scenario of improved water productivity and re-allocation of crops

Crop type	Percent of total cropland area in season 1[A,C] (%)	Percent of total cropland area in season 2[A,C] (%)	Water used for producing 1 kg of grain[E,F] (liters)	Yield per hectares in (kg/hectare)	Total water used by all crops in 2 season (liters)
A. Baseline scenario: with business as usual crops at present during season 1 and\or 2					
Rice	71	68	3400	2500	483579280000
Pulses	20	0	1608	1320	20247524352
Corn	3	3	1222	6500	19434932400
Onions	0	0	345	19000	0
Cropland fallow	6	29	100	0	0
Total Area of croplands (hectares)	47696	33864			532,262 billion liters
Other land cover area (hectares)	8910	22742	Current water use		523 billion liters
Total area (croplands + non-croplands) (hectares)	56606	56606			
B. New scenario: with improved water productivity, re-allocation of less water consuming water-smart, economically-smart crops					
Rice	46	19	2600	2400	181047672000
Pulses	36	17	1608	1320	49879799165
Corn	14	28	1222	6500	135842139160
Onions	0	15	345	19000	36607380750
Cropland fallow	4	22	100	0	0
Total Area of croplands (hectares)	47696	37231			403,377 billion liters
Other land use land cover area (hectares)	8910	19375	New reduced water use		403 billion liters
Total area (croplands + non-croplands) (hectares)	56606	56606			
Reduced water use in new scenario			Water Savings		120 billion liters

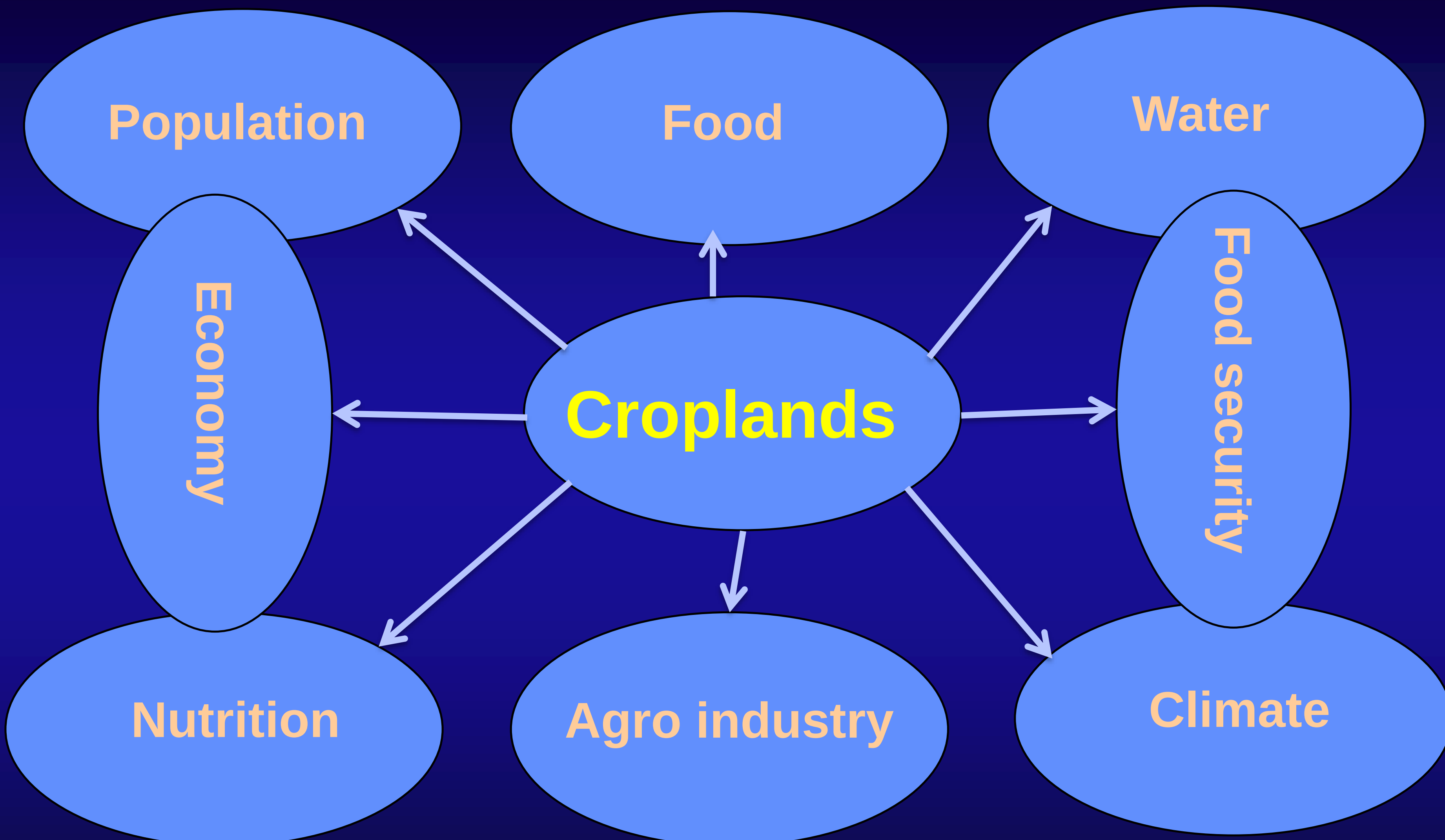
GFSAD30 Project: Background
6. Croplands-Crop Productivity-Crop Water Use-Crop Water Productivity-Population-Food Security

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/



Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Croplands Linked to Many Vital Human and Animal Needs and Human and Animal Welfare

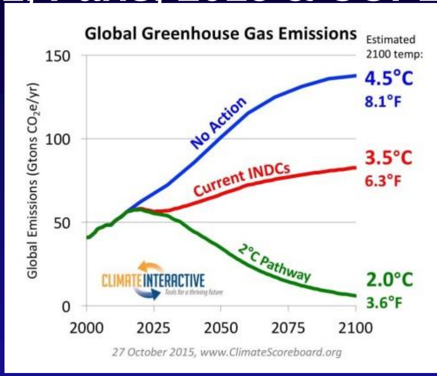


Global Food Security Support Analysis Data @ 30 m (GFSAD30) Project

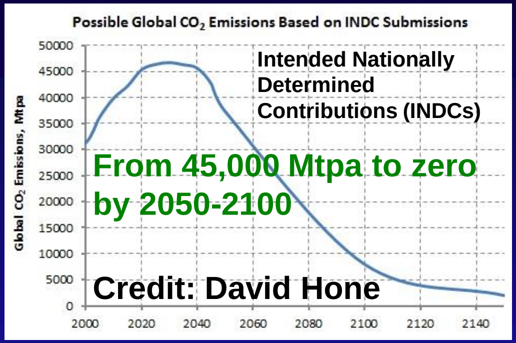
Keeping in View to Contribute Towards zero carbon economy, Climate Security

COP21, Paris, 2015 & COP22 Marrakech, Morocco

Towards zero carbon

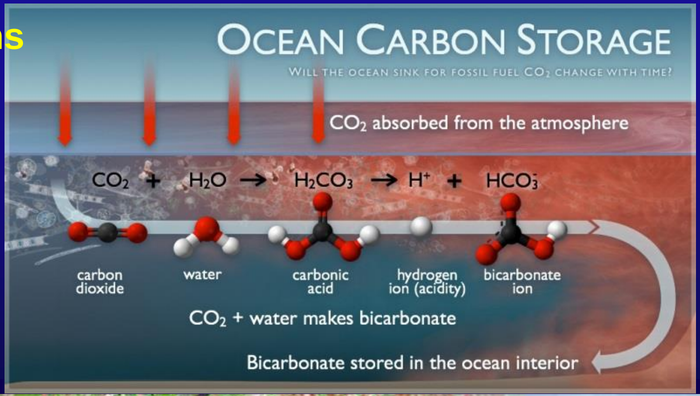


Towards Zero Carbon Economy by 2050 to 2100

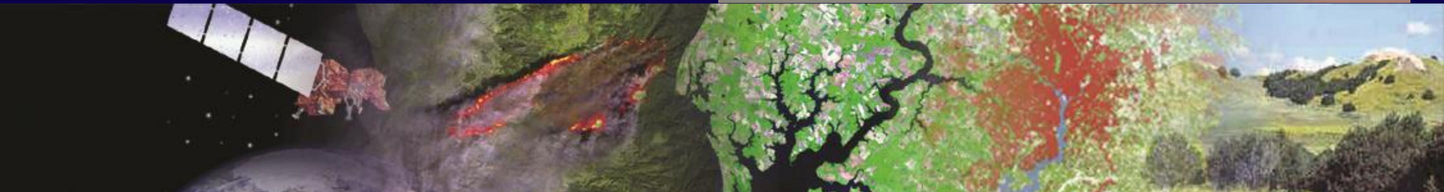


Towards green energy, clean energy, less dependent on fossil fuels

What is emitted is absorbed by soils, forests, oceans
......nothing left in atmosphere



USGS
science for a changing world



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GFSAD30 Project

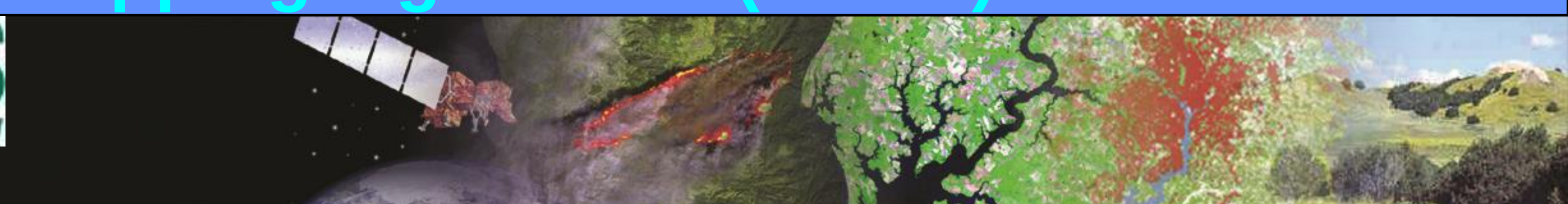
Goal and Key Products

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

Overarching Goal

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: (1) 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; (b) Uncertainties in differentiating irrigated areas from rainfed areas; (c) Absence of crop types and cropping intensities; and (e) Absence of a dedicated web\data portal for the dissemination of cropland products.

The overarching goal of this project is to produce consistent and unbiased estimates of global agricultural cropland areas, crop types, crop watering method, and cropping intensities using Multi-sensor, Multi-date Remote Sensing and mature cropland mapping algorithms (CMAs).



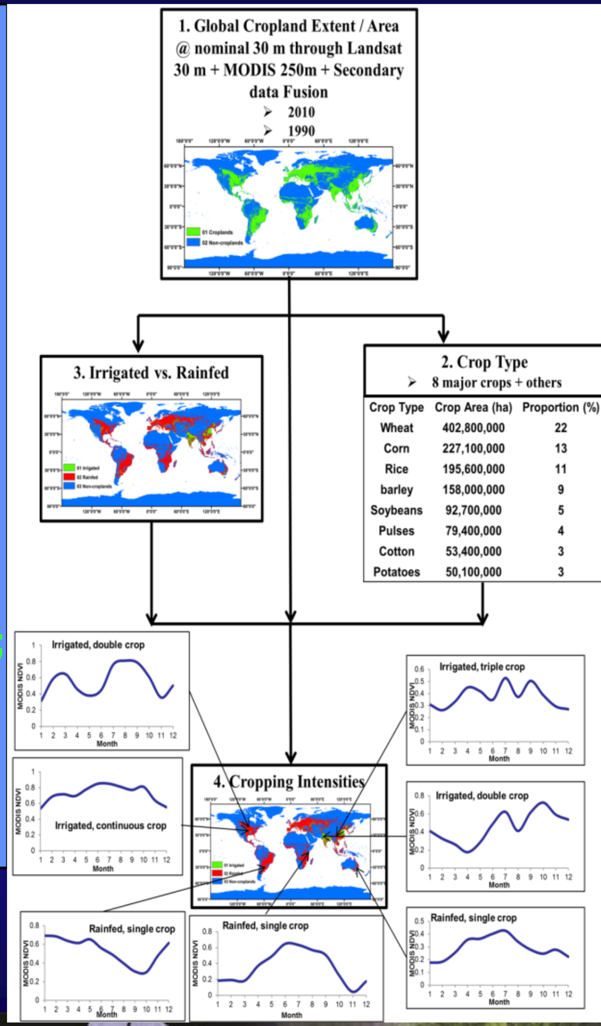
Global Food Security Support Analysis Data @ 30 m (GFSAD30) Project

Global Cropland Products

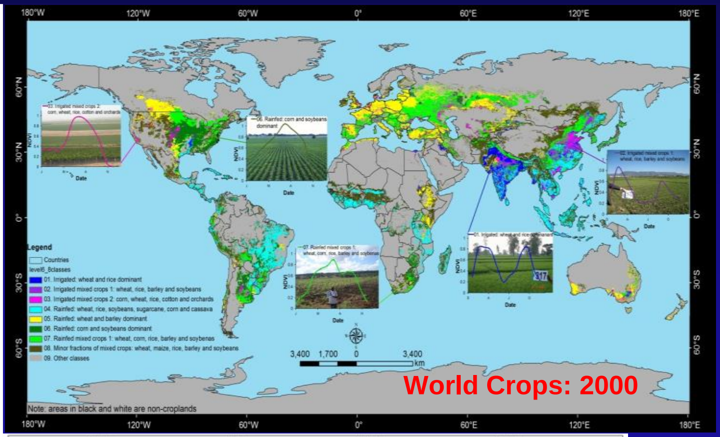
1. Cropland extent\areas;
2. Watering method (e.g., Irrigated versus rainfed);
3. Cropping intensity (e.g., single, double, triple, continuous);
4. Crop types (e.g., Major 8)
5. Croplands *versus* cropland fallows.

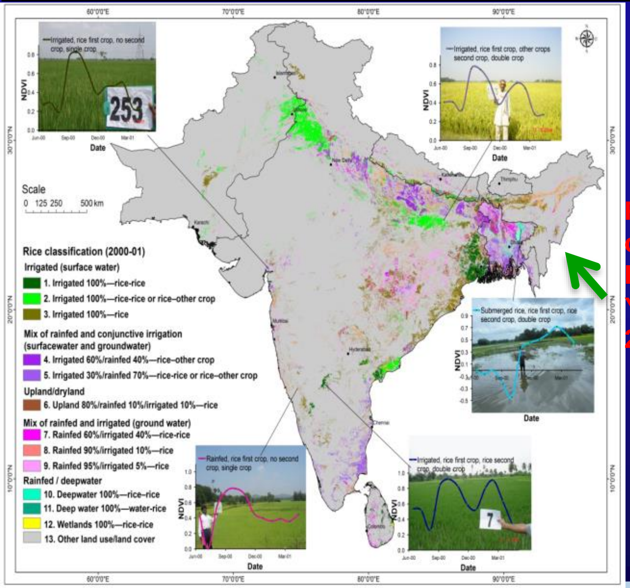
……the above products will lead to other higher level cropland products such as:

A. Crop productivity (kg\m^2);
B. Crop water use (m^3\m^2);
C. Crop water productivity ("crop per drop"; kg\m^3);



Crop Type	Crop Area (ha)	Proportion (%)
Wheat	402,800,000	22
Corn	227,100,000	13
Rice	195,600,000	11
barley	158,000,000	9
Soybeans	92,700,000	5
Pulses	79,400,000	4
Cotton	53,400,000	3
Potatoes	50,100,000	3





Rice crop in India: Year 2000

Global Cropland Products @ 3 Resolutions

1A. GCE 1km Crop Dominance (aka GCE V0.0)
- Cropland extent and areas;
- Cropland watering method: irrigation versus rainfed

To a lesser extent
- Crop dominance (not type)

1B. GCE 1km Multi-study Crop Mask (aka GCE V1.0)
- Cropland extent and areas;
- Cropland watering method: irrigation versus rainfed

1 km

2. GCE 250m Crop Dominance (aka GCE V2.0)
- Cropland extent and areas;
- Cropland watering method: irrigation versus rainfed;
- Cropping intensity;

To a lesser extent
- Crop type and\or dominance

250 m

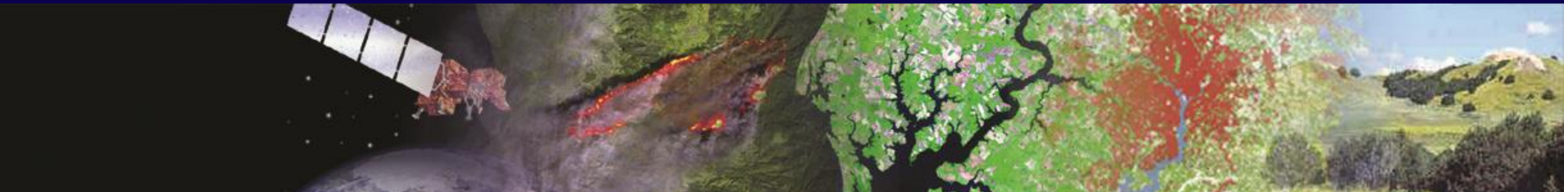
3. GCE 30m Crop Dominance (aka GCE V3.0)
- Cropland extent and areas;
- Cropland watering method: irrigation versus rainfed;
- Cropping intensity;
- Crop type and\or dominance

30 m

GFSAD30 Project

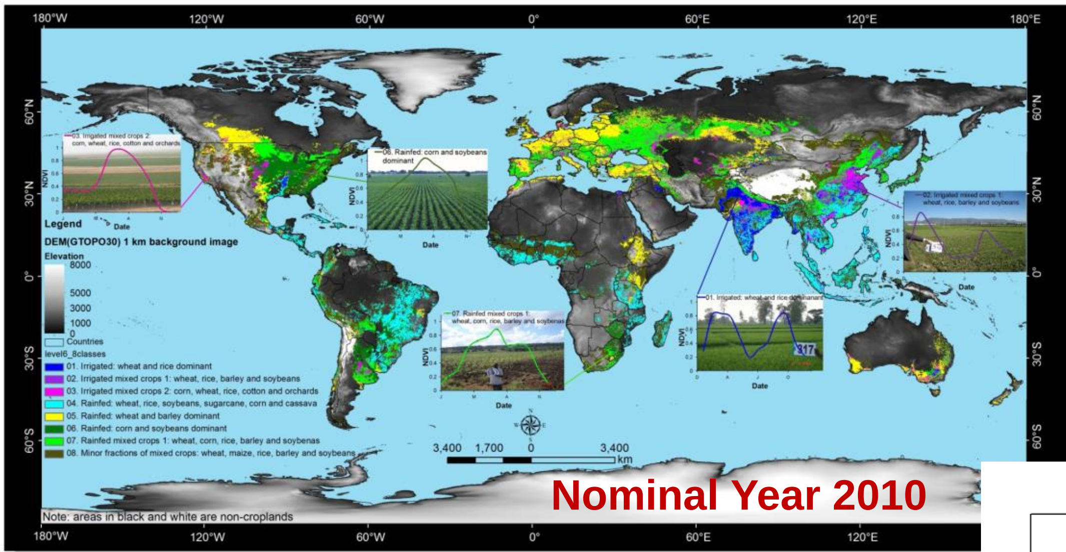
Global Croplands @ 1-km

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/



Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Global Croplands @ 1-km: Best Synthesis for Nominal Years 2010 and 2015



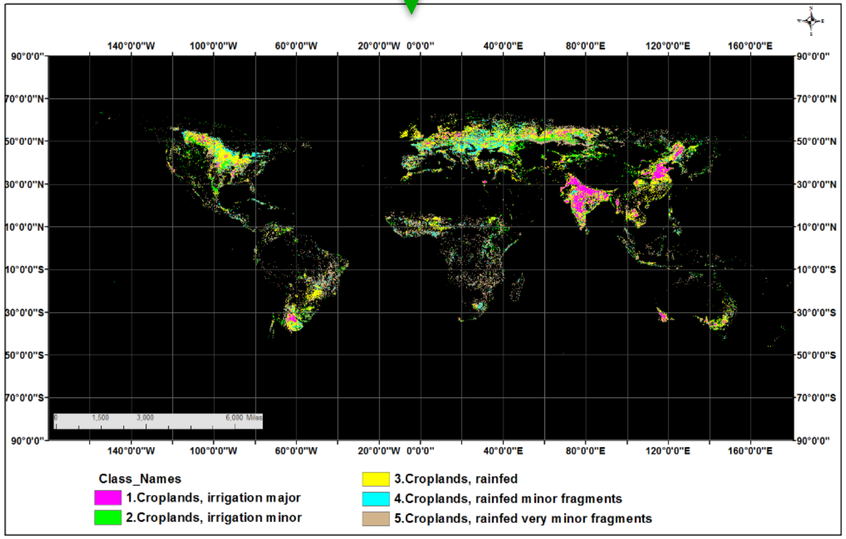
Nominal Year 2010

1. 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.

