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A cultivated planet in 2010 – Part 2: The global gridded agricultural-production maps

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S1. Collecting crop statistics

S1.1. Administrative units (*ADM$_k$*)

The coverage of FAO's Global Administrative Unit Layers (GAUL) is generally sufficient, despite some inconsistencies and incorrect assignments of administrative levels:

- The Bangladesh district Pirojpur is classified as belonging both to the Barisal division (which is correct) and the Khulna division (which is incorrect). The correct name of the district in the Khulna division is Bagerhat. Adjustments to the name for Bagerhat were made within the main code-link table, rather than the GAUL shapefile.
- In India the larger portion of Arunachal Pradesh is classified as 'disputed' area and considered as a 'country', which leaves Arunachal Pradesh with too few ADM2 units.
- Algeria has 1,541 ADM2 units (districts) in GAUL, which in Algeria's official publications were classified as ADM3 units (municipalities). SPAM2010 only has data for Algeria at ADM0 and ADM1 levels.

GAUL identified ADM2 units for China by numbers rather than explicit names. Thus, we opted to use the Database of Global Administrative Areas (GADM) Version 1 shapefiles for China, and attributed any overlaps between China (as designated by GADM) and neighboring countries (as designated by GUAL) to the neighbors (i.e., took some area away from China). For example, Disputed areas like Kashmir were not included in SPAM2010.

The country-specific administrative level used for the model is defined as the statistical reporting unit (SRU). For most countries SPAM is run at an ADM0 level, because of the SRUs are not universally available at the ADM1 level. Table S1 lists the countries which were modelled at an ADM1 level ($SRU=k_1$). All countries not listed in this table were modelled at an ADM0 level ($SRU=k_0$).

Table S1 Countries modeled at an ADM1 level statistical reporting unit (SRU)

Region	Country
Asia	Bangladesh
	China
	India
	Indonesia
	Japan
	Pakistan

Region	Country
	Vietnam
Russia	Russia
Europe	Germany
	Italy
	Turkey
Latin America and the Caribbean	Argentina
	Bolivia
	Brazil
	Colombia
	Costa Rica
	Mexico
	Venezuela
Middle East	Israel
	Iran
	Yemen
North America	Canada
	United States
Oceania	Australia
	New Zealand
Sub-Saharan Africa	Angola
	Benin
	Ethiopia
	Kenya
	Nigeria
	Senegal
	Sudan
	Tanzania
	Zambia

Note: All countries not listed in this table have a statistical reporting unit at an ADM0 level.

S1.2. Crop production statistics (*CropHPY*)

Data sources for crop statistics include FAOSTAT, EUROSTAT, CountrySTAT, ReSAKSS, national statistical offices, ministries of agriculture or planning bureaus of individual countries, household surveys and a variety of ad hoc reports related to a particular crop within a particular country. The data sources are slightly different between SPAM2005 (Wood-Sichra *et al.*, 2016) and SPAM2010 (see details in Table S2).

Table S2 Sources of crop production statistics by country and sub-national coverage

			Data		Harvested Area	
Country	Data Source	Year	ADM1	ADM2	ADM1	ADM2
Afghanistan	CountryStat	2009-2012	78.6	62.5	93.6	0.0
Albania	Ministria e Bujqësisë, Zhvillimit Rural dhe Administrimit të Ujërave	2010	80.8	-	65.4	-
Algeria	http://www.ons.dz/-Annuaire-Statistique-de-l-Algerie-.html	2009	85.7	-	98.6	-
Angola	Agromaps	2009-2011	100.0	-	100.0	-
Antigua And Barbuda	FAOSTAT		-	-	-	-
Argentina	Ministerio de Agroindustria	2009-2011	100.0	100.0	100.0	100.0
Armenia	Armenian Statistical Service of Republic of Armenia	2009-2011	92.9	69.5	98.5	3.0
Australia	Australian Bureau of Statistics	2009-2011	100.0	46.7	100.0	0.0
Austria	EUROSTAT	2009-2011	81.0	57.5	96.2	0.4
Azerbaijan	Azərbaycan Respublikasının Dövlət Statistika Komitəsi	2009-2011	97.6	95.5	100.0	98.1
Bahrain	FAOSTAT		-	-	-	-
Bangladesh	Bangladesh Bureau of Statistics (BBS)	2009-2011	100.0	98.4	100.0	100.0
Barbados	FAOSTAT		-	-	-	-
Belarus	http://belstat.gov.by/en/bgd/katalog-publikatsii/public_compilation/index_117/	2010-2012	85.7	85.7	86.5	86.5
Belgium	EUROSTAT	2009-2011	88.1	88.1	86.1	86.1
Belize	FAOSTAT		100.0	-	100.0	-
Benin	CountryStat	2009-2011	100.0	90.9	100.0	93.3
Bhutan	CountryStat	2009-2011	73.8	-	68.8	-
Bolivia	INE - Instituto Nacional de Estatistica	2009-2011	100.0	-	100.0	-
Bosnia And Herzegovi	Federalni zavod za statistiku	2009-2011	76.2	57.4	97.3	41.3
Botswana	Statistics Botswana	2009-2011	85.7	-	81.2	-
Brazil	Ministério da Agricultura	2009-2011	100.0	94.3	100.0	99.9
Brunei Darussalam	Agriculture and Agrifood Department	2013	78.6	-	12.0	-
Bulgaria	EUROSTAT	2009-2011	66.7	66.7	94.8	94.8
Burkina Faso	annuaire_statistique_agricoles__2012.pdf	2009-2011	88.1	85.0	99.1	98.7
Burundi	http://www.isteebu.bi/index.php/publications/annuaires-statistiques	2009-2011	71.4	-	84.8	-