Product released @:
https://e4ftl01.cr.usgs.gov/provisional/MEaSUREs/GFSAD/GFSADCD1KM/

2. 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 (GFSAD1km) 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.

Product released @:
https://e4ftl01.cr.usgs.gov/provisional/MEaSUREs/GFSAD/GFSADCM1KM/



Nominal Year 2015

Visit Page:
https://geography.wr.usgs.gov/science/croplands/products.html

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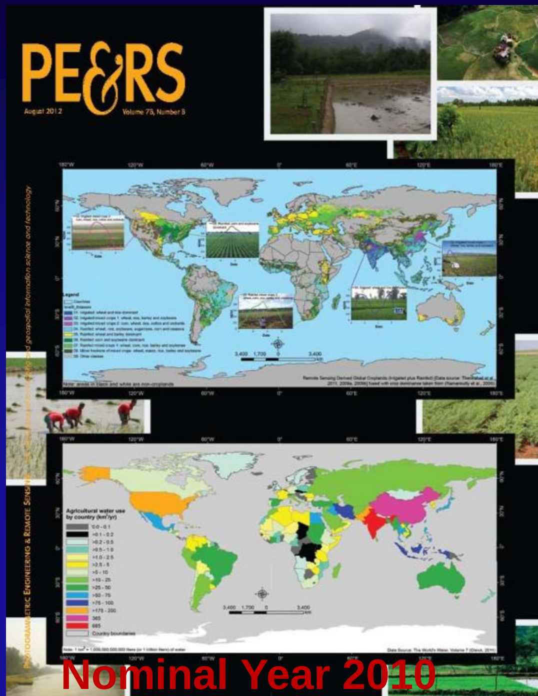
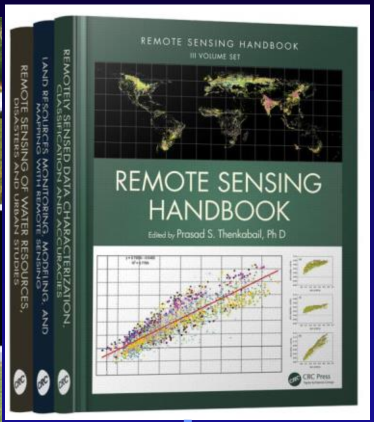
U.S. Geological Survey
U.S. Department of Interior

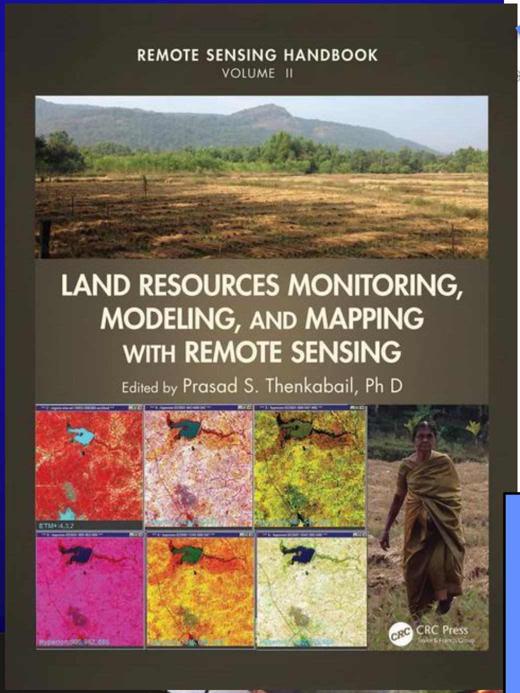
Note: Globally, there is ~1.6 billion hectares of croplands as of nominal Years 2000 and 2015, with 34% irrigated and 66% rainfed

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Global Croplands @ 1-km: Best Synthesis for Nominal Years 2010 and 2010

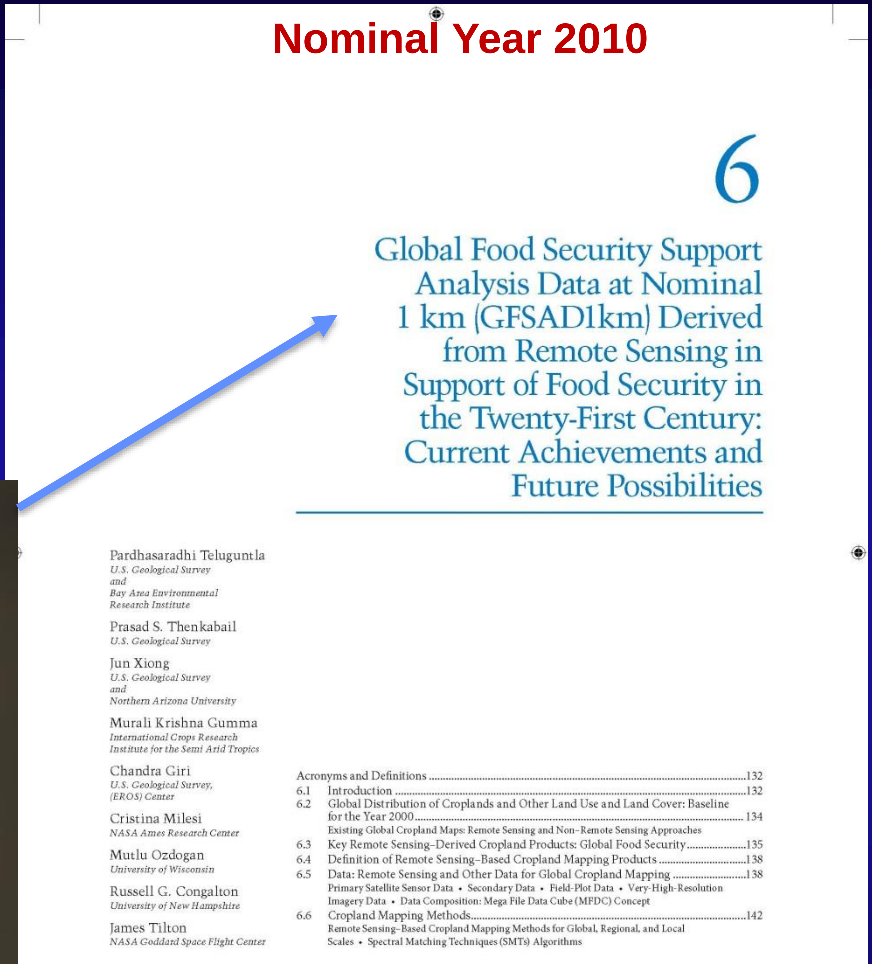






1. Thenkabail P.S., Knox J.W., Ozdogan, M., Gumma, M.K., Congalton, R.G., Wu, Z., Milesi, C., Finkral, A., Marshall, M., Mariotto, I., You, S. Giri, C. and Nagler, P. 2012. Assessing future risks to agricultural productivity, water resources and food security: how can remote sensing help?. Photogrammetric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

Nominal Year 2010



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

Pardhasaradhi Teluguntla
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Bay Area Environmental Research Institute

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and
Northern Arizona University

Murali Krishna Gumma
International Crops Research Institute for the Semi Arid Tropics

Chandra Giri
U.S. Geological Survey, (EROS) Center

Cristina Milesi
NASA Ames Research Center

Mutlu Ozdogan
University of Wisconsin

Russell G. Congalton
University of New Hampshire

James Tilton
NASA Goddard Space Flight Center

2. 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 (GFSAD1km) 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.

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U.S. Department of Interior

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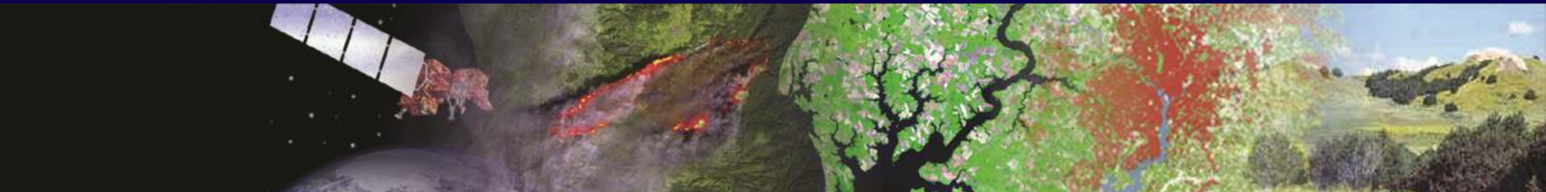
Global Croplands @ 250-m

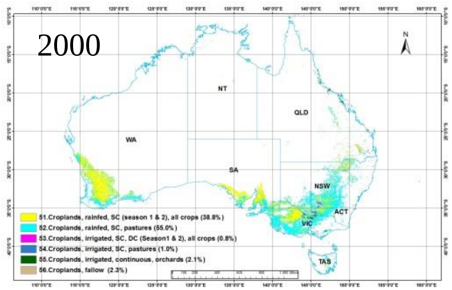
http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

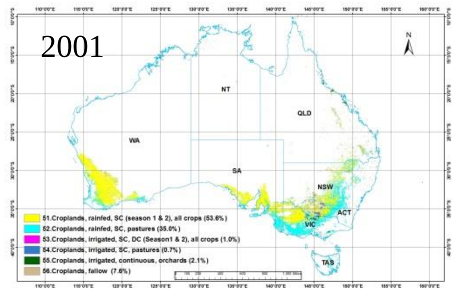


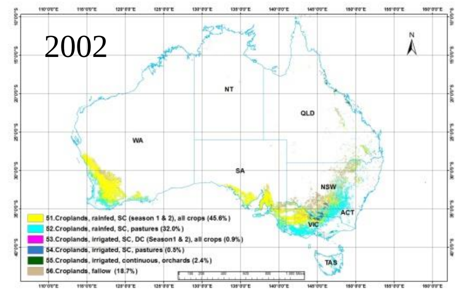
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

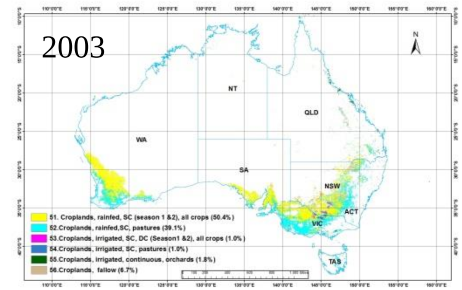
Global Croplands @ 250-m (e.g., 6 class map) using

Automated Cropland Classification Algorithms (ACCAs) (e.g., Australia 2000-2015)

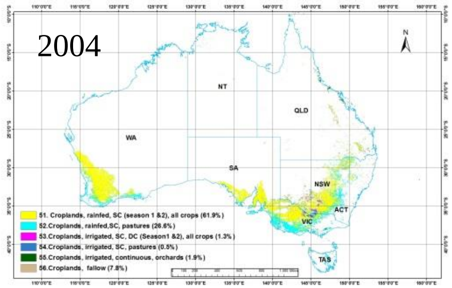


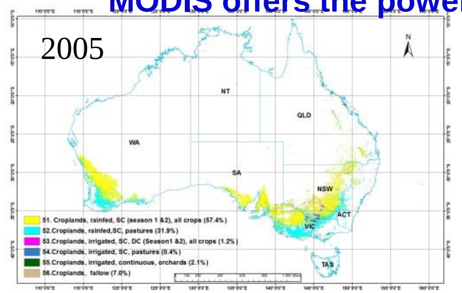


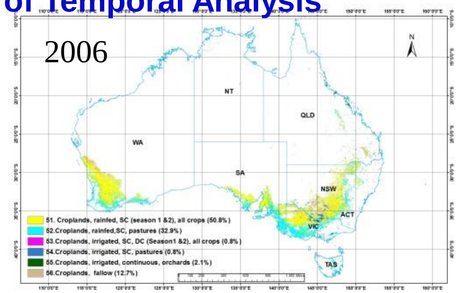


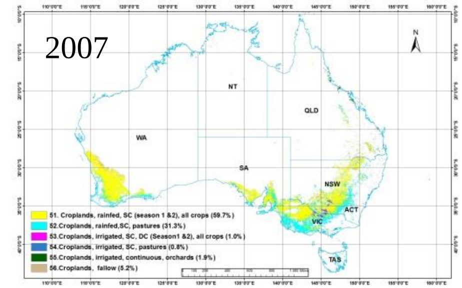


MODIS offers the power of Temporal Analysis

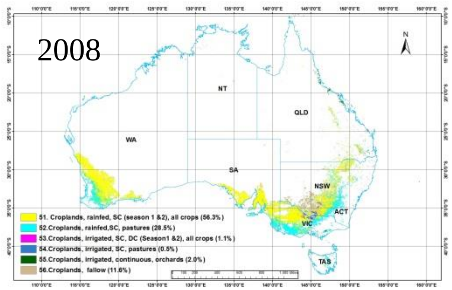


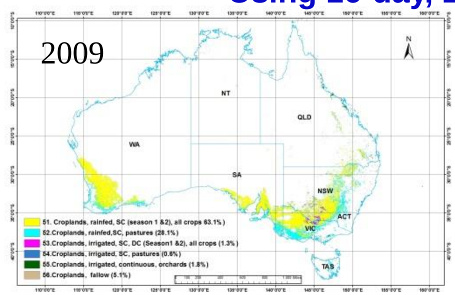


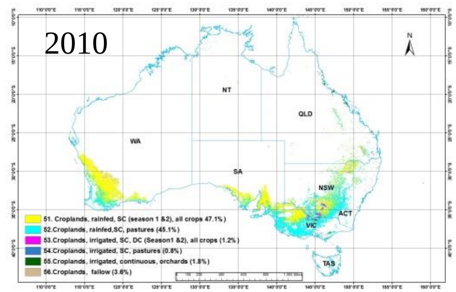


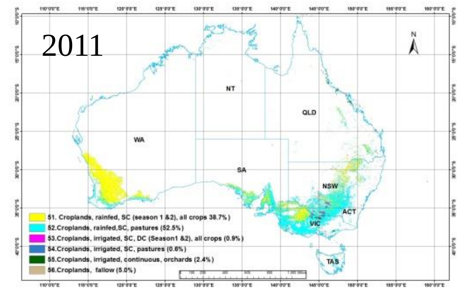


Using 16-day, 250-m time-series

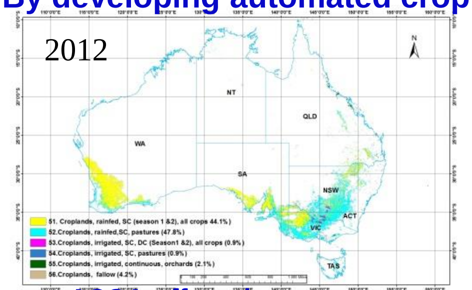


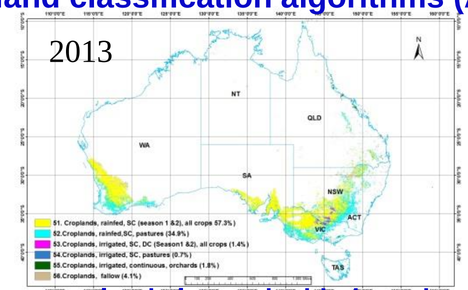


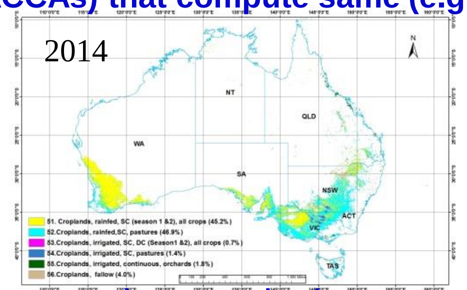


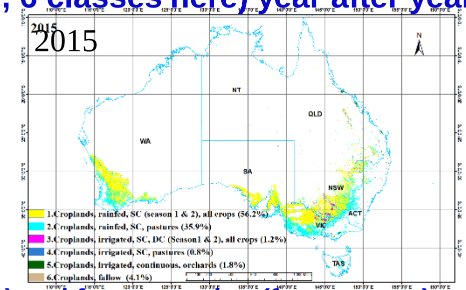


By developing automated cropland classification algorithms (ACCAs) that compute same (e.g., 6 classes here) year after year









ACCA offers the power to compute cropland classes by hind-casting (past years), now-casting (present year) and future-casting (future years)

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

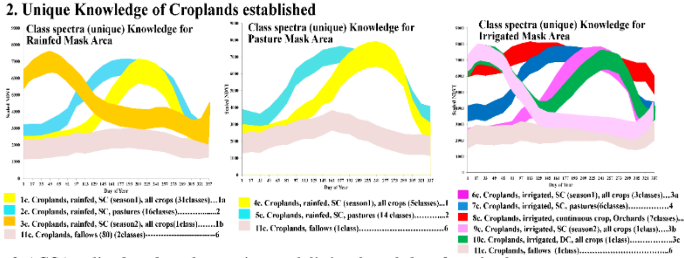
Global Croplands @ 250-m using

Automated Cropland Classification Algorithms (ACCAs) (e.g., Australia 2000-2015)

https://croplands.org/app/map; https://croplands.org/

1. MODIS 250m, every 16day NDVI time series data for year 2014

2. Unique Knowledge of Croplands established



3. ACCA coding based on above unique and distinct knowledge of croplands

ACCA for Rainfed Mask Area

Class 1a (Rainfed, single crop, season 2)
If ΣNDVI >= 22400 in time period 2 to 5 then Croplands, rainfed, Season2 crops

Class 6 (Rainfed, fallows)
If ΣNDVI <= 19600 in time period 11 to 17 then Croplands, rainfed, fallows

Class 1b (Rainfed, single crop, season 1)
If ΣNDVI <= 10200 In time period 6 to 8 then Croplands, rainfed, Season1 all crops

Class 2 (Rainfed, pasture)
If ΣNDVI > 10200 in time period 6 to 8 then Croplands, rainfed, pastures

Note: When coding this order must be noted to achieve best results:
1. First, class 1a is coded and the class 1a area is removed from further analysis;
2. Second, class 6 is coded and the class 6 area is removed from further analysis;
3. Third, , class 1b is coded and the class 1b area is removed from further analysis;
4. Fourth, rest of the area is class 2.
5. Finally, we merge class 1a and 1b into a single class 1. Even though they are significantly different in signature, class 1a is a very small area compared to class 1b. Both are rainfed single crop classes.

ACCA for Pasture Mask Area

Class 6 (Rainfed, fallows)
If ΣNDVI <= 14600 In time period 11 to 14 then Croplands, rainfed, fallows

Class 2 (Rainfed, pasture)
If NDVI(1)>3800
or if ΣNDVI > 9000 in time period 5 to 7
or if NDVI(5)>6000 or NDVI(6)>6000 or NDVI(7)>6000 or NDVI(8)>6000 or NDVI(9)>6000 Or NDVI(10)>6000 or
If ΣNDVI > 9000 and ΣNDVI < 12000 in time period 15 to 17 then Croplands, rainfed, pastures

Class 1 (Rainfed, single crop, season 1)
else Croplands, rainfed, Season1 all crops

Note: When coding this order must be noted to achieve best results:
1. First, class 6 is coded and the class 6 area is removed from further analysis;
2. Second, class 2 is coded and the class 2 area is removed from further analysis;
3. Third, rest of the area is class 1

ACCA for Irrigated Mask Area

Class 6 (Irrigated, fallows)
If ΣNDVI <= 10400 in time period 8 to 11 then Croplands, irrigated, fallows

Class 5 (Irrigated, continuous)
If ΣNDVI >= 28000 in time period 19to 22 then Croplands, irrigated, continuous orchards
or If ΣNDVI >= 18000 in time period 2 to 4
or (ΣNDVI <= 32400 and ΣNDVI >= 21600) in time period 13 to 18 then Croplands, irrigated, continuous, orchards

Class 3a (Irrigated, double crop)
If ΣNDVI >= 16800 in time period 2 to 4
and ΣNDVI <= 13800 in time period 8 to 10
and ΣNDVI > 22400 in time period 15 to 18
then Croplands, irrigated, double crop

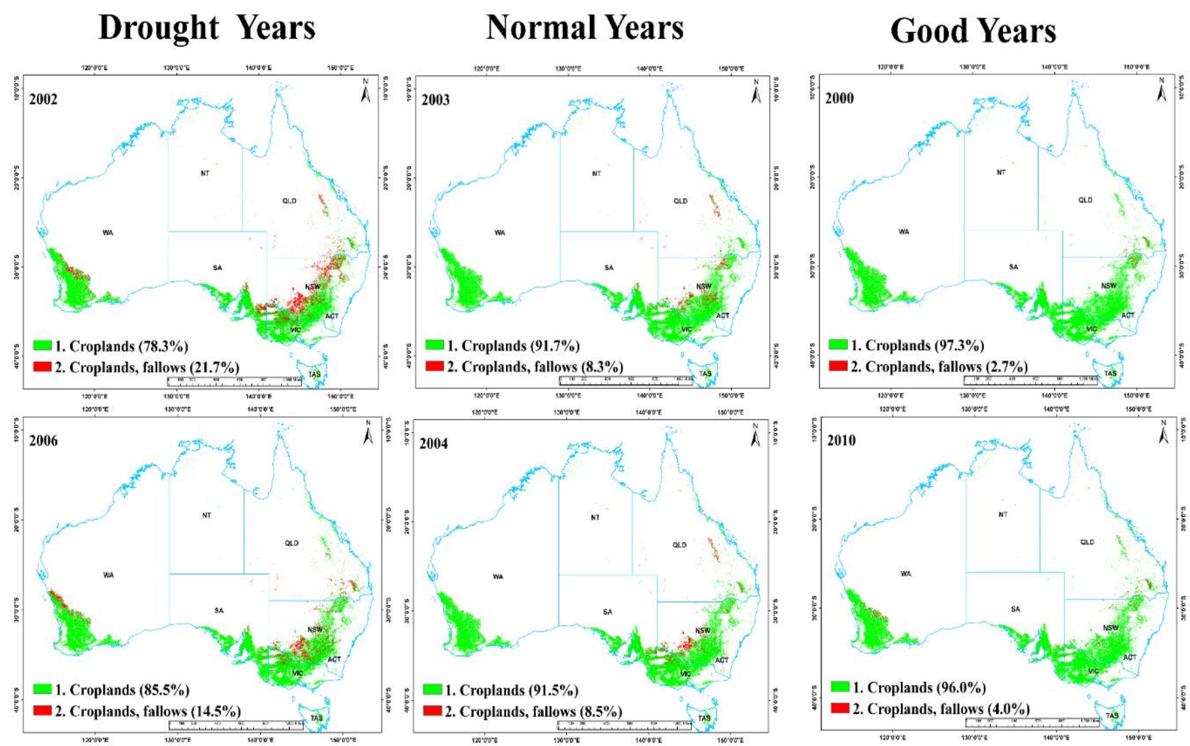
Class 3b (Irrigated, single crop, season2)
If ΣNDVI >= 16800 in time period 2 to 4
and ΣNDVI <= 8000 in time period 12 to 13
then Croplands, irrigated, season#2

Class 4 (Irrigated, pastures)
If ΣNDVI >= 16200 in time period 8 to 10 then Croplands, irrigated, pastures

Class 3c (Irrigated, single crop, season1)
else Croplands, irrigated, all crops

Note: When coding this order must be noted to achieve best results:
1. First, class 6 is coded and the class 6 area is removed from further analysis
2. Second, class 5 is coded and the class 5 area is removed from further Third, class 3a is coded and the class 3a area is removed from further analysis; then class3b coded and the class 3b area is removed from further analysis;
3. Fourth, class 4 is coded and the class 4 area is removed from further analysis;
4. rest of the area is class 3c;Finally, we merge class 3a, 3b and 3c into a single class3. Even though they are significantly different in signature, the areas are very smaller.

Note: One time period indicates 16-day MODIS composite



1. Developed automated cropland classification algorithms (ACCA);
2. ACCA algorithm was made available @ in ERDAS Imagine .gmd format: http://geography.wr.usgs.gov/science/croplands/algorithms/australia_250m.html
3. ACCA algorithm has ability to accurately and routinely compute cropland products year after year: **for the past years (hind-cast), present year (now-cast), and future years (future-acast);**

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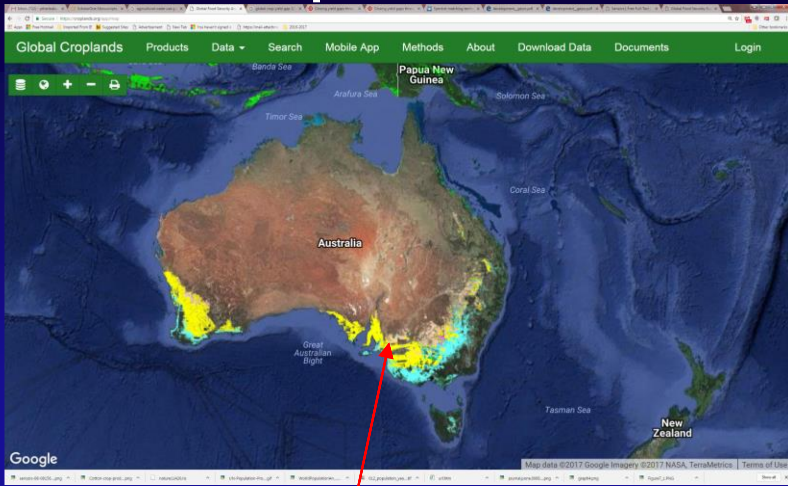
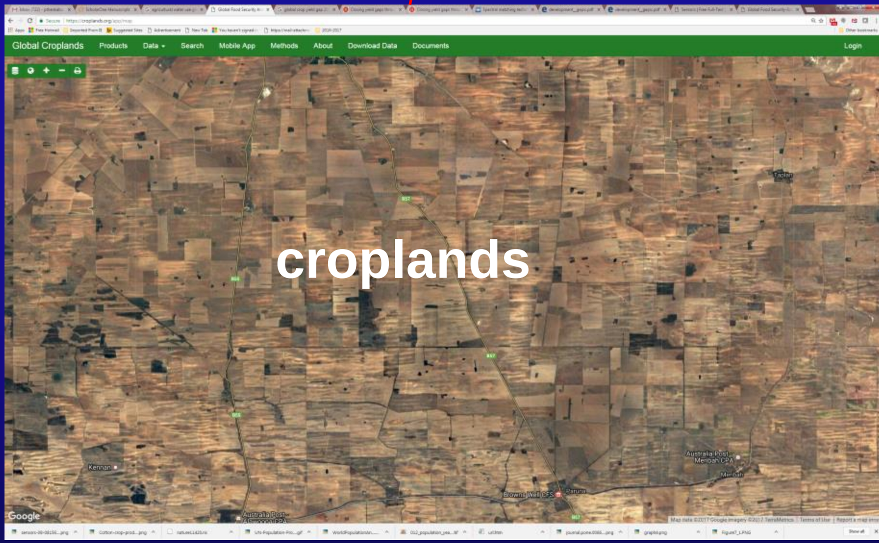
Teluguntla, P., Thenkabail, P.S., Xiong, J., Gumma, M.K., Congalton, R.G., Oliphant, A., Poehnelt, J., Yadav, K., Rao, M., and Massey, R. 2017. Spectral matching techniques (SMTs) and automated cropland classification algorithms (ACCAs) for mapping croplands of Australia using MODIS 250-m time-series (2000–2015) data, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1267269. IP-074181. Link to this article: http://dx.doi.org/10.1080/17538947.2016.1267269

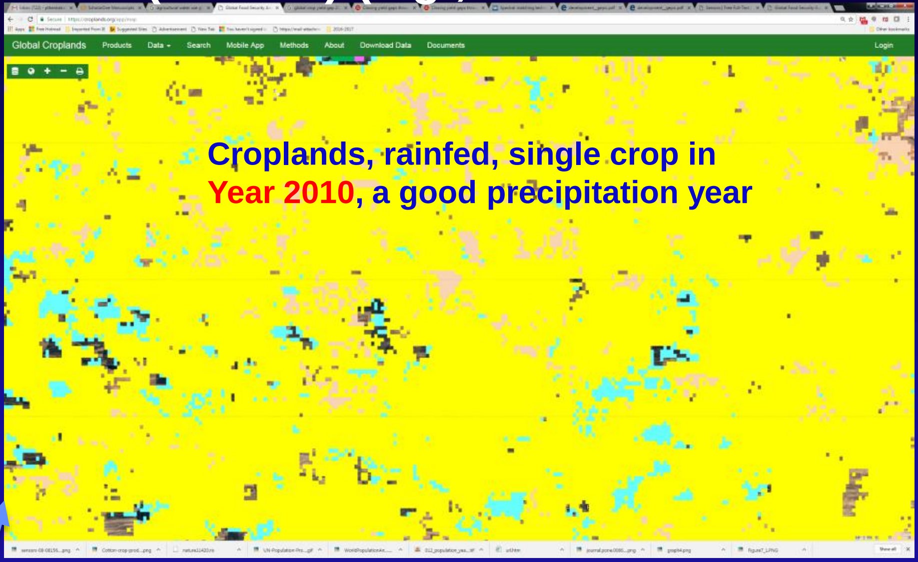
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

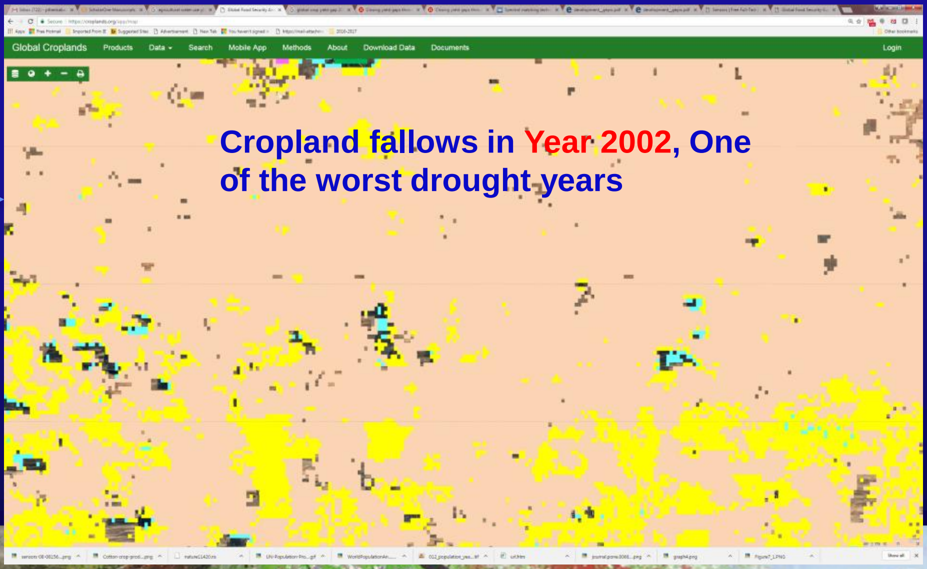
Global Croplands @ 250-m using

Automated Cropland Classification Algorithms (ACCAs) (e.g., Australia 2000-2015)









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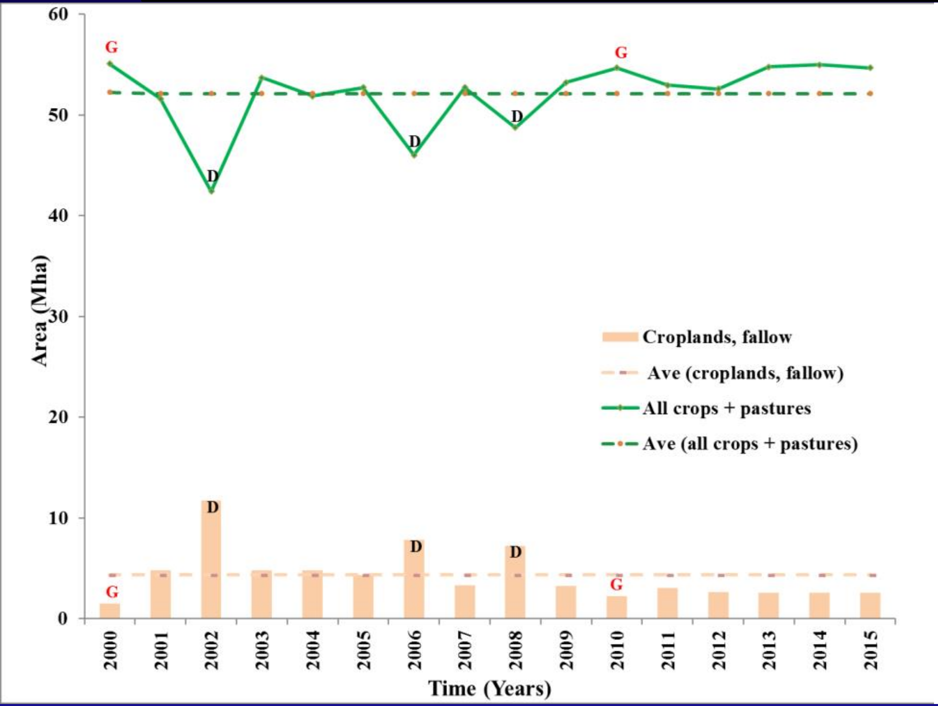
ACCA captures temporal changes across years in cropland dynamics

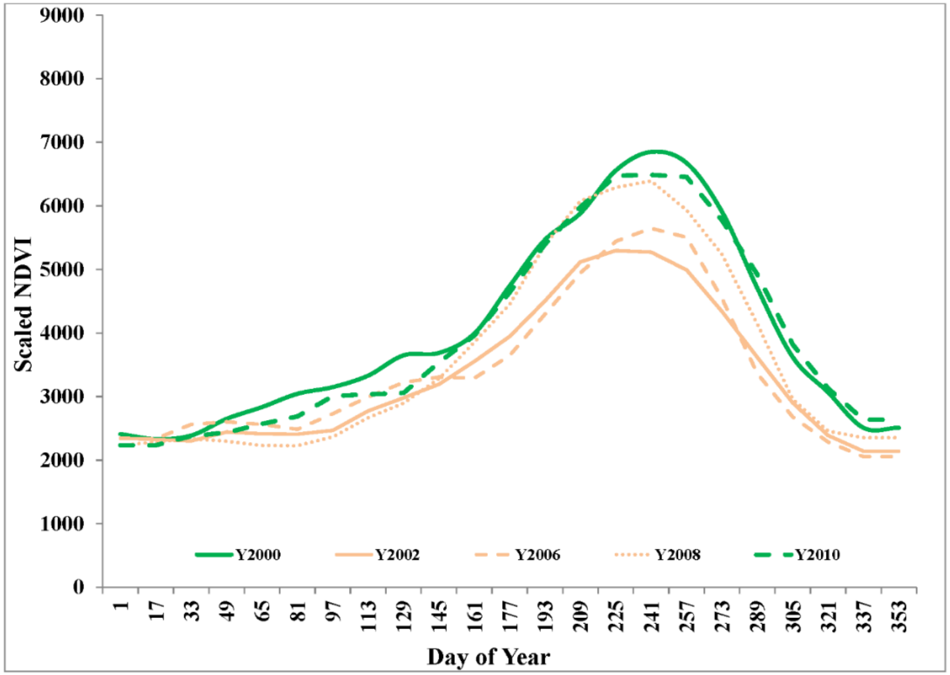
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Global Croplands @ 250-m using

Automated Cropland Classification Algorithms (ACCAs) (e.g., Australia 2000-2015)

https://croplands.org/app/map; https://croplands.org/





ACCA algorithm has ability to accurately and routinely compute cropland areas *versus* cropland fallow areas year after year: for the past years (hind-cast), present year (now-cast), and future years (future-acast);

ACCA algorithm has ability to accurately and routinely compute cropland vigor year after year: for the past years (hind-cast), present year (now-cast), and future years (future-acast);

Fluctuations in Cropland areas and Cropland Vigor will help determine Crop Productivity, leading to Food and Water Security Analysis

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U.S. Geological Survey
U.S. Department of Interior

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, DOI: 10.1080/17538947.2016.1267269. IP-074181. Link to this article: http://dx.doi.org/10.1080/17538947.2016.1267269

GFSAD30 Project
30-m, World
Approach: Overview

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

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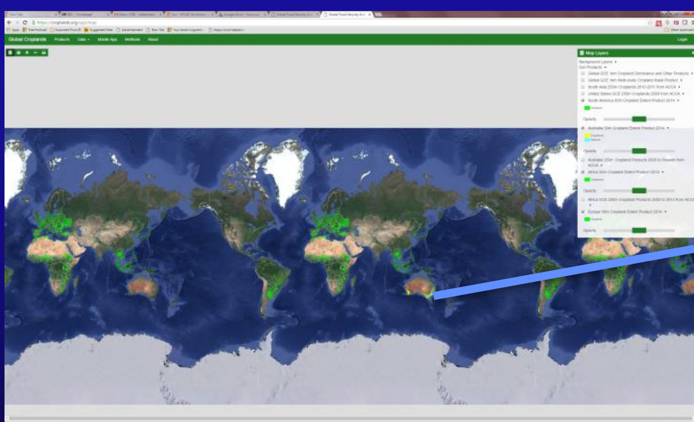
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Paradigm Shift in How we do Remote Sensing

Global Croplands @ 30-m Resolution based on Landsat and\or Sentinel Data

- **Cloud computing (e.g., Google Earth Engine, Amazon) to overcome: (a) data storage, (b) data processing, (c) code sharing, (d) handling massively large big data;**
- **Machine learning algorithms (e.g., Random Forest Classifier, support vector machines, decision trees) applied uniformly across the world;**
- **Automated cropland classifications (e.g., season after season, year after year);**



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Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Understanding Cropland Extent

Definitions: Cropland Extent Includes

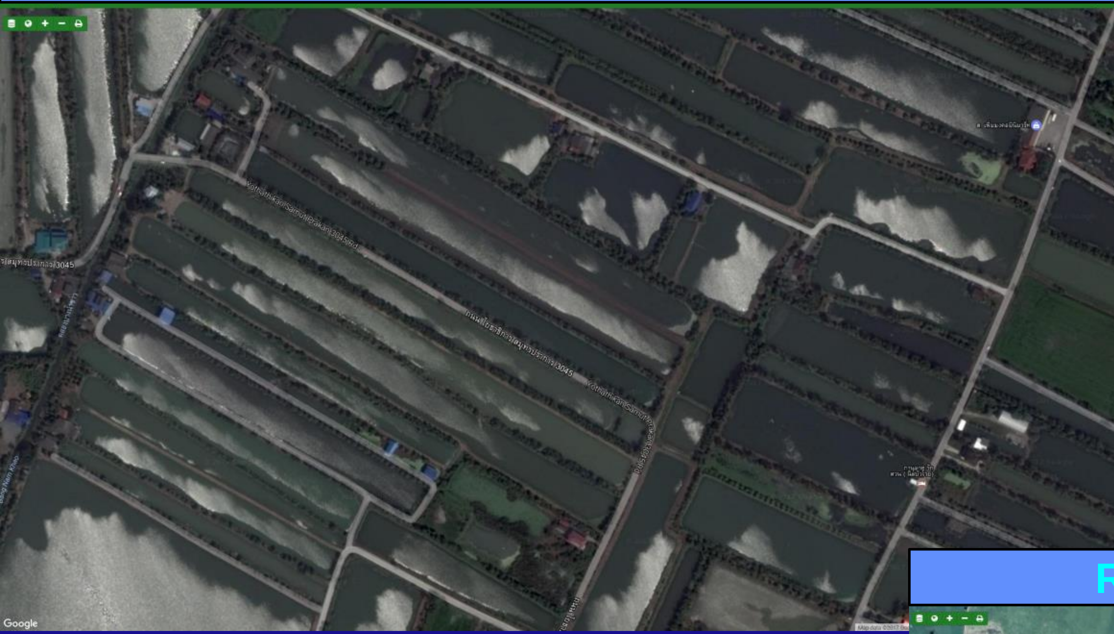
All croplands cultivated for food, feed, and fiber, including plantations (e.g., orchards, vineyards, coffee, tea, rubber) or croplands that are left fallow