Country	Data Source	Year	Data ADM1	Data ADM2	Harvested Area ADM1	Harvested Area ADM2
Cambodia	NIS (National Institutes of Statistics)	2013	100.0	-	100.0	-
Cameroon	http://www.minader.cm/fr/documents-de-statistiques-de-la-direction-des-statistiques-desa.html	2007-2008	57.1	57.1	50.9	50.9
Canada	local government websites	2009-2011	100.0	81.3	100.0	85.0
Cayman Islands	FAOSTAT		-	-	-	-
Cent Afr Rep	FAOSTAT		-	-	-	-
Chad	http://www.minagri-tchad.org/fr/index.php/publications/autres-publications-scientifiques/166-statistiques-grandes-cultures-1999-2011	2009-2011	73.8	56.3	78.2	2.4
Chile	Instituto Nacional de Estadisticas, Chile	2009-2011	92.9	75.9	97.0	34.0
China	http://zzys.agri.gov.cn/nongqing.aspx	2009-2011	100.0	95.0	100.0	86.6
Colombia	Agronet MinAgricultura	2009-2011	100.0	85.2	100.0	81.4
Comoros	FAOSTAT		-	-	-	-
Congo, Dem R	http://www.plan.gouv.cd/bibliotheque.php	2009-2011	52.4	23.7	84.8	0.5
Congo, Rep	FAOSTAT		-	-	-	-
Costa Rica	Secretaría Ejecutiva de Planificación Sec torial Agropecuaria	2010-2012	100.0	88.4	100.0	78.6
Cote Divoire	AgroMaps	2005-2007	47.6	36.5	26.5	1.4
Croatia	EUROSTAT	2010-2012	69.1	-	45.2	-
Cuba	Oficina Nacional de Estadísticas	2008-2010	78.6	-	67.5	-
Cyprus	EUROSTAT	2010-2012	-	-	-	-
Czech Republic	EUROSTAT	2009-2011	88.1	-	97.7	-
Denmark	EUROSTAT	2009-2011	88.1	-	98.5	-
Djibouti	FAOSTAT		95.2	95.2	55.6	55.6
Dominica	FAOSTAT		-	-	-	-
Dominican Republic	MINISTERIO DE AGRICULTURA	2010-2012	73.8	-	64.8	-
Ecuador	Instituto Nacional de Estadística y Censos	2009-2011	100.0	-	100.0	-
Egypt	Central Agency for Public Mobilization and Statistics (CAPMAS)	2010-2012	86.3	-	95.3	-
El Salvador	Ministerio de Agricultura y Ganadería, Dirección General de Economía Agropecuaria	2010-2012	59.5	-	90.6	-
Eq Guinea	FAOSTAT		-	-	-	-
Eritrea	FAOSTAT		-	-	-	-
Estonia	EUROSTAT	2010-2012	-	-	-	-
Ethiopia	Agricultural Sample Survey 2008/2009, 2009/2010, 2010/2011 and Oromia Field Information 2001	2009-2011	100.0	99.6	100.0	100.0
Fiji Island	IFPRI Final Report (edited)-reviewed-May22-Clean.docx	2009	59.5	59.5	79.6	79.6
Finland	EUROSTAT	2009-2011	95.2	95.2	98.8	98.8
France	EUROSTAT	2010-2012	78.6	-	94.9	-