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Understanding Cropland Extent

Definitions: Agricultural Systems, Not Croplands

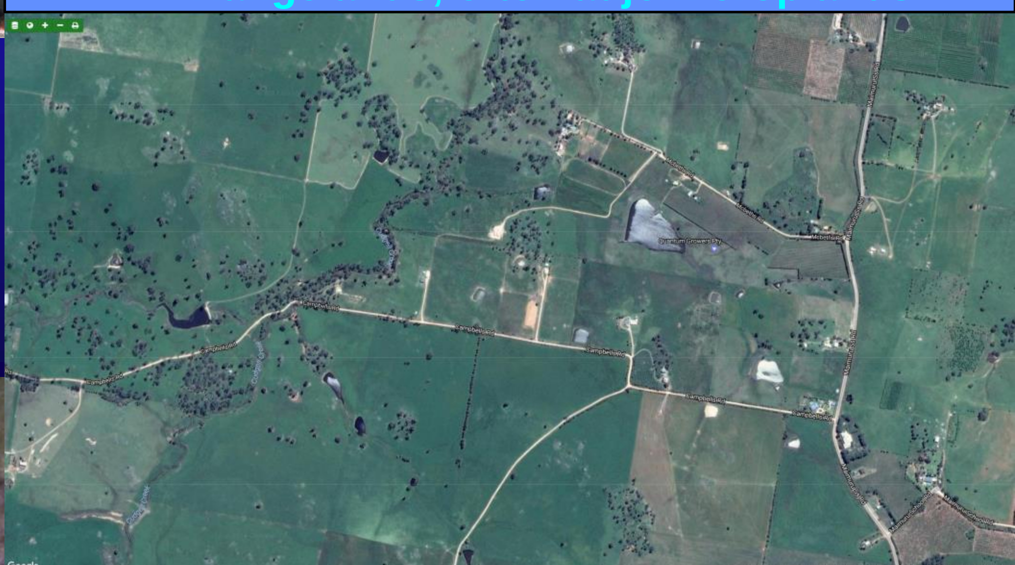
Aquaculture, fish ponds, often adjoin rice fields



We should include aquaculture\fish ponds because they often adjoin rice fields and\or often part of heavily cultivated deltas

Managed Rangelands are large part of agricultural systems of many countries (e.g., Australia, NewZealand), we should map them, but keep them as a separate class

Rangelands, often adjoin croplands



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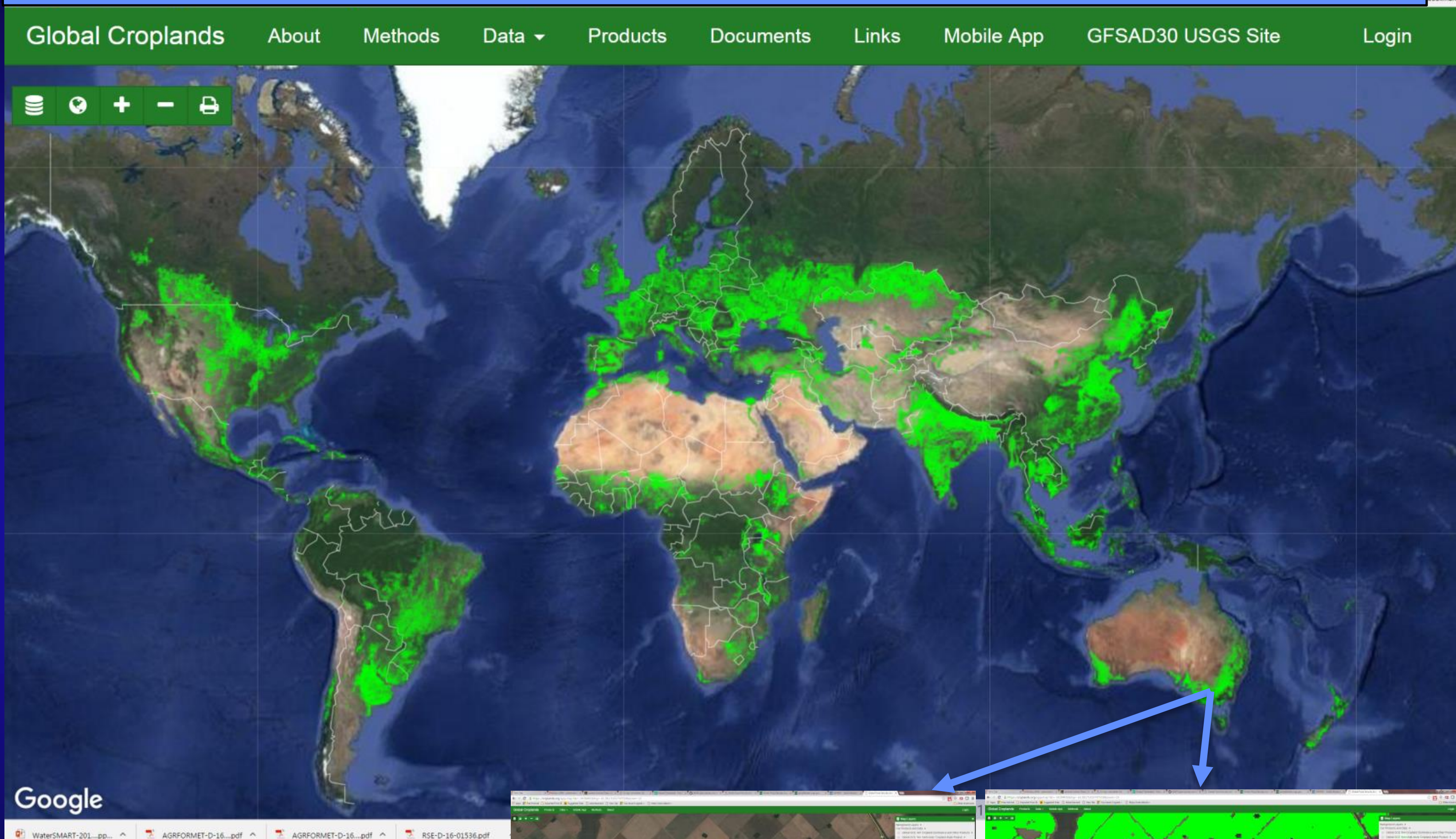
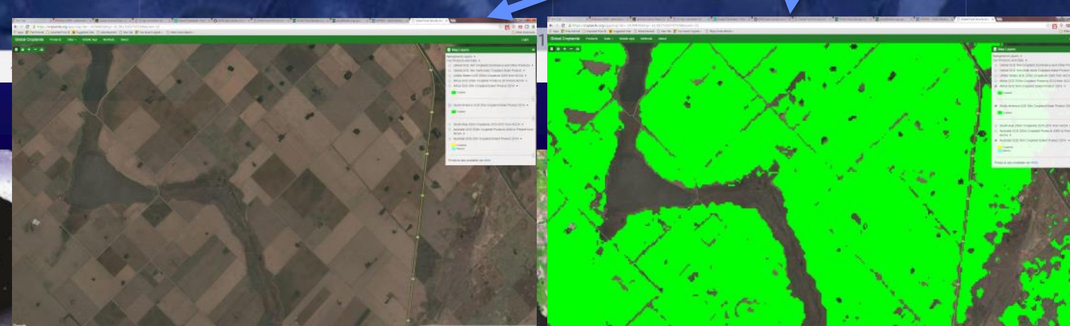
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Global Cropland Extent Product @ nominal 30-m Produced using Machine Learning Algorithms(e.g.,Random Forest, Support Vector Machines, decision trees)

https://croplands.org/app/map; https://croplands.org/





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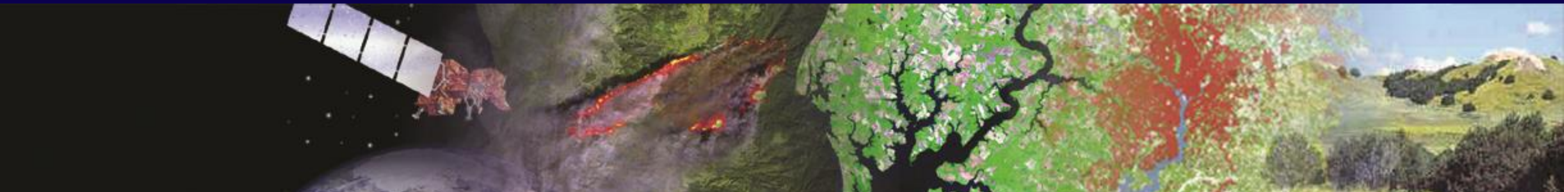
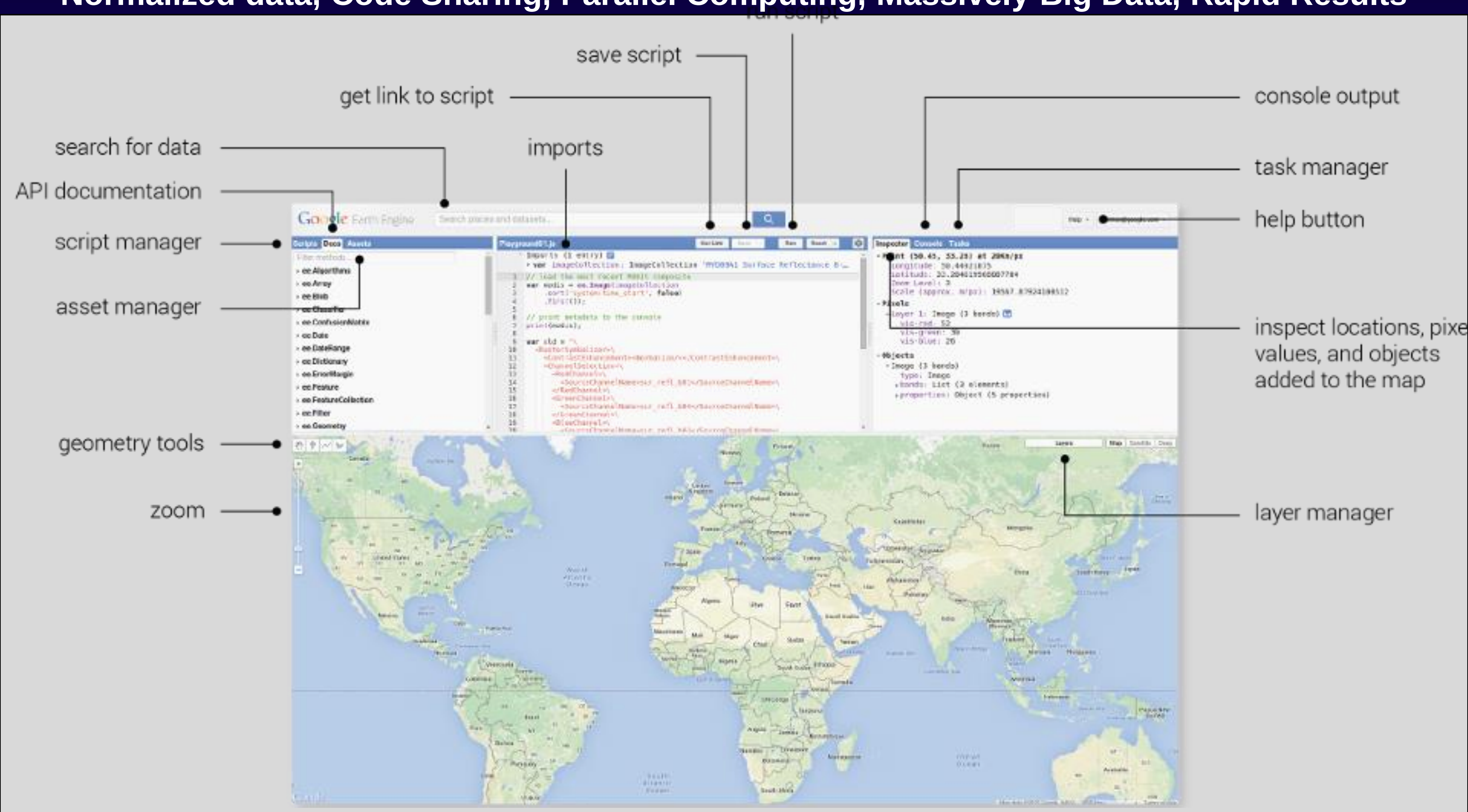
GFSAD30 Project
30-m, World
Cloud Computing

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/



Accessing and Computing Massively Large Big Data (e.g., on GEE Cloud Computing)

Normalized data, Code Sharing, Parallel Computing, Massively Big Data, Rapid Results



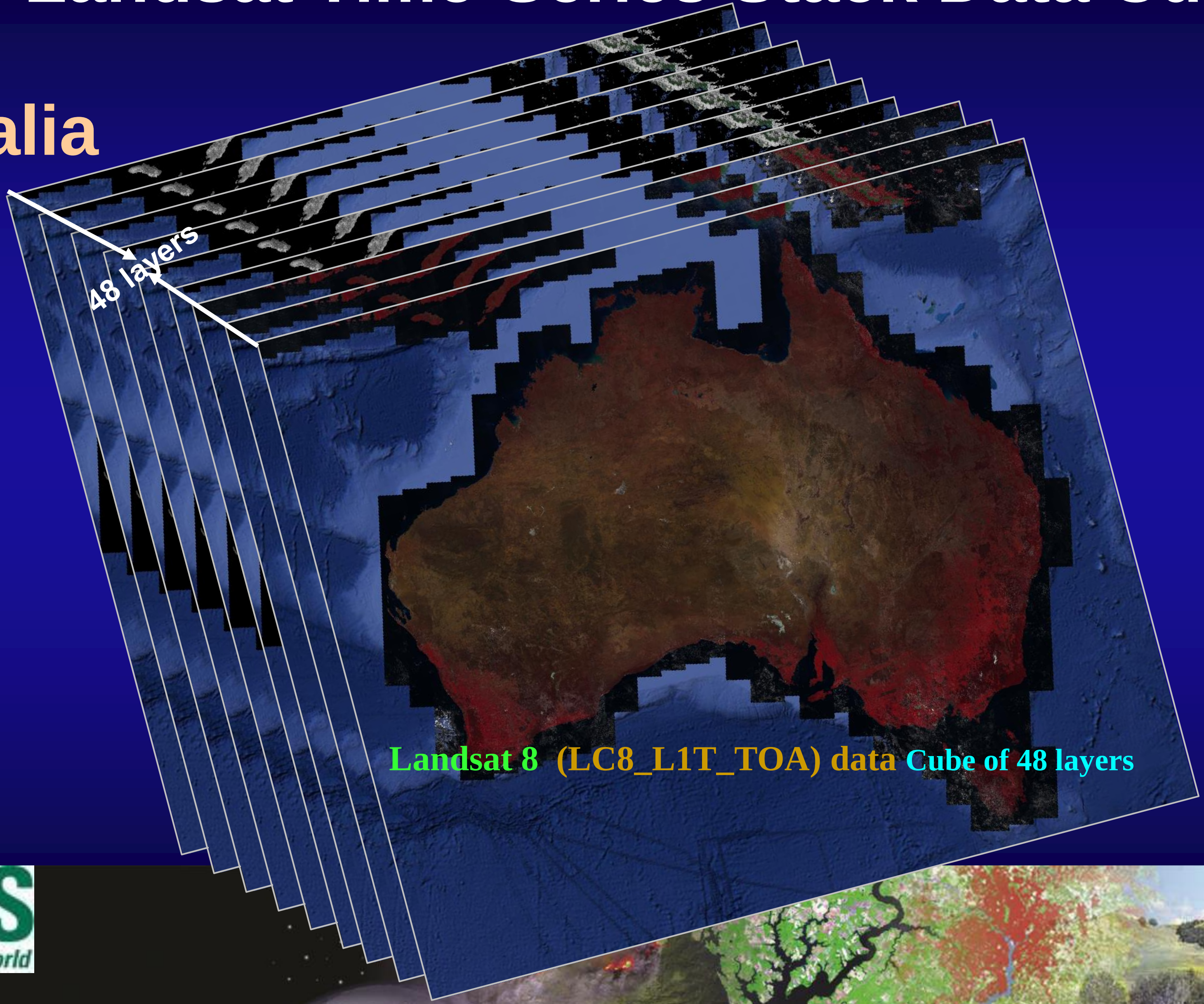
GFSAD30 Project
30-m, World
Datasets

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

Landsat 30-m OLI and ETM+ Data

16-day Landsat Time-Series Stack Data Cube

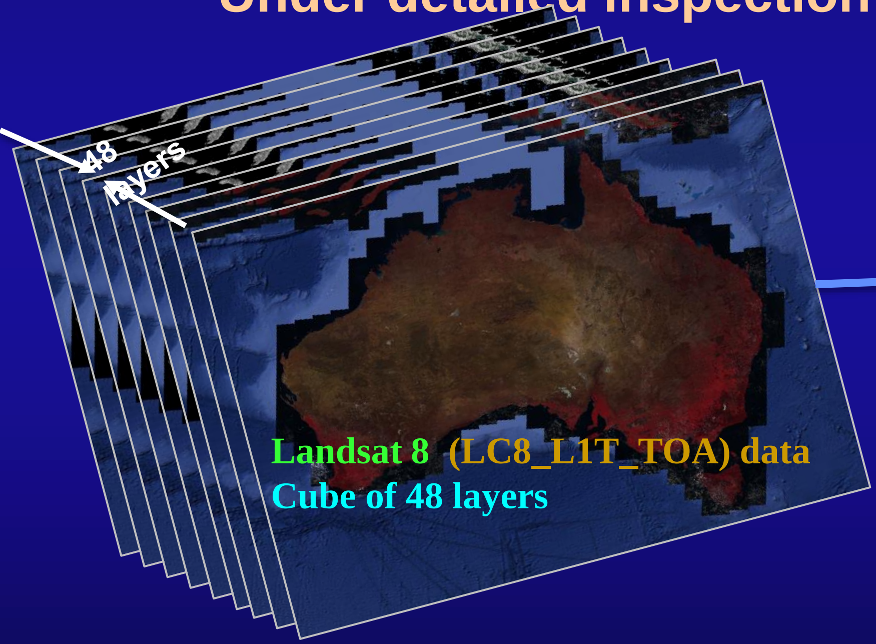
e.g., Australia



Landsat 30-m OLI and ETM+ Data

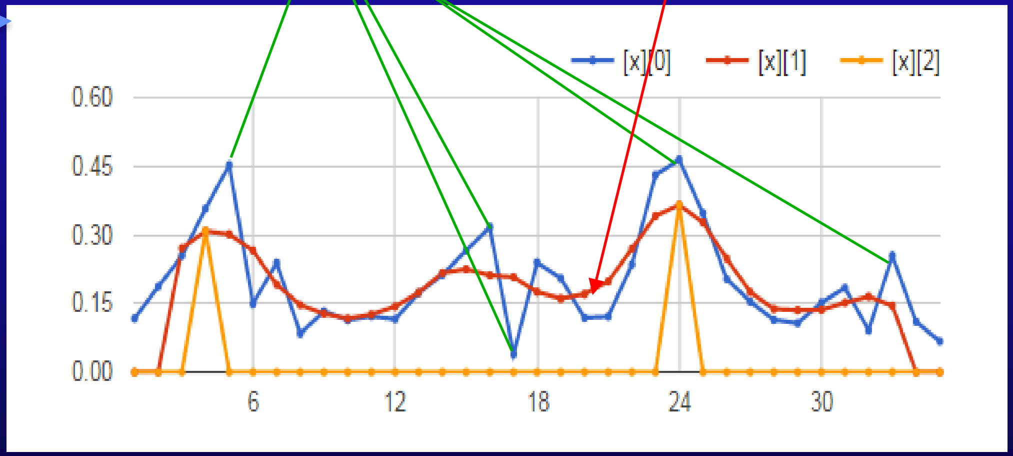
Peak Counting to Overcome Cloud, Haze, Noise

- Local maximum value based on smoothed VI time-series
- Separate single/double/multi-crop-cycle automatically
- Current algorithm enable to scale to continental scale quickly
- Under detailed inspection in erratic error cases



Cloud, haze, noise in data

Smoothed line that overcomes Cloud, haze, noise in data and produces cleaner data



Landsat 30-m OLI and ETM+ Data

e.g., 3 Year Composite used for South East Asia, N&S Korea, and Japan

1. Three year of Landsat OLI and ETM+: 2013-2016;
2. Top of atmosphere reflectance product;
3. Three distinct composites leading to 3 images.
Image composites were, Julian days:

1-60
61-120
121-180
181-300 (because of cloud during monsoon season)
301-365

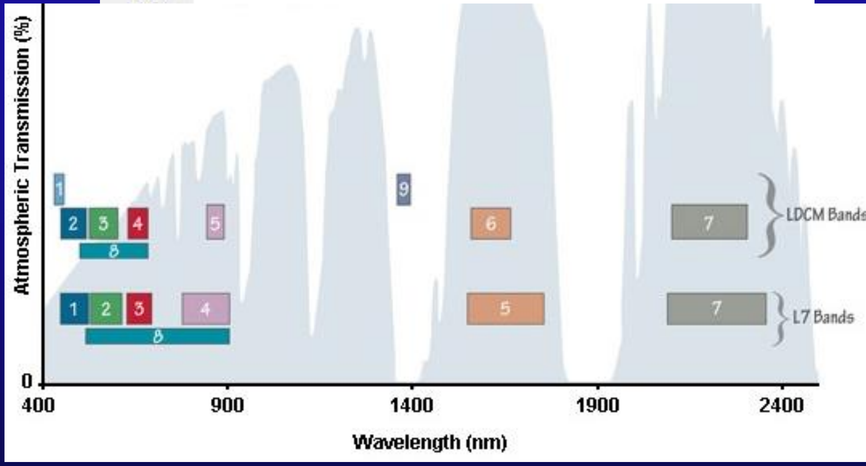
3. Total of 9 bands per composite image (e.g., 1-60 Julian day has 9 bands which are as follows): bands 1, 2, 3, 4, 5, 7, and NDVI and NBR2.
4. Total of 5 bi-monthly * 9 bands = 45 band stack

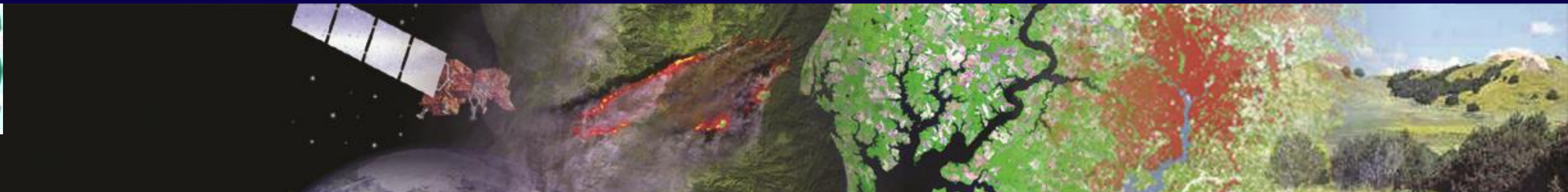
$$NBR2 = \frac{SWIR2 - SWIR1}{SWIR2 + SWIR1}$$

$$NDWI = \frac{Green - SWIR1}{Green + SWIR1}$$

Coding for composites in Google Earth Engine (GEE)

```
//Parameters
var startDate = ee.Date.fromYMD(2013,1,1);
var endDate = ee.Date.fromYMD(2016,3,1);

var startJulian1 = 1;
var endJulian1 = 60;

var startJulian2 = 61;
var endJulian2 = 120;

var startJulian3 = 121;
var endJulian3 = 180;

var startJulian4 = 181;
var endJulian4 = 300;

var startJulian34 = 301;
var endJulian34 = 365;

var cloudThresh = 30;//Threshold for cloud masking
```





GFSAD30 Project

30-m, World

VHRI Reference Data

http://geography.wr.usgs.gov/science/croplands/index.html

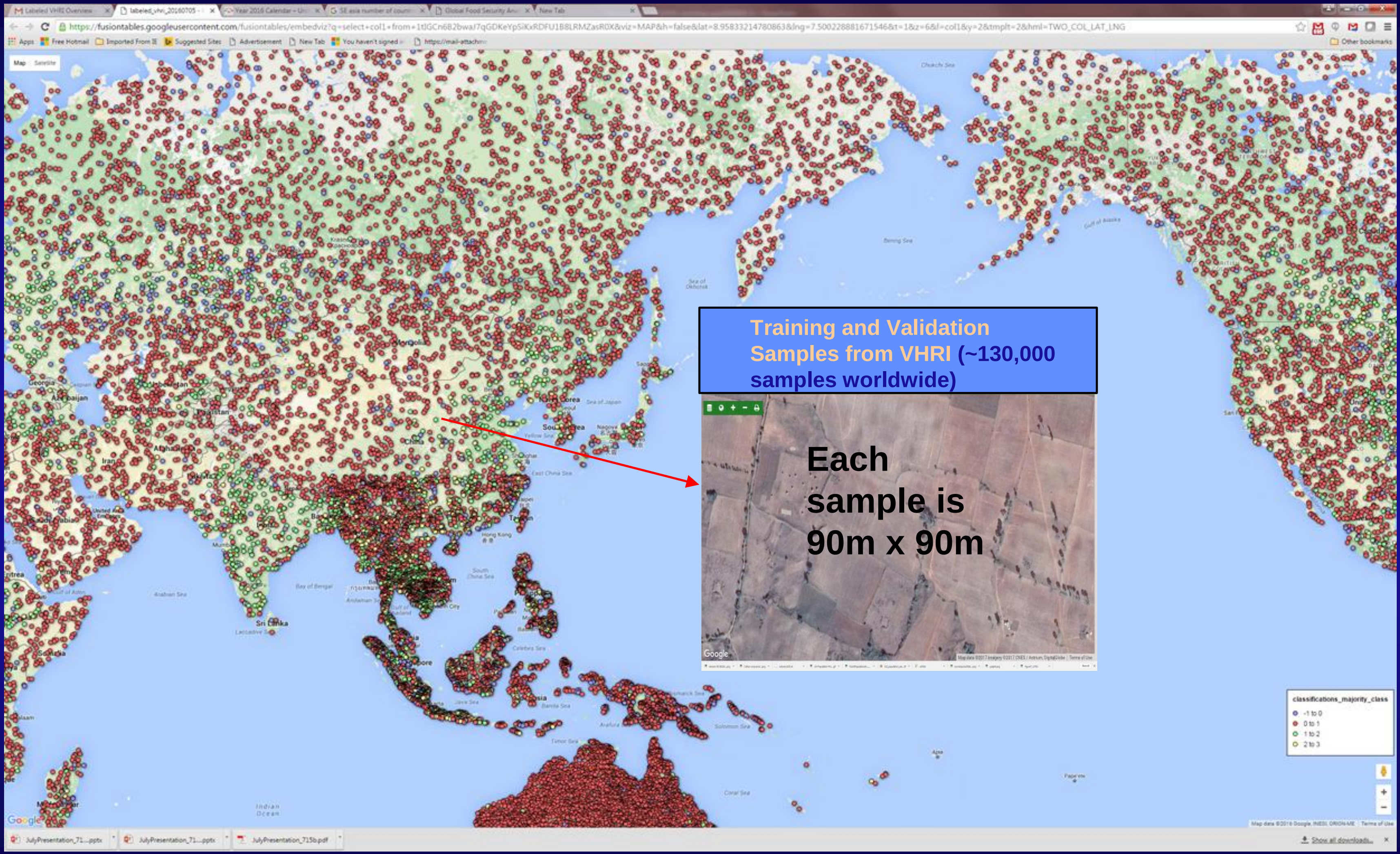
https://croplands.org/app/map

https://www.croplands.org/

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Reference Data used for Training and Validation

e.g., sub-meter to 5-m Very High Resolution Data (VHRI) Locations



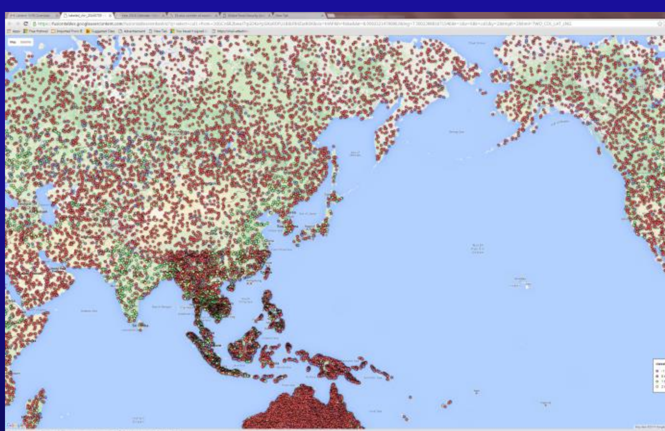
Reference Data used for Training and Validation

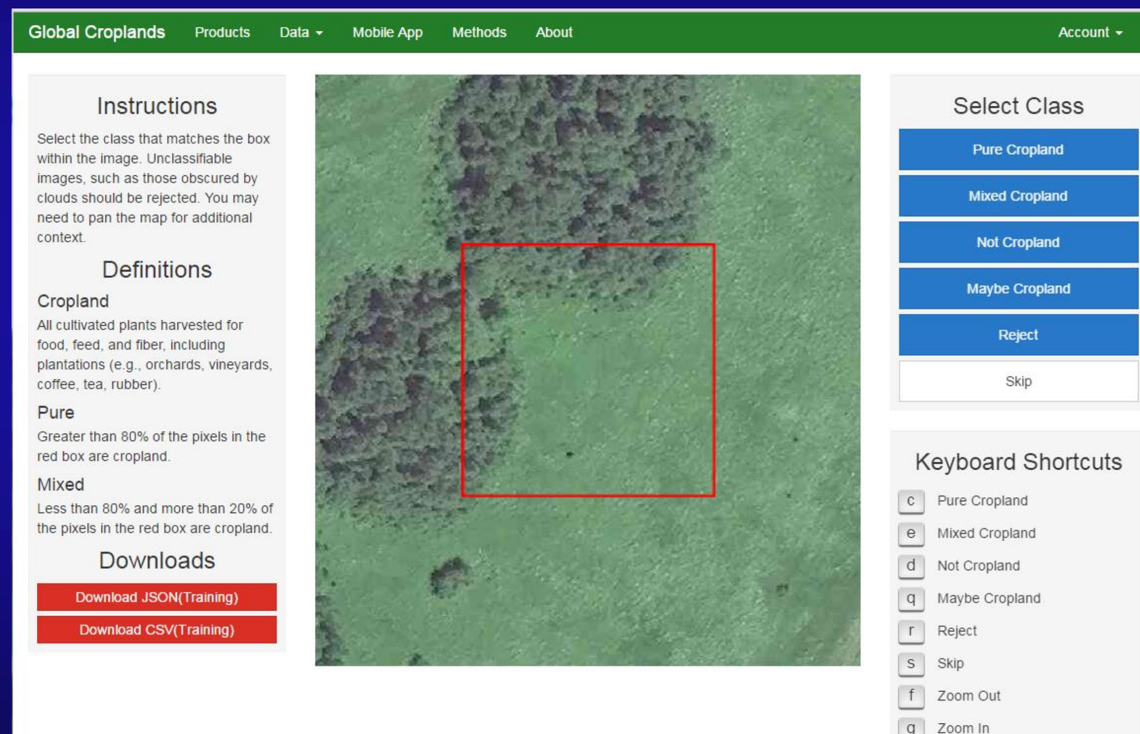
e.g., sub-meter to 5-m Very High Resolution Data (VHRI) Locations

Validation points generated by Justin's app on Global Croplands

Samples designated as training were only used to check the classification accuracy

Only points which were classified twice as the same class were used





Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Reference Data used for Training and Validation

e.g., Ground Data for Thailand

Vegetables

Rainfed single crop
Jasmine rice

Double crop
irrigated rice

Plantations
Rubber and
Mango

Coconut,
oil palm
banana

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Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Reference Data used for Training and Validation

e.g., Ground Data for Indonesia

Java

Double crop irrigated rice

Bali

Double crop irrigated rice followed by short season crop

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GFSAD30 Project

30-m, World

Methods: Machine Learning Algorithms

http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

Cropland Mapping Algorithms (CMAs)
Machine Learning Algorithms (MLAs) in Global Cropland Mapping

We have successfully applied a wide array of **machine learning algorithms (MLAs)** in this research, that have also been used successfully in automating them to apply year after year with ability to: 1. hind-cast (e.g., past years), 2. now-cast (present year), and 3. future-cast (e.g., future years):

A. Random forest algorithms (Tatsumi et al., 2015, Gislason et al., 2006);
B. Automated cropland classification algorithms (Thenkabail et al., 2010, Teluguntla et al., 2017);
C. Spectral matching techniques (Thenkabail et al., 2007, Teluguntla et al., 2017)
D. Support vector machines (Mountrakis et al., 2011);
E. Decision Tree algorithms (Friedl and Brodley, 1997, Defries et al., 1998, Waldner et al., 2015);
F. Linear discriminant analysis (Imani and Ghassemian, 2015);
G. Principal component analysis, change detection analysis (Jensen, 2000);
H. kMeans, Isoclass clustering (Duveiller et al., 2015, Jensen et al., 2000);
I. Classification and Regression Tree (CART) (Egotov et al., 2015, Deng and Wu, 2013);
J. Tree-based regression algorithm (Ozdogan and Gutman, 2008);
K. Phenology based methods (Dong et al., 2015);
L. Fourier harmonic analysis (Zhang, 2015, Geerken et al., 2005);

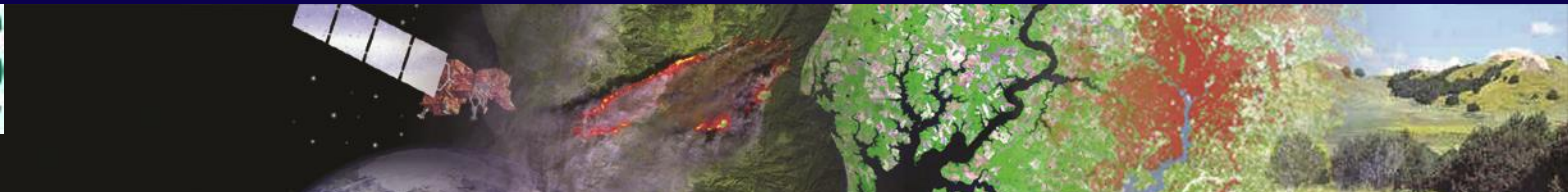
Cropland Mapping Algorithms (CMAs)
Machine Learning Algorithms (MLAs) in Global Cropland Mapping

Cropland mapping

1. Linear mixture model for monitoring rice crop intensity (Chen et al., 2012);
2. Automated annual cropland mapping (Waldner et al., 2015);
3. Automated computational methodology to extract agricultural crop fields (Yan and Roy, 2016);
4. Supervised classification (Egorov et al., 2015);
5. integration of pixel- and object-based methods with knowledge (POK-based) (Chen et al., 2015);
6. A spatial-temporal consistency model, Maximum a Posteriori Markov Random Fields (MAP-MRF) (Wang et al., 2015);
7. Phenological approaches in cropland versus rangeland mapping (Jaganathan et al., 2014, Begue et al., 2014, Gumma et al., 2014);
8. automated computational methodology to extract agricultural crop fields (Yan and Roy, 2014);

Irrigated versus Rainfed

1. Random forest model for analyzing irrigated crop rotation patterns (Conrad et al., 2016);
2. Random forest for identification of irrigated areas (Peña-Arancibia et al., 2014);



Cropland Mapping Algorithms (CMAs)

Machine Learning Algorithms (MLAs) in Global Cropland Mapping

Crop Type Mapping

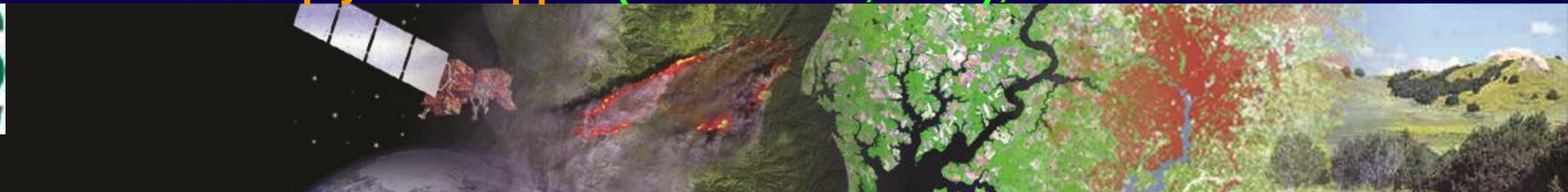
1. Crop type mapping using time-series vegetation index data (Brown et al., 2013);
2. Phenology based paddy rice mapping algorithm (Zhou et al., 2016, Zhang et al., 2015);
3. support vector machine classifier with polynomial function kernel (pSVM) for mapping crop types (Vaudour et al., 2015);
4. pixel- and phenology-based algorithm are used to map paddy rice planting area (Qun et al., 2015, Gumma et al., 2014);
5. C5.0 tree classifier is applied to identify main crop types and grassland based on the input imagery and the derived seasonality indices (Esch et al., 2014);
6. phenology-based classification method was developed to map corn and soybean in multiple years using training data limited to a single year (Zhong et al., 2014)

Cropping Intensity Mapping

1. double-cropping croplands mapping methodology for time series datasets through continuous wavelet transform (Qiu et al., 2014);
2. Automated mapping of vegetation trends with polynomials using NDVI imagery (Jamali et al., 2014);

Croplands versus Cropland Fallows

1. Random forest algorithm for mapping abandoned farmlands (Estel et al., 2015);
2. scalable satellite-based crop yield mapper (Lobell et al., 2015);



GFSAD30 Project

Croplands *versus* Non-Croplands

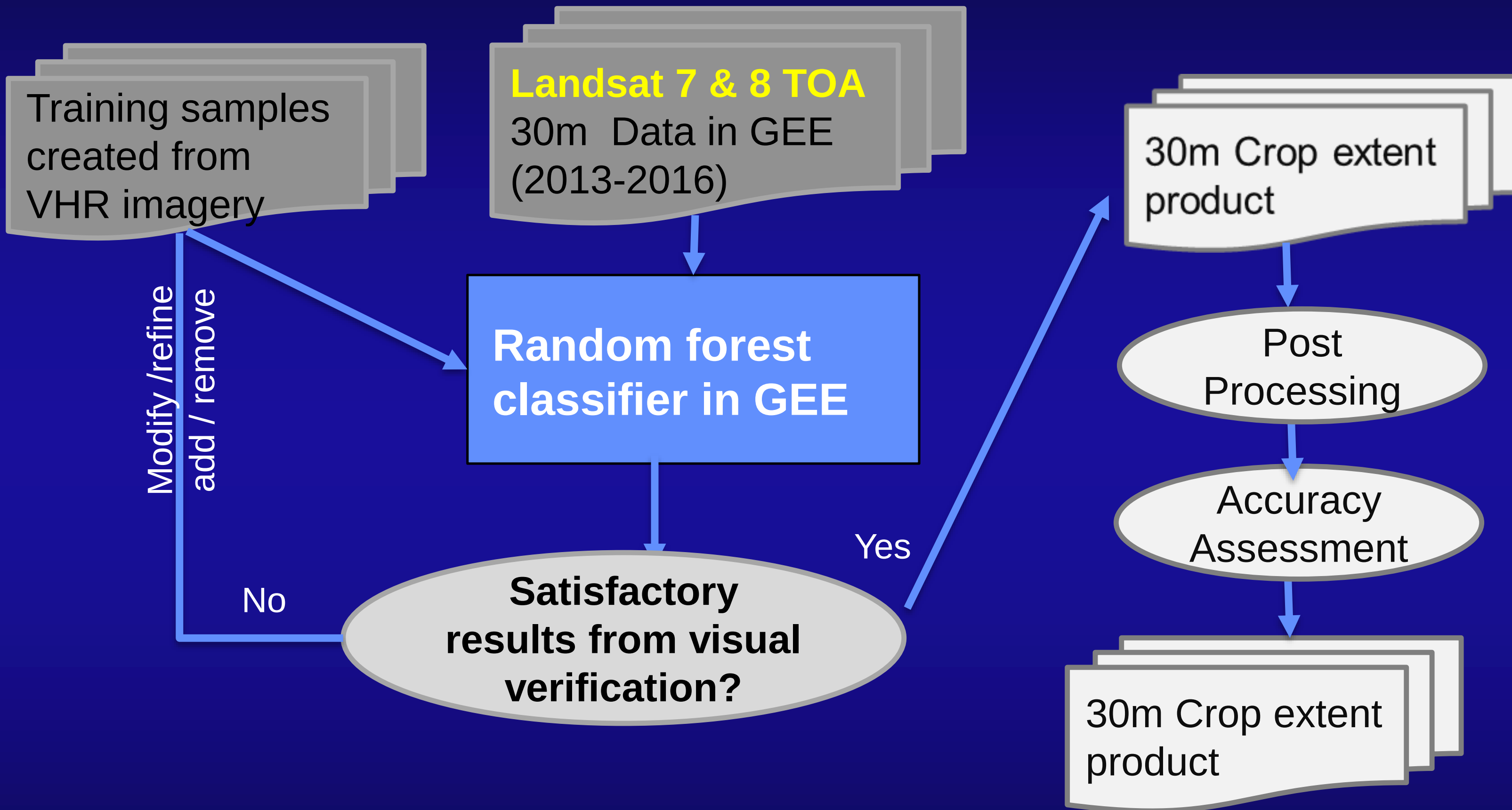
Methodology Application

(First example)