			Data		Harvested Area	
Country	Data Source	Year	ADM1	ADM2	ADM1	ADM2
French Guiana	FAOSTAT		75.0	-	1.0	-
Gabon	Ann09.pdf	2007-2009	59.5	-	1.6	-
Gambia	http://gambia.africadata.org/en/BulkDownload	2005-2007	76.2	-	92.2	-
Georgia	http://en.wikipedia.org/wiki/Abkhazia#Economy	2009-2011	100.0	-	100.0	-
Germany	EUROSTAT	2009-2011	100.0	77.0	100.0	56.4
Ghana	Agromaps	2009-2011	90.5	90.5	99.5	99.5
Greece	EUROSTAT	2010-2012	59.5	45.5	42.4	0.2
Grenada	FAOSTAT		-	-	-	-
Guadeloupe	FAOSTAT		-	-	-	-
Guatemala	Guatemala CD	2006-2008	76.2	-	98.6	-
Guinea	Direction Nationale de la Statistique (DNS)	2009-2011	50.0	-	63.4	-
Guineabissau	Agromaps	2009-2011	78.6	-	83.5	-
Guyana	FAOSTAT		-	-	-	-
Haiti	folder "FromKai_CIMMYT" / file "agriculture.gouv.ht.zip"	2013	85.7	-	92.6	-
Honduras	Instituto Nacional de Estadistica, Honduras	2010	88.4	-	98.9	-
Hungary	EUROSTAT	2009-2011	71.4	71.4	96.9	96.9
Iceland	EUROSTAT		-	-	-	-
India	Http://eands.dacnet.nic.in/APY_96_To_07.htm	2006-2011	100.0	88.2	100.0	93.5
Indonesia	Badan Pusat Statistik	2009-2011	100.0	91.2	100.0	97.9
Iran	Ministry of Agriculture - Islamic Republic of Iran	2009-2011	100.0	49.3	100.0	0.4
Iraq	FAOSTAT		-	-	-	-
Ireland	EUROSTAT	2009-2011	88.1	-	90.1	-
Israel	Central Bureau of Statistics israel	2008, 2010, 2012	100.0	-	100.0	-
Italy	EUROSTAT	2010-2012	100.0	49.4	100.0	0.7
Jamaica	FAOSTAT		-	-	-	-
Japan	Ministry of Agriculture, Forestry and Fisheries	2008,2009, 2011	100.0	-	100.0	-
Jordan	The Department of Statistics (DoS)	2004-2006	97.6	70.6	100.0	5.2
Kazakhstan	http://www.eng.stat.kz/digital/Agriculture/Pages/default.aspx	2009-2011	84.4	52.5	97.7	0.0
Kenya	CountryStat	2006-2008	100.0	87.5	100.0	87.9
Kiribati	FAOSTAT		-	-	-	-
Kuwait	SPAM2000		80.5	-	2.4	-
Kyrgyzstan	National Statistical Committee of the Kyrgyz Republic	2009-2011	97.6	-	99.0	-
Lao-Pdr	Lao Statistics Bureau	2009-2011	76.2	-	91.5	-
Latvia	EUROSTAT	2010-2012	-	-	-	-
Lebanon	The Central Administration of Statistics (CAS)	2010	88.1	61.8	99.7	41.2
Lesotho	http://www.bos.gov.ls/	2009-2011	90.5	-	94.2	-
Liberia	IR13.Liberia.xlsx	2011	59.5	-	43.6	-

			Data		Harvested Area	
Country	Data Source	Year	ADM1	ADM2	ADM1	ADM2
Libya	http://bsc.ly/	2010	-	-	-	-
Liechtenstein	Vereinigung Bäuerlicher Organisationen	2013	-	-	-	-
Lithuania	Oficialiosios statistikos rengėjai	2010-2012	97.6	97.6	99.9	99.9
Luxembourg	http://ec.europa.eu/eurostat/data/database	2010-2012	-	-	-	-
Macedonia	http://makstat.stat.gov.mk/PXWeb2007bazi/Database/Statistics%20by%20municipality/databasetree.asp	2009-2011	76.2	76.2	96.8	96.8
Madagascar	Annuaire-MINAGRI-2009-2010.xlsx	2008-2010	64.3	64.2	91.4	91.4
Malawi	IFPRI/Malawi	2009-2011	86.9	72.0	95.1	83.8
Malaysia	DEPARTMENT OF AGRICULTURE MINISTRY OF AGRICUL AND AGRO-BASED MINISTRY MALAYSIA	2009-2011	88.1	76.6	97.3	26.1
Mali	Agromaps	2009-2011	59.5	-	90.3	-
Martinique	FAOSTAT		-	-	-	-
Mauritania	Serie Statistique Agricole	2007-2008	71.4	-	61.8	-
Mauritius	http://statsmauritius.govmu.org/English/StatsbySubj/Documents/Digestagri2013.pdf	2009-2011	79.5	-	18.2	-
Mexico	Servicio de Información Agroalimentaria y Pesquera	2009-2011	100.0	96.9	100.0	96.4
Moldova	Biroul Naţional de Statistică	2009-2011	92.9	91.2	96.2	90.4
Mongolia	Ministry of Food, Agriculture and Light Industry	2009-2011	93.2	82.3	97.0	5.2
Montenegro	Statistical Office of Montenegro - MONSTAT	2010	92.9	-	97.0	-
Montserrat	FAOSTAT		-	-	-	-
Morocco	Haut-Commissariat au plan	2006-2012	85.7	85.1	99.9	99.9
Mozambique	Mozambique_2010CAP_VF.pdf	2010	86.3	-	96.9	-
Myanmar (Burma)	http://www.myanmar.cm/myanmardata2009/s050701.htm	2007-2009	88.9	-	90.4	-
Namibia	Namibian Agronomic Board	2001-2003	83.0	-	96.2	-
Nepal	Agri Census 2011-2012_Nepal National_Final.xls	2011	100.0	97.6	100.0	99.6
Netherlands	EUROSTAT	2009-2011	85.7	-	83.0	-
New Caledonia	FAOSTAT		-	-	-	-
New Zealand	Statistics New Zealand	2009-2011	100.0	-	100.0	-
Nicaragua	INSTITUTO NACIONAL DE INFORMACIÓN DE DESARROLLO - INIDE, Julio 2012	2011	92.9	-	99.2	-
Niger	Agromaps	2009-2011	71.4	-	99.0	-
Nigeria	NASS-2011.pdf	2010	100.0	-	100.0	-
North Korea	FAOSTAT		-	-	-	-
Norway	Agriculture, forestry, hunting and fishing - SSB	2009-2011	92.9	92.9	96.5	96.5
Oman	http://www.maf.gov.om/Pages/PageCreator.aspx?lang=EN&I=0&CId=0&CMSId=800631&DId=0		78.6	-	61.2	-