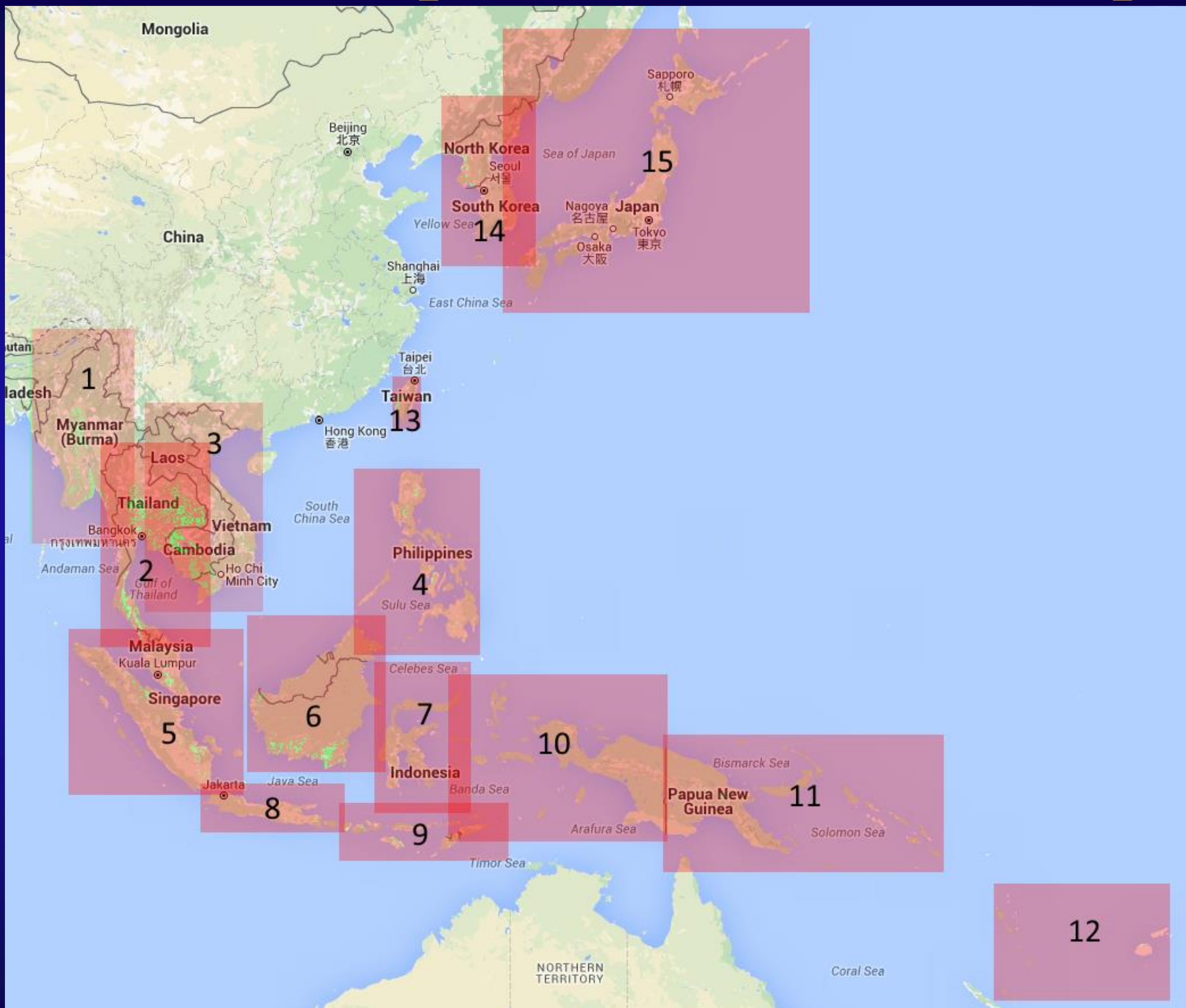
http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Methodology FlowChart for Random Forest to Classify Croplands *versus* Non-croplands @ 30-m

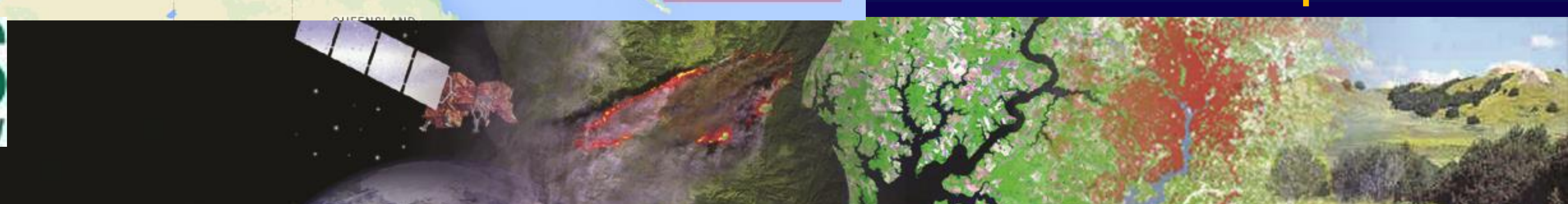


Stratification into Sub-Regions (e.g., SE Asia, Japan, N&S Korea) to Classify Croplands *versus* Non-croplands @ 30-m



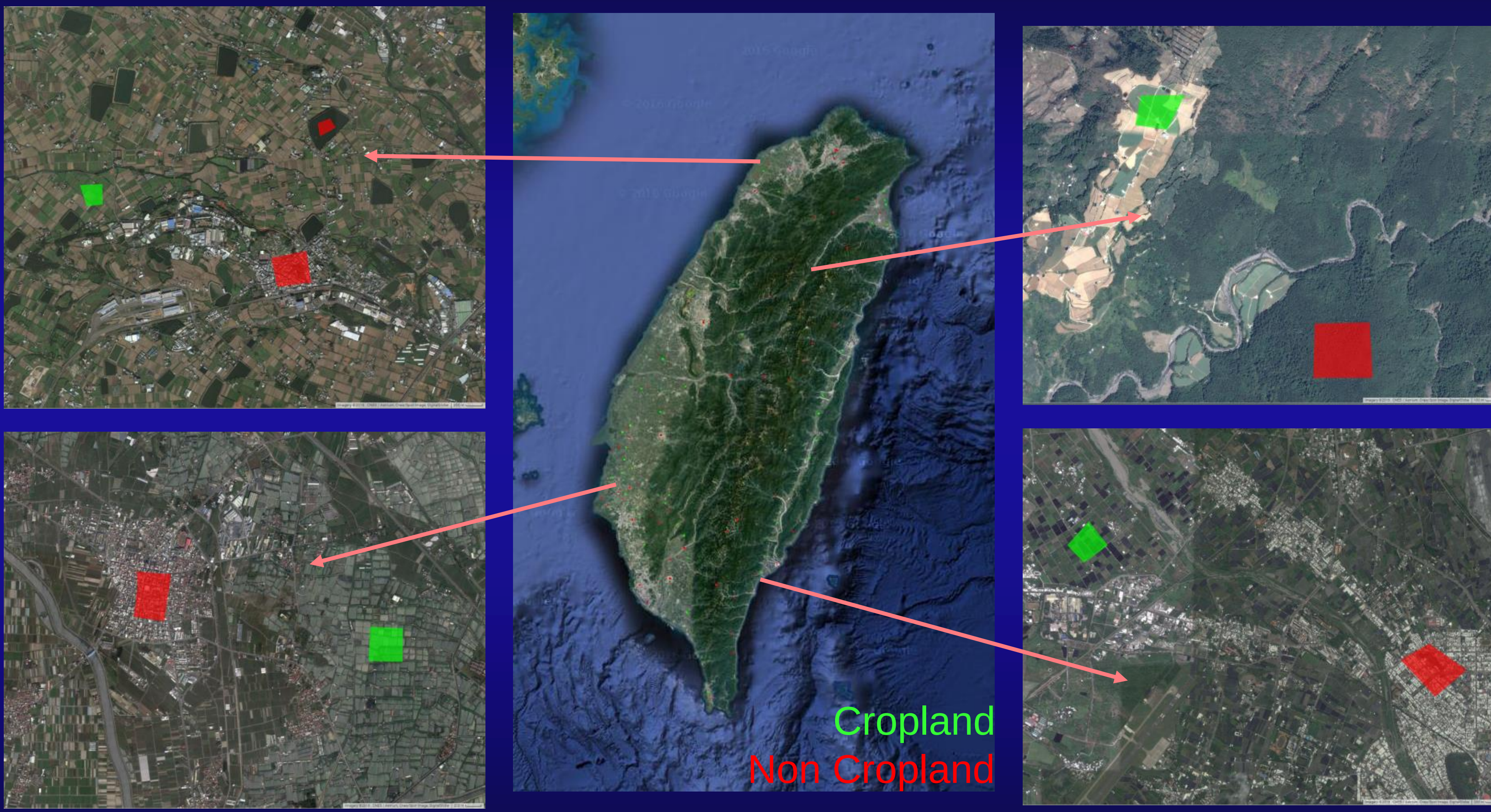
Zones
1. Myanmar
2. Thailand
3. Vietnam, Laos, Cambodia
4. Philippines
5. Sumatra & Malaysia
6. Kalimantan & Malaysia
7. Sulawesi
8. Java & Bali
9. Indonesia & East Timor
10. Papua Indonesia
11. Paupa New Guinea & Solomon Islands
12. Vanuatu & Fuji
13. Taiwan
14. South & North Korea
15. Japan

Oliphant et al.



Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Training Sample Selection for Random Forest Algorithm to Train Croplands *versus* Non-croplands @ 30-m (e.g., Taiwan)



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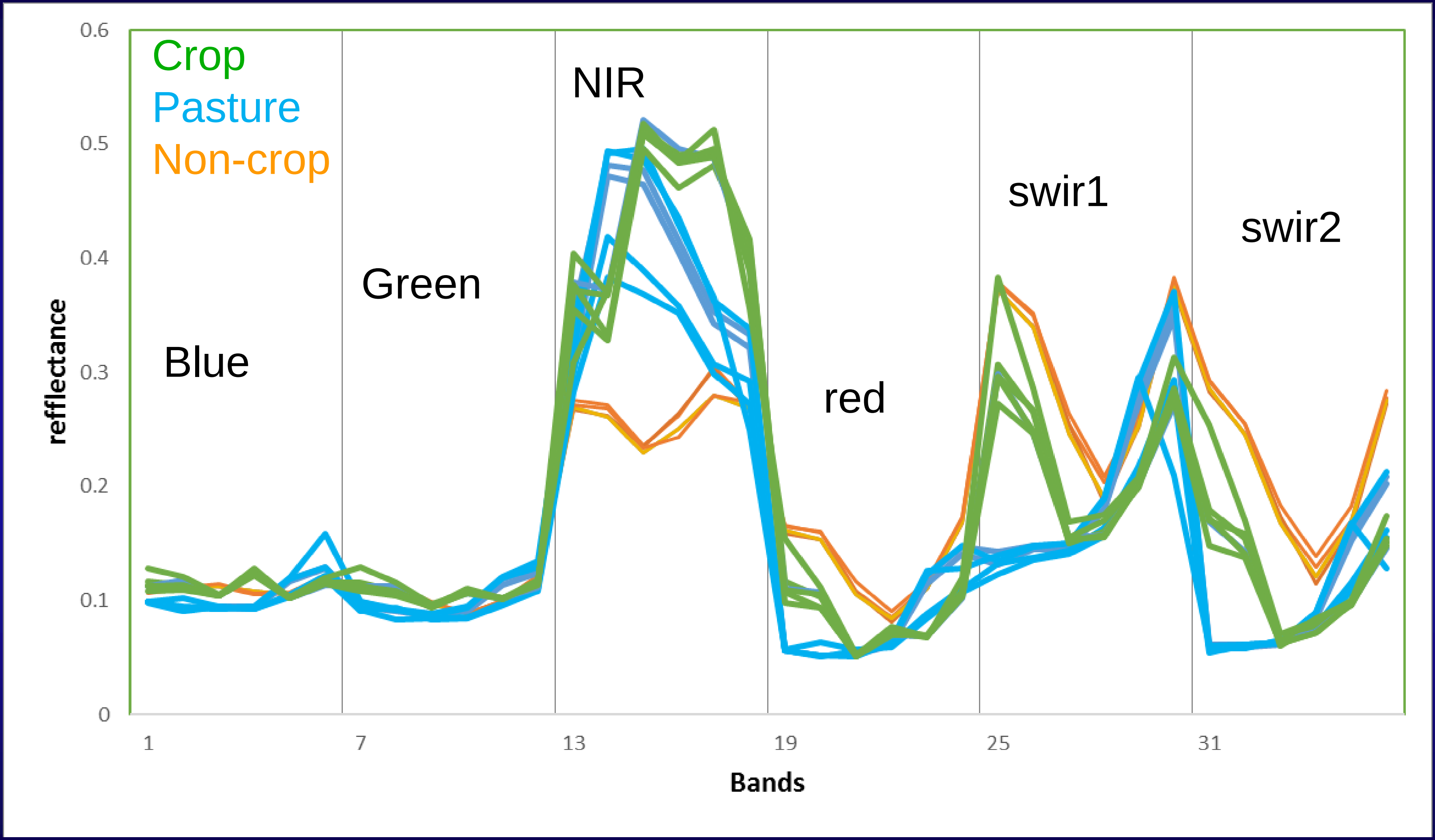
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Knowledge Generation for Random Forest Algorithm to Derive Croplands *versus* Non-croplands @ 30-m



U.S. Geological Survey
U.S. Department of Interior

Teluguntla et al.

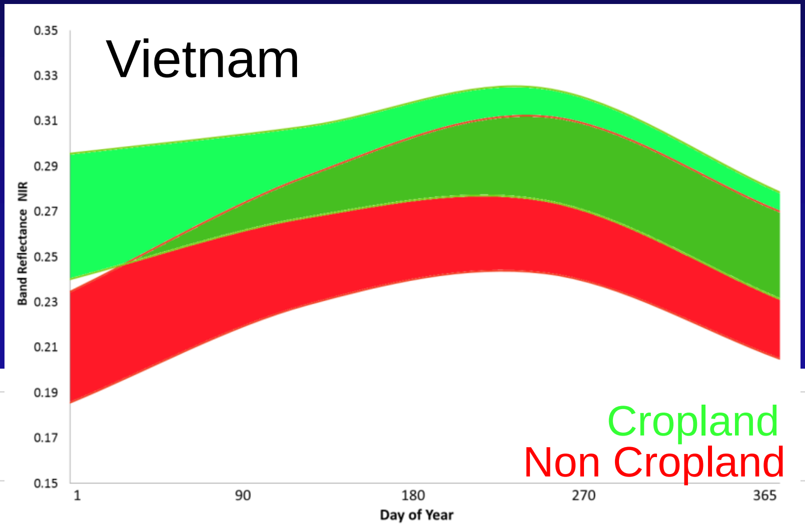
Training Sample Selection for Random Forest Algorithm to Train Croplands *versus* Non-croplands @ 30-m (e.g., Argentina)

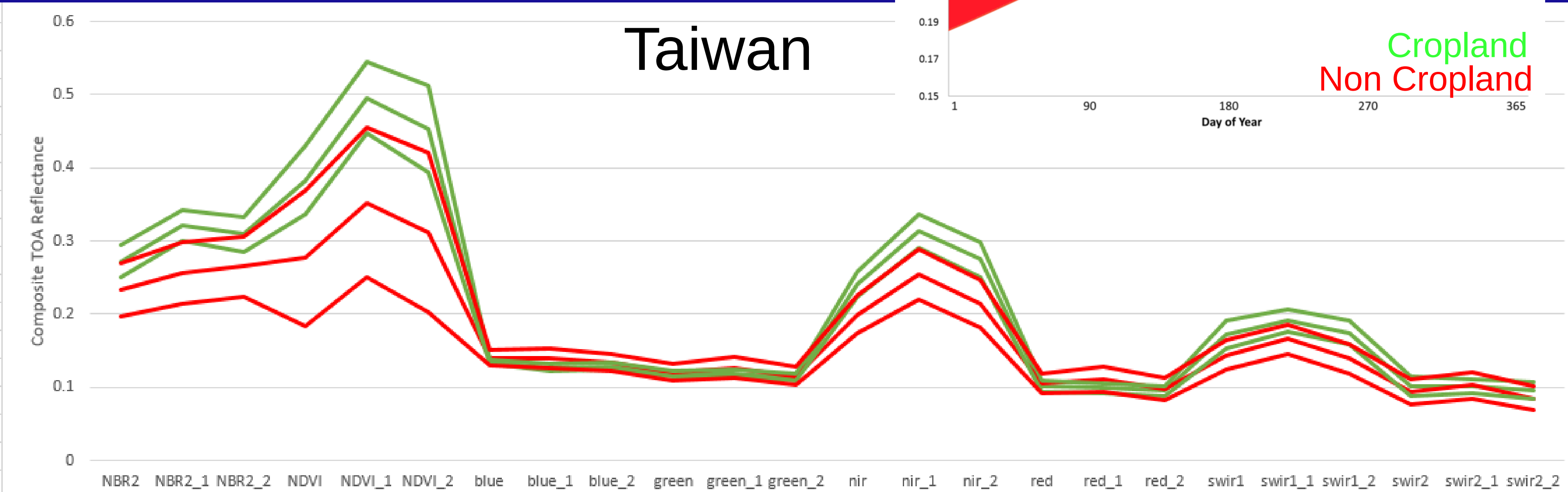
- **Land cover classes:**
  Cropland, Fallow, Others

- **Homogeneous polygons**

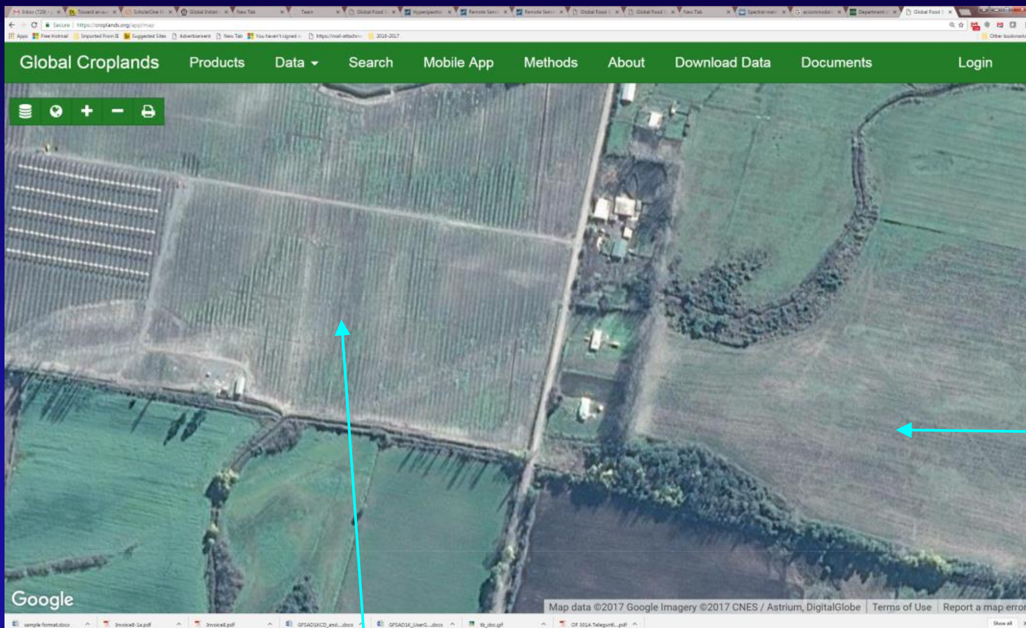
- **Selection system:**
  a. Random selection
  b. Manually selection
- **Reference data**
  Very high resolution imagery (VHRI): <5-m;
  Ground data;
  Other reliable and accurate products (e.g., USDA CDL);