			Data		Harvested Area	
Country	Data Source	Year	ADM1	ADM2	ADM1	ADM2
Pakistan	Agricultural Statistics of Pakistan 2011-2012 (pdf) from The Ministry of National Food Security and Research (NFS&R)	2009-2011	100.0	93.7	100.0	99.8
Panama	El Instituto Nacional de Estadística y Censo (INEC)	2011	90.5	48.6	98.7	1.2
Papua New Guinea	Book	2000-2006	80.8	60.5	68.3	0.3
Paraguay	http://www.mag.gov.py/index-b.php?pag=publicaciones-dgp-todos.html	2009-2011	71.4	-	95.6	-
Peru	or http://siea.minag.gob.pe/siea/?q=publicaciones/anuarios-estadisticos	2009-2011	100.0	54.5	100.0	13.6
Philippines	CountryStat	2009-2011	77.6	76.5	97.8	97.8
Poland	EUROSTAT	2009-2011	85.7	-	96.3	-
Portugal	EUROSTAT	2009-2011	69.1	69.1	74.4	74.4
Puerto Rico	FAOSTAT		71.4	66.6	59.0	0.1
Quatar	FAOSTAT		-	-	-	-
Romania	EUROSTAT	2009-2011	76.2	76.2	94.8	94.8
Russia	Федеральная служба государственной статистики: Главная	2009-2011	100.0	-	100.0	-
Rwanda	National Institute of Statistics Rwanda (NNISR)	2008,2013-2015	100.0	97.1	100.0	97.5
Sao Tome Prn	FAOSTAT		-	-	-	-
Saudi Arabia	SPAM2000		81.9	-	57.6	-
Senegal	http://www.ansd.sn/index.php?option=com_content&view=article&id=302&Itemid=417	2008-2012	100.0	81.1	100.0	52.0
Serbia	http://webrzs.stat.gov.rs/WebSite/public/ReportView.aspx	2011, 2009-2011	95.2	69.4	99.7	78.7
Seychelles	countrySTAT		90.5	-	62.9	-
Sierra Leone	CountryStat	2008-2009	71.4	71.4	83.7	83.7
Singapore	FAOSTAT		-	-	-	-
Slovakia	EUROSTAT	2009-2011	73.8	-	96.5	-
Slovenia	EUROSTAT	2009-2011	76.2	-	90.7	-
Solomon Islands	FAOSTAT		-	-	-	-
Somalia	SPAM2000		68.8	-	67.8	-
South Africa	Directorate of Agriculture, Forstry and Fisheries	2009-2011	95.8	51.8	99.4	0.0
South Korea	KOSIS KOrean Statistical Information Service	2009-2011	83.3	-	95.6	-
Spain	EUROSTAT	2010-2012	64.3	41.6	86.0	5.2
Sri Lanka	http://www.statistics.gov.lk/agriculture/hcrops/index.html	2007-2009	100.0	97.6	100.0	99.5
St Vincent & The Gre	FAOSTAT		-	-	-	-
St. Kitts And Nevi	FAOSTAT		-	-	-	-
St. Lucia	FAOSTAT		-	-	-	-
Sudan	Stat_book_2009.pdf	2007-2009	100.0	-	100.0	-

			Data		Harvested Area	
Country	Data Source	Year	ADM1	ADM2	ADM1	ADM2
Suriname	FAOSTAT		-	-	-	-
Swaziland	CountrySTAT	2000-2012	73.8	-	85.6	-
Sweden	EUROSTAT	2009-2011	90.5	90.5	95.4	95.4
Switzerland	Schweizer Bauernverband :: sbv-usp.ch	2009-2011	97.6	-	100.0	-
Syria	http://www.cbssyr.sy/index-EN.htm	2008-2012	50.0	-	65.3	-
Tajikistan	Agency on Statistics TJ 2012.	2009-2011	57.1	54.8	71.9	32.3
Tanzania	Tanzania ag prod & input 1984-2011.xls	2009-2011	100.0	95.1	100.0	98.8
Thailand	Agricultural Census - National Statistical Office of Thailand	2013	90.5	49.6	99.8	69.4
Timor Leste	http://www.fao.org/docrep/010/ah866e/ah866e00.HTM#3	2007	78.6	-	80.4	-
Togo	Countrystat	2008-2010	61.9	-	83.8	-
Trinidad And Tobago	http://cso.planning.gov.tt/category/statistics-category/agricultural-statistics	2010, 2011, 2012	-	-	-	-
Tunisia	Statistiques Tunisie	2011-2013	78.6	-	37.3	-
Turkey	EUROSTAT	2010-2012	100.0	65.7	100.0	71.9
Turkmenistan	Turkmenistan Agricultural Sector Review, FAO Investment Centre, 2012		78.1	-	43.9	-
Uganda	Uganda Bureau of Statistics	2009	67.0	40.1	86.0	49.4
Ukraine	State Statistics Service of Ukraine	2009-2011	78.6	-	90.9	-
United Arab Emirates	FAOSTAT		75.1	-	0.0	-
United Kingdom	EUROSTAT	2010-2012	83.3	74.8	84.3	0.1
United States	USDA	2009-2011	100.0	87.0	99.8	94.0
Uruguay	Ministerio de Ganadería, Agricultura y Pesca	2009-2012	61.9	58.3	12.0	2.2
Uzbekistan	Committee on statistics	2013	64.6	-	55.3	-
Vanuatu	FAOSTAT		-	-	-	-
Venezuela	VII Censo Agrícola Nacional	2008	100.0	99.0	100.0	97.7
Vietnam	Agriculture, Forestry and Fishery - General Statistics Office Of VIET NAM	2009-2011	100.0	68.7	100.0	76.4
Virgin Islands	FAOSTAT		-	-	-	-
Yemen	Republic of Yemen - Ministry of Agriculture and Irrigation	2009-2011	100.0	-	100.0	-
Zambia	Central Statistics Organization's Crop Forecast Survey	2009-2010	100.0	79.9	100.0	82.5
Zimbabwe	http://196.43.99.13/agriculture-and-environment	2012&2015	85.7	-	98.6	-

Source: Developed by authors

S2. Defining crop types (*Crop*$_j$)

When individual countries reported on a crop of which the FAOSTAT category was not immediately apparent, efforts were made to identify the English name of the crop and assign it to the appropriate category. Table S3 lists the SPAM2010 crops and their respective FAO code. The list is comprised of 33 individual crops (millet and coffee are each split into two sub-categories) and crop aggregates. For millet and coffee we used country-level data to determine the shares in the respective sub-categories, and partitioned FAO's country totals accordingly.

Table S3 SPAM2010 crop categories

	SPAM2010 Crop		FAO Crop			
ID	Long Name	Short Name	Name	Code	Group	Classification
1	Wheat	whea	Wheat	15	Cereals	Food
2	Rice	rice	Rice	27	Cereals	Food
3	Maize	maiz	Maize	56	Cereals	Food
4	Barley	barl	Barley	44	Cereals	Food
5	Pearl Millet	pmil	Millet	79	Cereals	Food
6	Small Millet[a]	smil	Millet[b]	79	Cereals	Food
7	Sorghum	sorg	Sorghum	83	Cereals	Food
8	Other Cereals[c]	ocer	Other Cereals ++	68, 71, 75, 89, 92, 94, 97, 101, 103, 108	Cereals	Food
9	Potato	pota	Potato	116	Roots & Tubers	Food
10	Sweet Potato	swpo	Sweet Potato	122	Roots & Tubers	Food
11	Yams	yams	Yam	137	Roots & Tubers	Food
12	Cassava	cass	Cassava	125	Roots & Tubers	Food
13	Other Roots	orts	Yautia ++	135, 136, 149	Roots & Tubers	Food
14	Bean	bean	Beans, Dry	176	Pulses	Food
15	Chickpea	chic	Chickpea	191	Pulses	Food
16	Cowpea	cowp	Cowpea	195	Pulses	Food
17	Pigeon Pea	pige	Pigeon Pea	197	Pulses	Food
18	Lentil	lent	Lentils	201	Pulses	Food
19	Other Pulses	opul	Broad Beans ++	181, 187, 203, 205, 210, 211	Pulses	Food
20	Soybean	soyb	Soybean	236	Oilcrops	Food
21	Groundnut	grou	Groundnut, With Shell	242	Oilcrops	Food
22	Coconut	cnut	Coconut	249	Oilcrops	Food
23	Oilpalm	oilp	Oil Palm Fruit	254	Oilcrops	Non-Food
24	Sunflower	sunf	Sunflower Seed	267	Oilcrops	Non-Food
25	Rapeseed	rape	Rapeseed, Mustard Seed	270, 292	Oilcrops	Non-Food
26	Sesame Seed	sesa	Sesame Seed	289	Oilcrops	Non-Food