Knowledge Generation for Random Forest Algorithm to Derive Croplands *versus* Non-croplands @ 30-m (e.g., Taiwan)





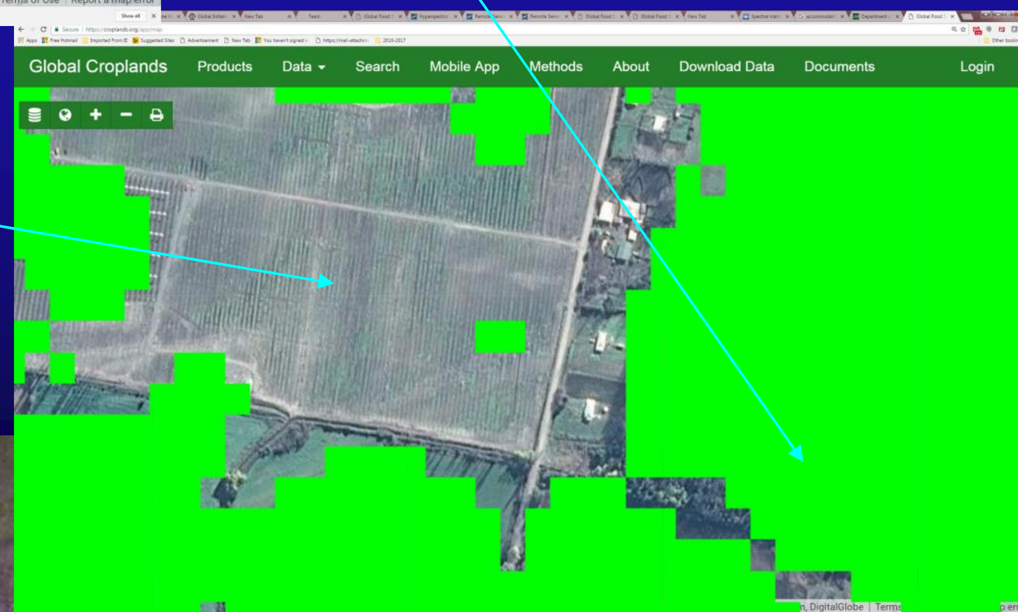
Iterations for Random Forest Algorithm to Improve Croplands *versus* Non-croplands @ 30-m (e.g., Chile)



Iterations: In such scenarios, mask out correctly mapped croplands and work on rest of the area to capture missing croplands….several iterations are required before all croplands are captured

Croplands mapped as croplands

Croplands missing



Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

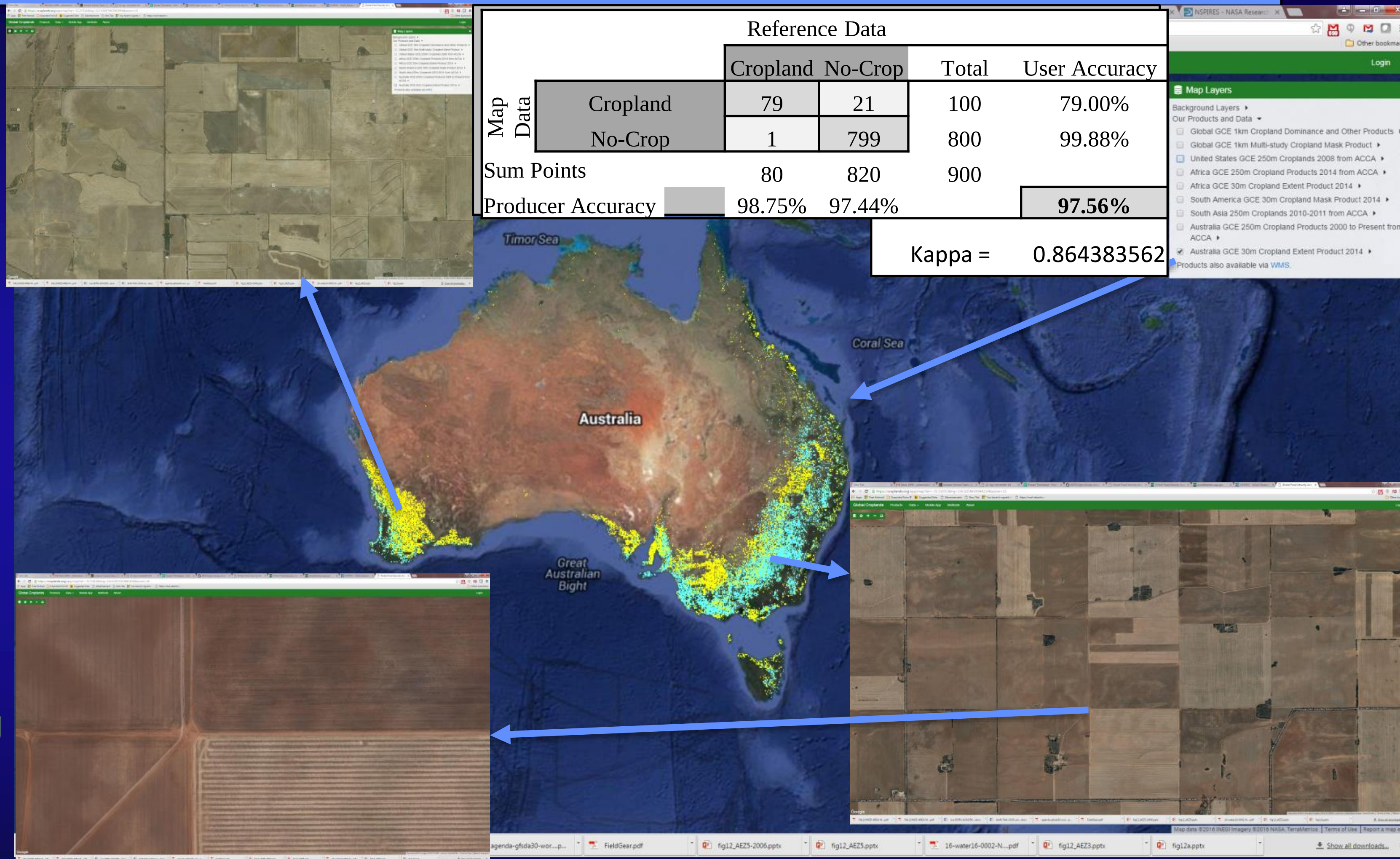
Croplands *versus* Non-croplands (e.g., Australia) @ 30-m - Final Product

Product @: https://croplands.org/app/map; https://croplands.org/

Computed using Random Forest Algorithm in Google Earth Engine (GEE) Cloud Computing

		Reference Data			
		Cropland	No-Crop	Total	User Accuracy
Map Data	Cropland	79	21	100	79.00%
	No-Crop	1	799	800	99.88%
Sum Points		80	820	900	
Producer Accuracy		98.75%	97.44%		**97.56%**

Kappa = 0.864383562



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U.S. Department of Interior

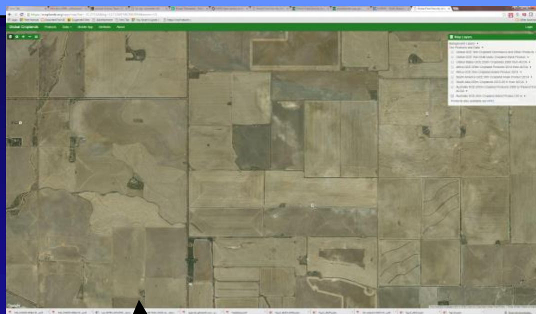
Manuscript:
Teluguntla et al. 2017: http://dx.doi.org/10.1080/17538947.2016.1267269

Automated algorithm:
http://geography.wr.usgs.gov/science/croplands/algorithms/africa_250m.html

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Croplands *versus* Non-croplands (e.g., Australia) @ 30-m – Accuracy Error Matrix

Product @: https://croplands.org/app/map; https://croplands.org/



		Reference Data			
		Cropland	No-Crop	Total	User Accuracy
Map Data	Cropland	79	21	100	79.00%
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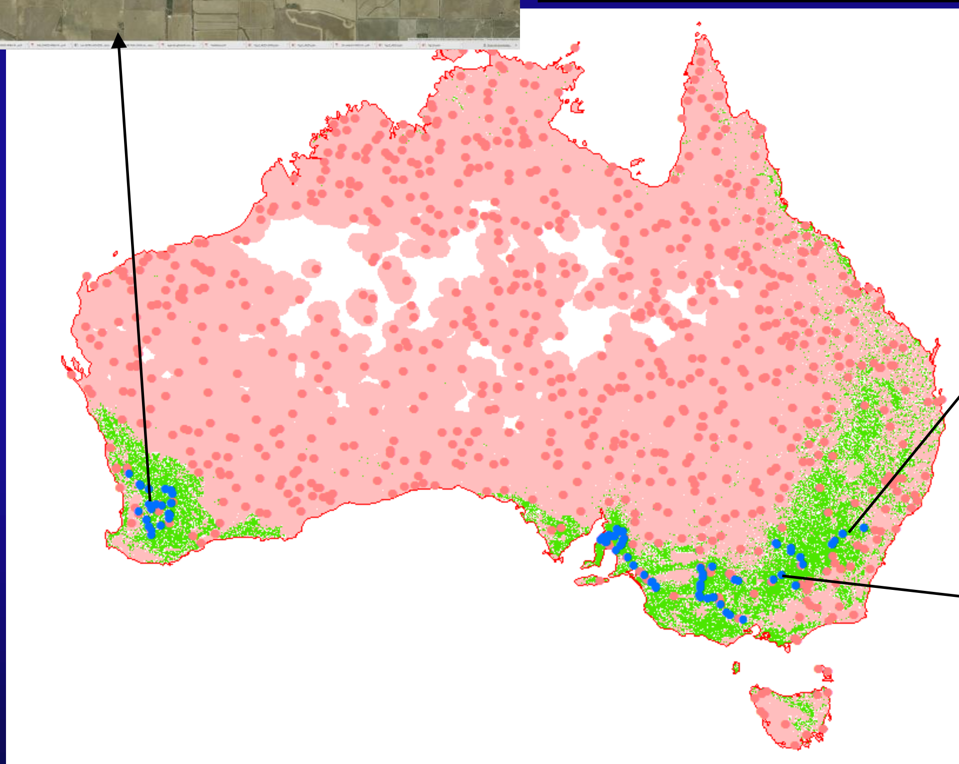
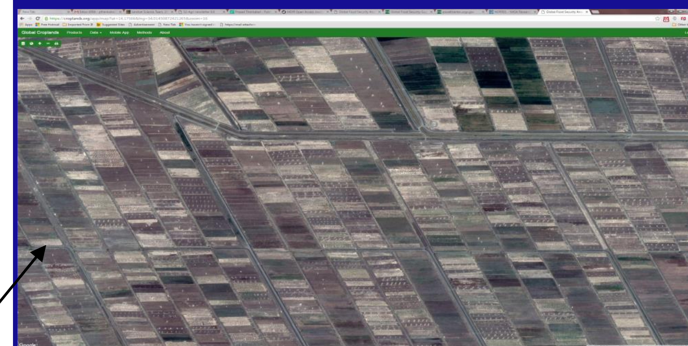
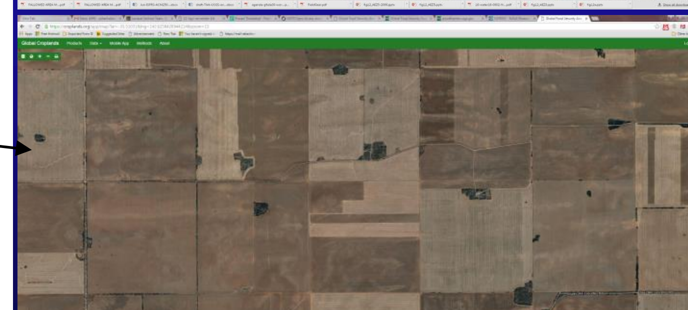
Computed using Random Forest Algorithm in Google Earth Engine (GEE) Cloud Computing







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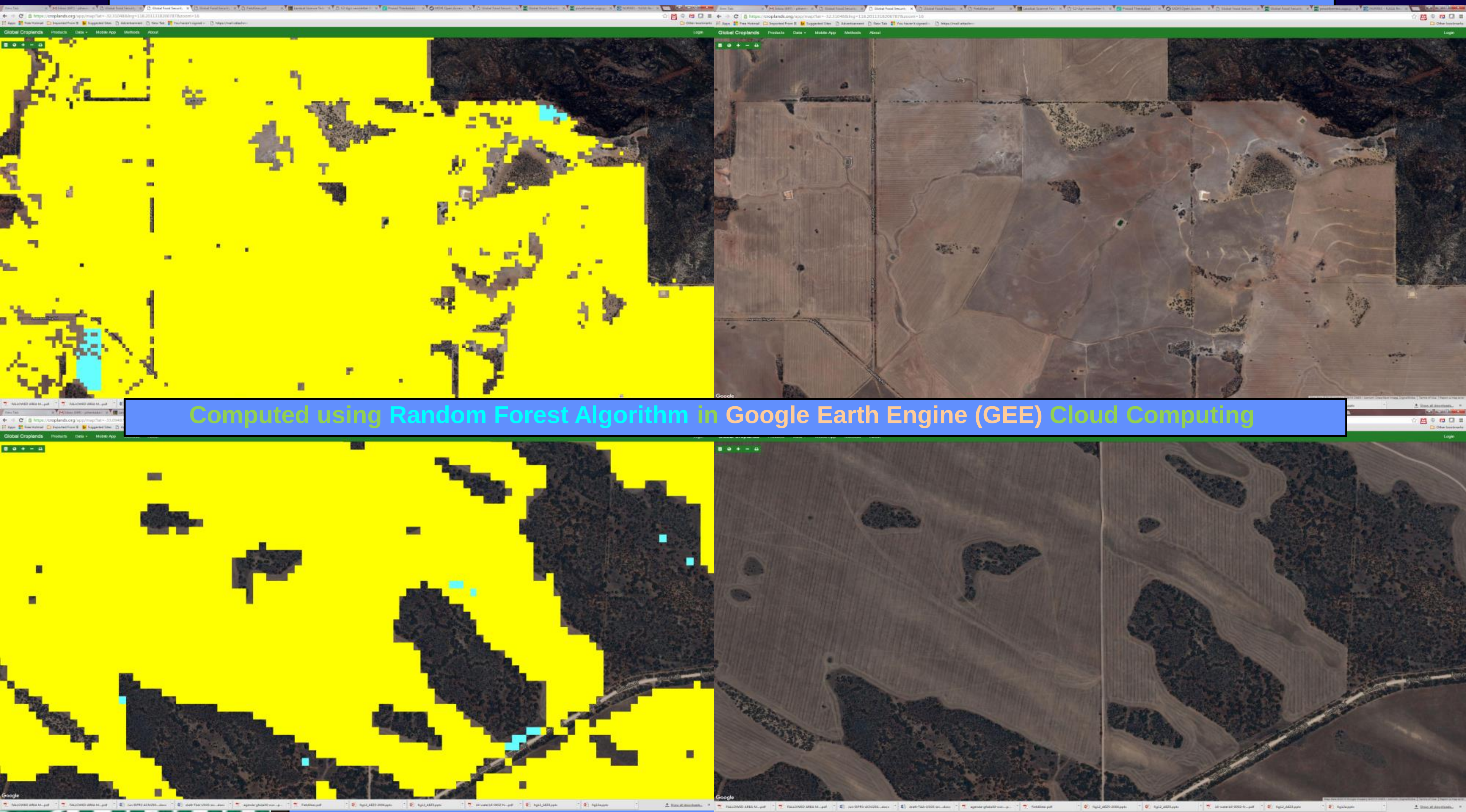
Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

Croplands *versus* Non-croplands (e.g., Australia) @ 30-m – Final Product, Zoom in

Product @: https://croplands.org/app/map; https://croplands.org/



Computed using Random Forest Algorithm in Google Earth Engine (GEE) Cloud Computing

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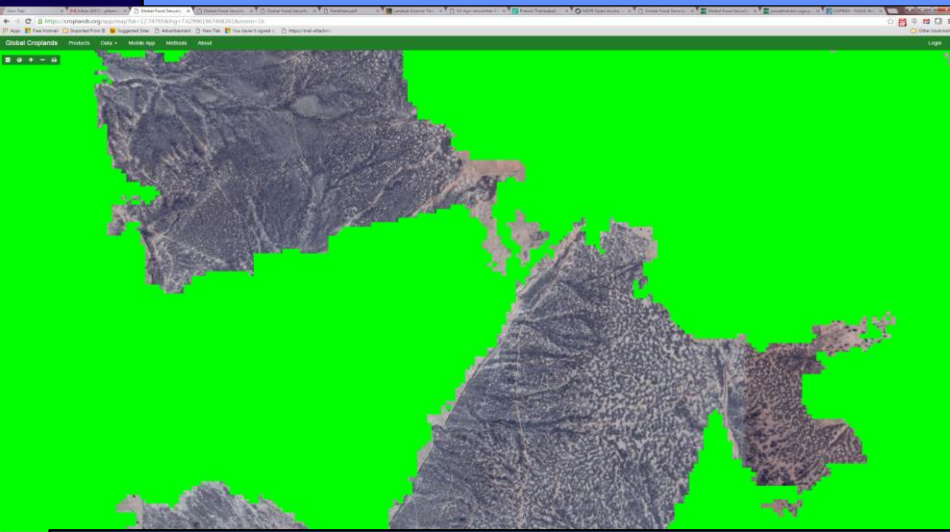
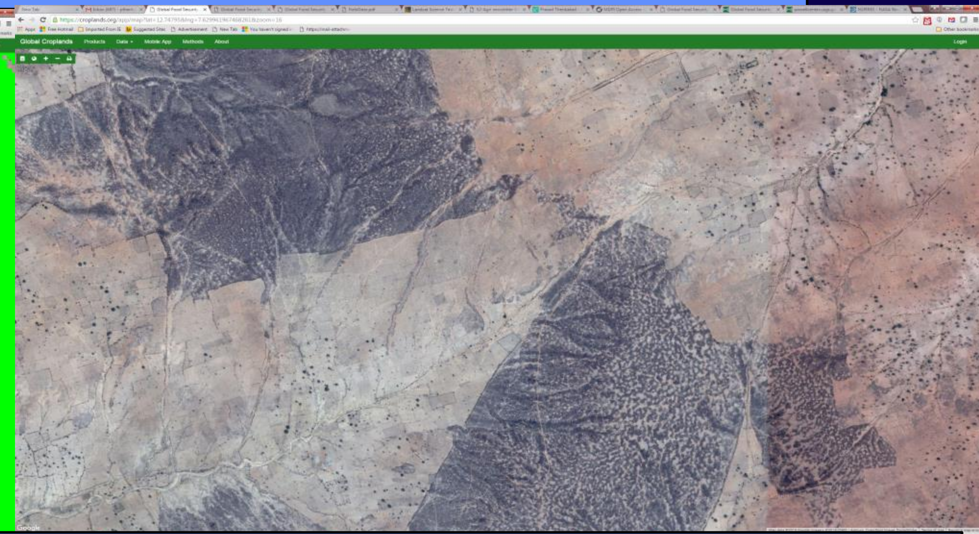
Teluguntla et al. 2017: http://dx.doi.org/10.1080/17538947.2016.1267269