	SPAM2010 Crop		FAO Crop			
ID	Long Name	Short Name	Name	Code	Group	Classification
27	Other Oil Crops	ooil	Olives ++	260, 263, 265, 275, 280, 296, 299, 333, 336, 339	Oilcrops	Non-Food
28	Sugarcane	sugc	Sugar Cane	156	Sugar Crops	Non-Food
29	Sugarbeet	sugb	Sugarbeet	157	Sugar Crops	Non-Food
30	Cotton	cott	Seed Cotton	328	Fibres	Non-Food
31	Other Fibre Crops	ofib	Other Fibres ++	773,777, 780, 782, 788, 789, 800, 809, 821	Fibres	Non-Food
32	Arabica Coffee	acof	Coffee, Green[d]	656	Stimulates	Non-Food
33	Robusta Coffee	rcof	Coffee, Green	656	Stimulates	Non-Food
34	Cocoa	coco	Cocoa, Beans	661	Stimulates	Non-Food
35	Tea	teas	Tea	667	Stimulates	Non-Food
36	Tobacco	toba	Tobacco, Unmanufactured	826	Stimulates	Non-Food
37	Banana	bana	Banana	486	Fruits	Food
38	Plantain	plnt	Plantain	489	Fruits	Food
39	Tropical Fruit	trof	Oranges ++	490,– 495, 497, 507, 512, 567, 568, 569, 571, 572, 574, 577, 587, 591, 600, 603	Fruits	Food
40	Temperate Fruit	temf	Apples ++	515, 521, 523, 526, 530, 531, 534, 536, 541, 542, 544, 547, 549, 550, 552, 554, 558, 560, 592, 619	Fruits	Food
41	Vegetables	vege	Cabbages And Other Brassicas ++	358, 366, 367, 372, 373, 388, 393, 394, 397, 399, 401, 402, 406, 407, 414, 417, 420, 423, 426, 430, 446, 449, 459, 461, 463	Vegetables	Food
42	Rest Of Crops	rest	All Individual Other Crops (e.g., Spices, Tree Nuts, Other Sugar Crops, Mate, Rubber)	161,216, 217, 220, 221, 222, 223, 224, 225, 226, 234, 671, 677, 687, 689, 692, 693, 698, 702, 711, 720, 723, 748, 754, 836, 839		Non-Food

Source: Developed using information from FAOSTAT (FAO 2015).

Note: ++ indicates that all crops identified by the FAO code in the adjacent column are also assigned to the respective SPAM2010 crop. For example, “Yautia ++” would read “Yautia, Taro, Roots and Tubers, nes”.

[a] Also known as finger millet which includes foxtail, proso, japanese and Kodo varieties.

[b] FAO’s millet crop was split between pearl and small at a ratio specific to the country in question.

[c] Teff was part of ‘other cereals’ in SPAM and FAOSTAT, despite the explanation in FAOSTAT that it was part of the ‘millets’ commodity.

[d] FAO’s coffee crop was split between Arabica and Robusta at a ratio specific to the country in question.

S3. Adjusting the crop statistics (*$AdjCropHPY_{jk}$*)

SPAM2010 calculations were based on the 2009-2011 average of the crop production statistics. All efforts were made to collect statistics from these three years, but if data was missing from this time period the average was calculated from the available data spanning the years 2005 to 2015:

$$AvgCropHPY_{jk} = \frac{\sum_{t=2009}^{t=2011} CropHPY_{jkt}{}^{1}}{3} \quad if\ \exists\ CropHPY_{jkt}\ \forall t \in [2009, 2011]$$

$$AvgCropHPY_{jk} = \frac{\sum_{t=m_1}^{t=m_n} CropHPY_{jkt}}{n} \quad if\ \nexists\ CropHPY_{jkt}\ \forall t \in [2009, 2011]$$

where $k_0, k_1, k_2 \in k$, $m_1, \dots, m_n$ are the set of years with data available on crop j and administrative unit k closest to the 2009-2011 time period (but not earlier than 2005 or later than 2015), n was the total number of years used to calculate the average for crop j and administrative unit k.

Note: Average statistics on yield were always taken as a harvested area weighted average

To improve the comparability of the crop production statistics and better align the sub-national data with data derived from the cropland and irrigation maps, we adjusted all national and sub-national statistics using the national 2009-2011 average from FAO ($AvgFAOCropHPY_{jk0}$) by crop j and country k_0:

i. National (ADM0) harvested area (H), production (P) and yield (Y) statistics

$$AdjCropHP_{jk_0} = AvgFAOCropHP_{jk_0}$$

$$AdjCropY_{jk_0} = \frac{AdjCropP_{jk_0}}{AdjCropH_{jk_0}}$$

ii. Sub-national (ADM1 or ADM2) harvested area (H), production (P) and yield (Y) statistics

$$AdjCropHP_{jk} = \frac{AvgCropHP_{jk}}{AvgCropHP_{jk_0}} \times AvgFAOCropHP_{jk_0}, \forall k = k_1, k_2$$

$$AdjCropY_{jk} = \frac{AdjCropP_{jk}}{AdjCropH_{jk}}, \forall k = k_1, k_2$$

In situations where a country only reported one of the three variables for a crop (i.e., harvested area, production or yield), we used FAO national statistics ($AvgFAOCropHPY_{jk0}$) to infer the missing variables.

Issues of measurement might arise because FAO occasionally updates historical data without documenting which years or crops were changed. This can lead to inconsistencies when users compare SPAM2010 results with published FAO numbers which have been retroactively adjusted since the version used in SPAM2010.

[1] Average statistics on yield were always taken as a harvested area weighted average.

S4. Obtaining the farming system shares ($Percent_l$)

The four farming systems are referred to as ***irrigated (I)***, ***rainfed – high (H)***, ***rainfed – low (L)*** and ***subsistence (S)***. To run, the model requires knowledge of the share of area cropped by each farming system l, crop j and administrative unit k ($Percent_{jlk}$); where $l = (I, H, L, S)$. Farming system shares were constructed either at the $k = k_0$ (ADM0 level) or $k = k_1$ (ADM1 level) depending on country's SRU.

The share of crop area and production belonging to each of these farming systems when total area and production are given is often times hard to come by. We rely extensively on expert judgment, but some documented assessments were assembled from household surveys, FAO publications and publications from national statistical offices. It was often necessary to use farming system shares from one crop as proxies for similar crops (e.g., farming system shares for beans were used for all pulses) or shares from one country and apply them to similar countries (e.g., Kuwait, Oman and Qatar were assigned the same farming system shares).

For a small number of large countries, listed in Table S4, we were able to source data on farming system shares at the ADM1 level. For the remaining countries we first assigned the national farming system shares to each ADM1 level, and then adjusted individual ADM1 farming system shares in light of the supporting evidence. For example, if the national share for irrigation of wheat was 30 percent, we assigned that to all ADM1 units. Then we looked at individual units, and if supporting evidence (e.g., the Global Map of Irrigation Areas (GMIA) data) indicated that there was no irrigated area present in a particular AMD1 unit, we set the irrigation share of wheat to zero in that administrative unit. Finally the farming system shares at national level were recalculated as the weighted average of the adjusted ADM1 estimates.

Table S4 Sources of sub-national farming systems data

Country	All/Some Crops	Source of data
Argentina	All	Irrigation from MIRCA, rest expert judgment
Australia	Some	Irrigation from MIRCA, rest expert judgment
Bangladesh	Some	2013 Statistical Yearbook for Bangladesh
Bolivia	All	Same as national, adjust for some crops
Brazil	All	Irrigation from MIRCA, rest expert judgment
Canada	All	Irrigation from StatCanada, rest expert judgment
China	All	Expert judgment
Congo, DRC	All	Same as national, adjust for some crops
Ethiopia	Some	Irrigation from Agricultural Sample Surveys from 2009 - 2011, rest expert judgment

Country	All/Some Crops	Source of data
India	All	Irrigation from MIRCA, rest India Statistics and expert judgment
Indonesia	All	Same as national, adjust for some crops
Japan	All	Same as national, adjust for some crops
Mexico	All	Same as national, adjust for some crops
Nigeria	All	Same as national, adjust for some crops
Pakistan	All	Water Management Research Centre, Pakistan, personal contact
Russia	All	Same as national, adjust for some crops
Sudan	All	Sudan Statistical Yearbook for 2014
Uganda	Some	Same as national, adjust for some crops
United States	All	USDA for irrigated shares, rest is rainfed high, expert judgment

Note: Any countries from Table S1 not listed in this table were sourced from MIRCA. Countries listed in this table were adjusted as needed according to expert judgment.