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

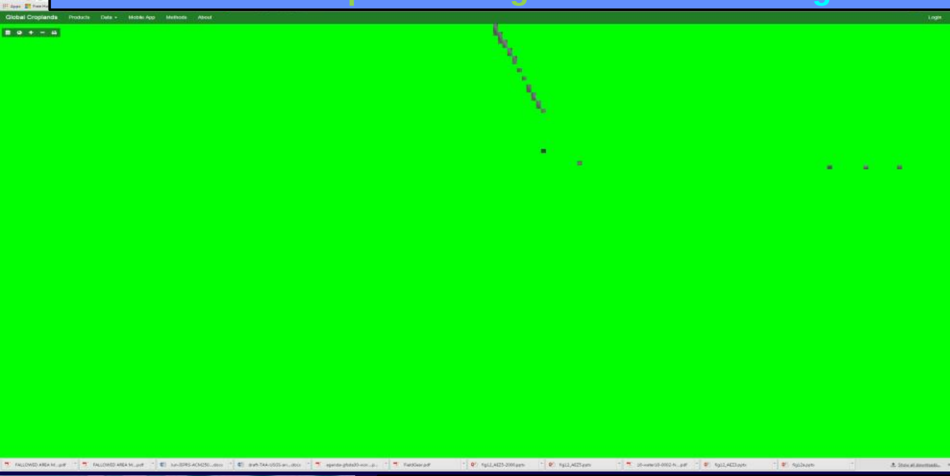
Croplands *versus* Non-croplands @ 30-m (e.g., Africa) – Final Product, Zoom in

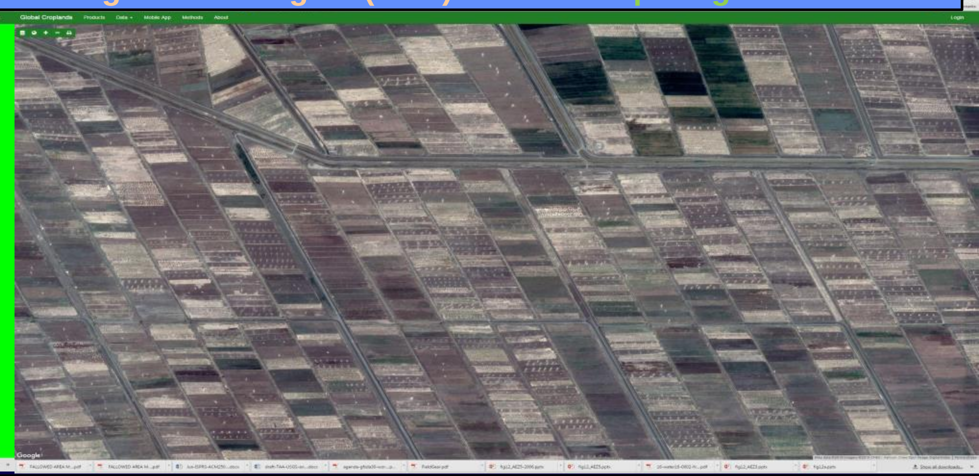
Product @: https://croplands.org/app/map; https://croplands.org/





Computed using Random Forest Algorithm in Google Earth Engine (GEE) Cloud Computing





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Xiong et al. Manuscript in review

GFSAD30 Project

Croplands *versus* Non-Croplands

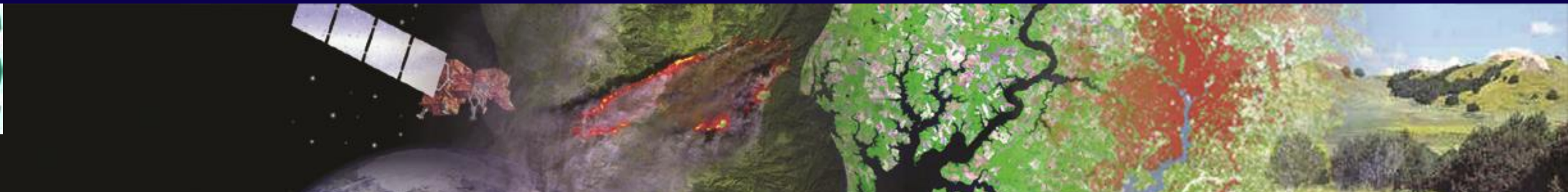
Methodology Application

(second example)

http://geography.wr.usgs.gov/science/croplands/index.html

https://croplands.org/app/map

https://www.croplands.org/



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Approach for Africa Using Ensemble Classifiers

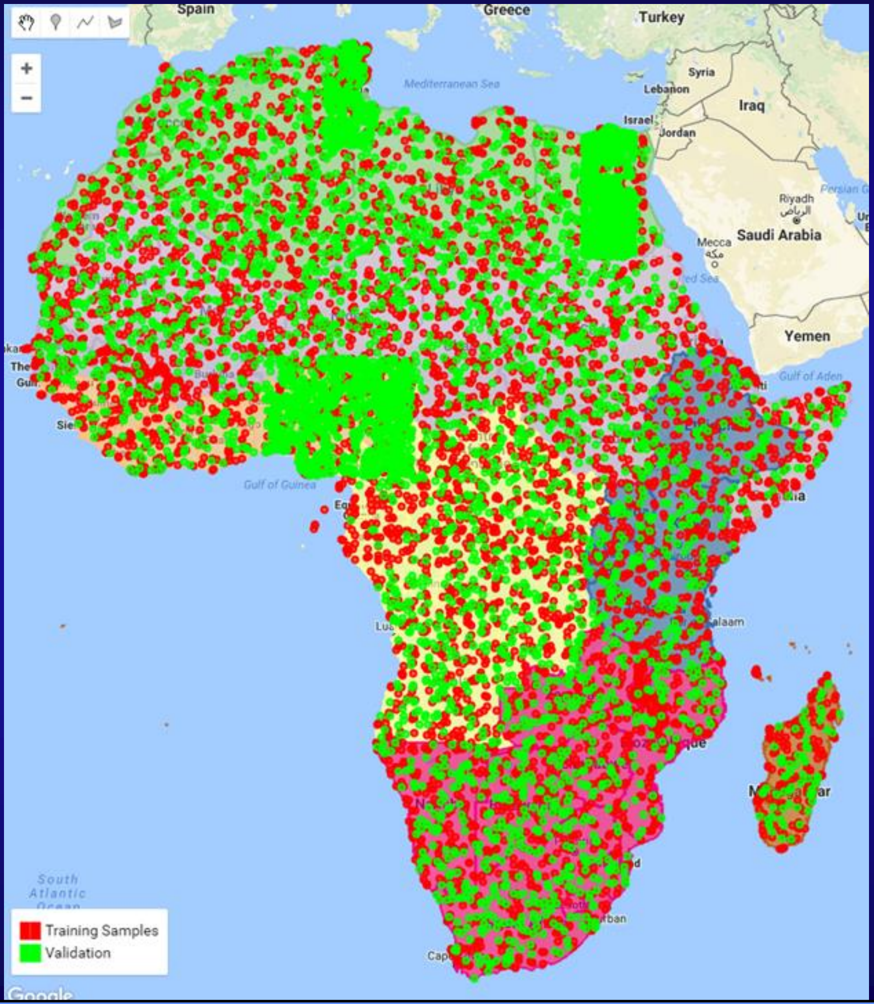
Croplands *versus* Non-croplands @ 30-m

Same training were used as previous version

Classifiers:

1. Random Forest
2. SVM
3. CART
4. HSEG

Output: 0, 1, 2, 3



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U.S. Geological Survey
U.S. Department of Interior

Manuscript:
Jun Xiong et al. in preparation

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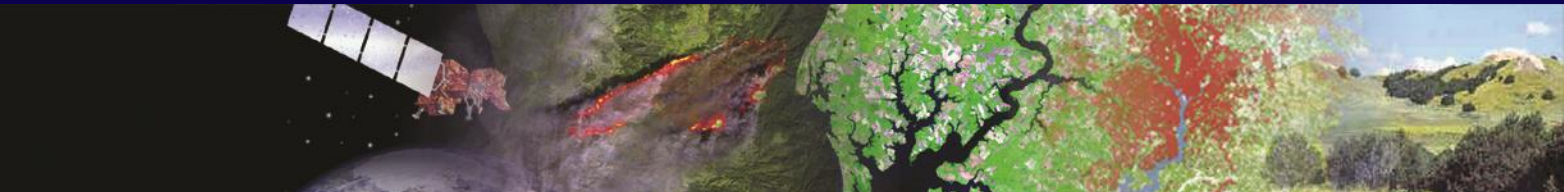
Croplands *versus* Non-Croplands

Results: 30-m Global

http://geography.wr.usgs.gov/science/croplands/index.html

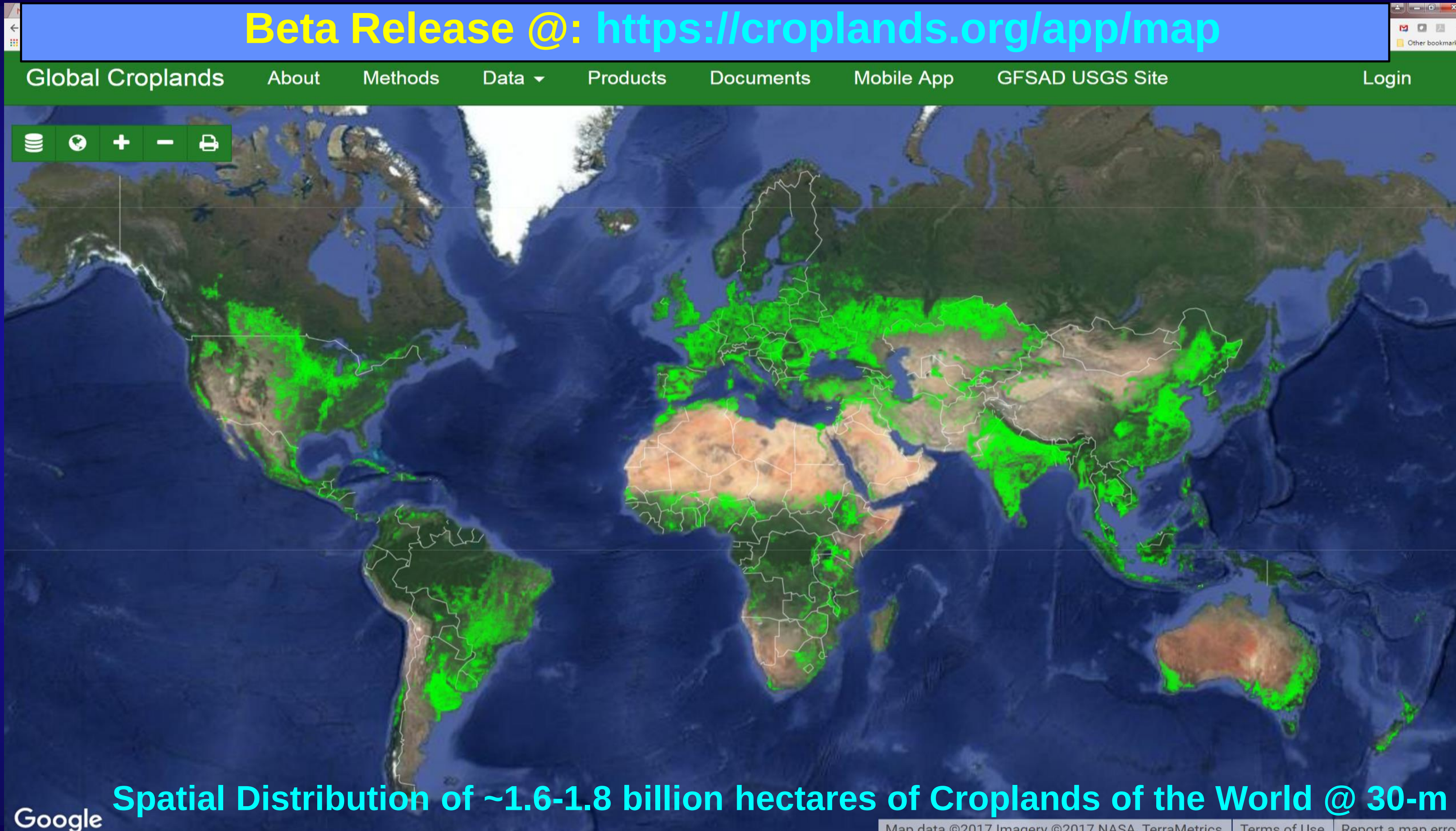
https://croplands.org/app/map

https://www.croplands.org/



First Global Cropland Map of the World @ Nominal 30-m (Landsat & some Sentinel)

Croplands *versus* Non-croplands: Global @ 30-m (Beta Release)

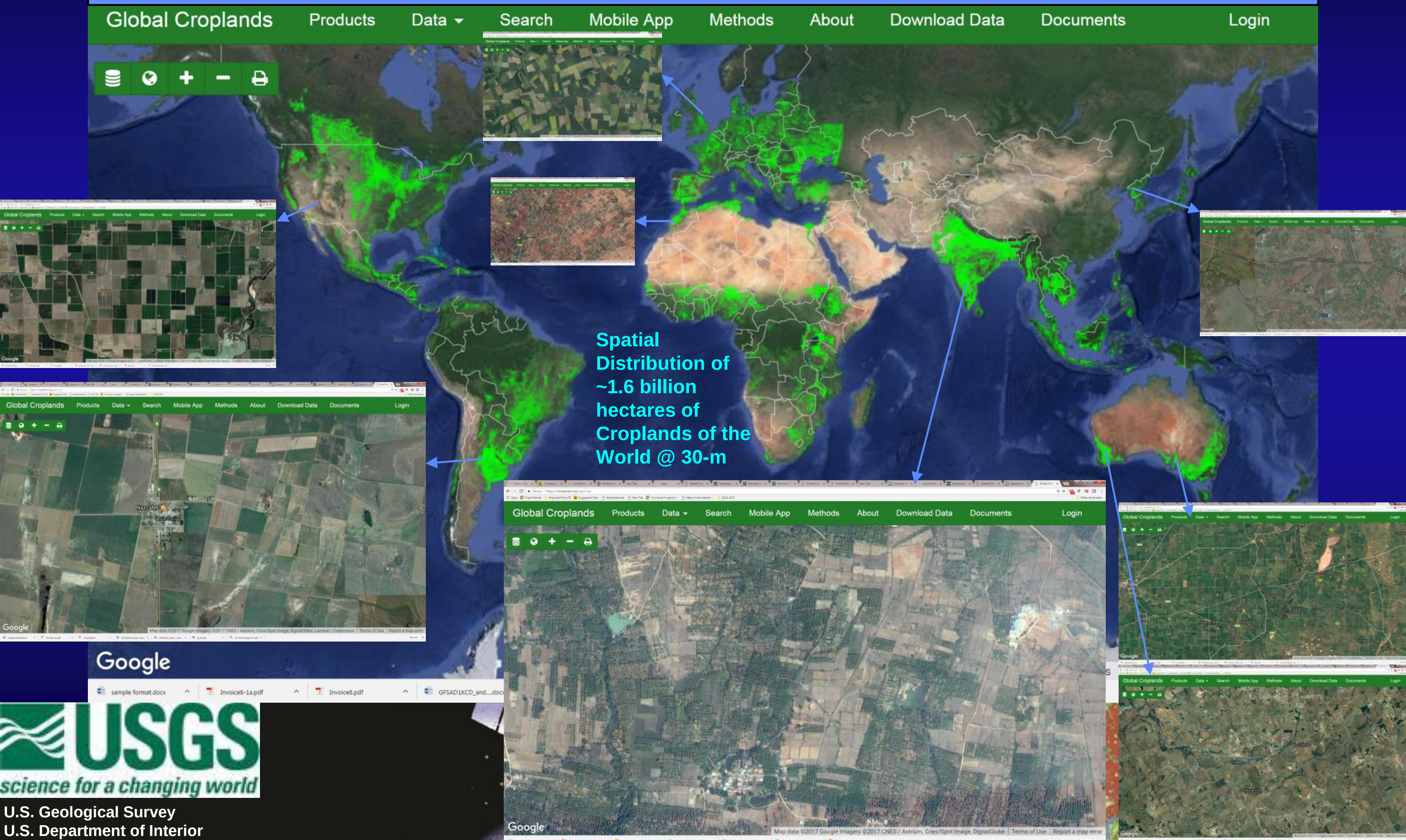


Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

First Global Cropland Map of the World @ Nominal 30-m (Landsat & some Sentinel)

Croplands *versus* Non-croplands: Global @ 30-m (Beta Release)

Beta Release @: https://croplands.org/app/map



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Croplands *versus* Non-Croplands Results: 30-m Global Details for Every Study Area

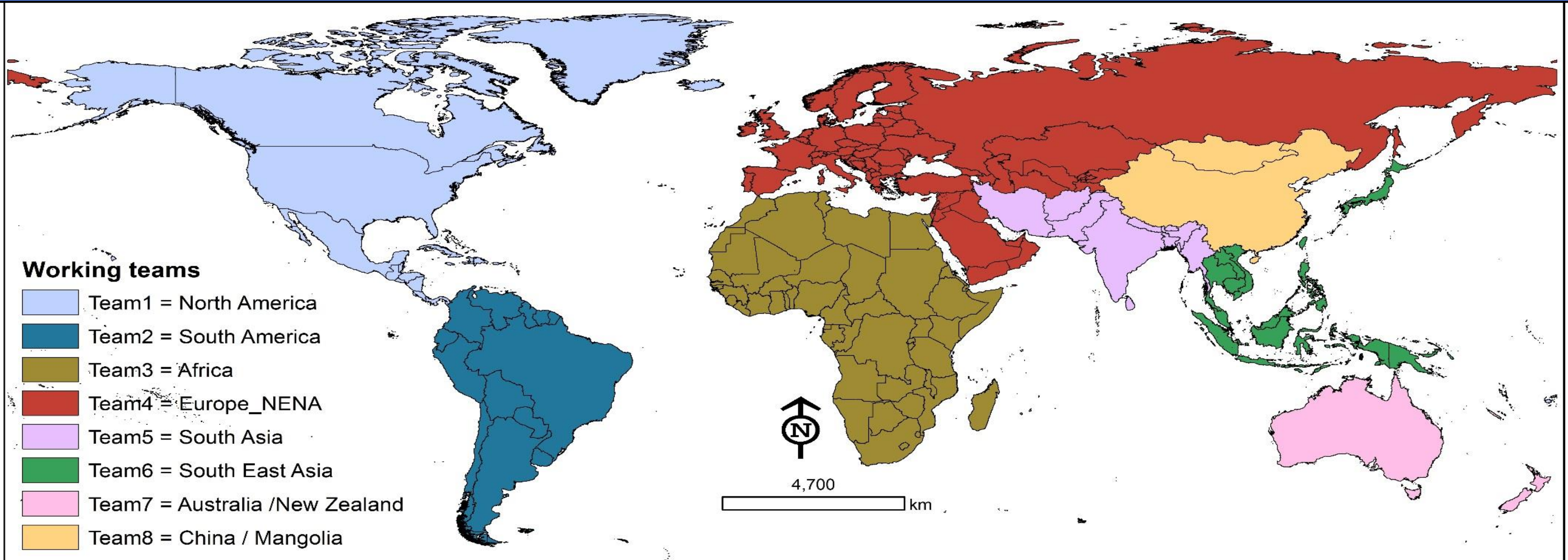
http://geography.wr.usgs.gov/science/croplands/index.html
https://croplands.org/app/map
https://www.croplands.org/

Global Food Security Support Analysis Data @ 30-m (GFSAD30) Project

First Global Cropland Map of the World @ Nominal 30-m (Landsat & some Sentinel)

Croplands *versus* Non-croplands: Global @ 30-m (Beta Release)

Over next three days, Every Team will make detailed presentation of their work for continents\study areas that include: (a) datasets used, (b) approaches taken, (c) methods adopted and\or developed, (d) results, (e) accuracies, (f) products, (g) access, (h) manuscripts.



Note: Team 1: Richard, Teki et al., Team 2: Varsha, Giri et al., Team 3: Jun, Prasad, Murali et al., Team 4: Aparna, Mutlu et al., Team 5: Murali, Prasad, Jun et al., Team 6: Adam, Prasad et al., Team 7: Pardha, Prasad et al. and Team 8: Pardha\Prasad\Teki et al.,

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Food for Thought

"It is now 14 years since I first suggested that organic farming might have some benefits and ought to be taken seriously. I shall never forget the vehemence of the reaction, much of it coming from the sort of people who regard agriculture as an industrial process, with production as the sole yardstick of success"

- Prince Charles, on Sept. 18th, 2009