Shares on irrigated production by crop *j* and administrative unit *k* ($Percent_{jIk}$) were derived by dividing the harvested area cultivated under full control irrigation $IrrArea_{jk}$ obtained from AQUASTAT, MIRCA, and country-level statistics by the overall harvested area $AvgCropH_{jk}$. Rainfed shares ($Percent_{jHk}$, $Percent_{jLk}$, $Percent_{jSk}$) were primarily estimated based on generalized assumptions for individual countries and crops. For example, all cereals in Western Europe were either grown under irrigated or rainfed – high farming systems, whereas 20 percent of each of the cereals in SSA were grown under a subsistence farming system. We also assumed that fertilization was a proxy for high-input use, so if irrigated crop areas and overall fertilized and non-fertilized areas of a crop were known, it was possible to deduce rainfed high input shares by subtracting the irrigated areas from fertilized areas. The remainder of fertilized area was then classified as rainfed – high area and the non-fertilized areas (1 - $Percent_{jIk}$ - $Percent_{jHk}$) were split, using expert judgment, between rainfed – low ($Percent_{jLk}$) and subsistence ($Percent_{jSk}$) shares. Assignment of rainfed – subsistence shares occurred frequently when there was not enough suitable area for rainfed – low conditions to satisfy the completeness of disaggregated crop statistics in terms of area extent and/or production quantity. In such cases a portion of the rainfed-low statistics were assumed to stem from rainfed – subsistence agriculture, for which area was allocated solely on the condition of rural population and not any crop suitability criteria.

Table S5 shows the shares of production under irrigated and rainfed systems for selected crop groups and countries. We choose Brazil, China, Ethiopia, France, India, Indonesia, Nigeria, Turkey and the United States, because they vary in agro-ecology, region, income level and geographical size. For cereal crops, the three Asian countries (China, India and Indonesia) have the highest shares of irrigated area, whereas the two Sub-Saharan countries (Ethiopia and Nigeria) have the lowest shares of irrigated area. For roots, tubers and pulses production, the United States and both European countries have the highest shares of irrigated areas, while the Sub-Saharan countries again have less than one percent each. Aggregating across all crops, the three Asian countries rank highest in terms of irrigated area shares while the two Sub-Saharan countries rank lowest.

Table S5 Farming system shares (in area) by crop groups and selected countries

Country	Farming system	Cereals	Roots Tubers	Pulses	Oil Crops	Sugar Crops	Fiber Crops	Stimulants	Fruits Vegetables	Other Crops	All Crops
		(percent)									
Brazil	I	4.61	2.78	2.57	0.25	5.61	1.41	2.61	9.53	22.67	3.34
Brazil	R	95.39	97.22	97.43	99.75	94.39	98.59	97.39	90.47	77.33	96.66
China	I	65.13	4.43	10.47	21.94	17.09	76.47	0	17.97	10	43.68
China	R	34.87	95.57	89.53	78.06	82.91	23.53	100	82.03	90	56.32
Ethiopia	I	0.94	1.16	0.23	0.31	21.45	7.13	3.06	5.4	6.53	1.41
Ethiopia	R	99.06	98.84	99.77	99.69	78.55	92.87	96.94	94.6	93.47	98.59
France	I	9.67	38.78	15.74	0.69	13.83	8.8	100	15.34	100	9.42
France	R	90.33	61.22	84.26	99.31	86.17	91.2	0	84.66	0	90.58
Indonesia	I	41.58	0	9.83	1.49	91.85	0	0	13.1	0	19.97
Indonesia	R	58.42	100	90.17	98.51	8.15	100	100	86.9	100	80.03
India	I	52.41	10.62	10.15	15.36	84.94	27.3	0	12.24	16.73	35.95
India	R	47.59	89.38	89.85	84.64	15.06	72.7	100	87.76	83.27	64.05
Nigeria	I	0.72	0.52	0	0	100	2.18	0.05	7.01	4.33	1.3
Nigeria	R	99.28	99.48	100	100	0	97.82	99.95	92.99	95.67	98.7
Turkey	I	20.11	20.27	20.28	0	0	0	0	7.72	0	15.16
Turkey	R	79.89	79.73	79.72	100	100	100	100	92.28	100	84.84
USA	I	13.99	0.03	16.2	9	59.83	39.49	18.17	48.42	64.47	14.75
USA	R	86.01	99.97	83.8	91	40.17	60.51	81.83	51.58	35.53	85.25

Source: Developed by authors using data from AQUASTAT and MIRCA (Portmann *et al.*, 2010), the FAO's *World Agriculture: Towards 2015/30* report and expert judgment.

Note: Farming systems – irrigated (I); rainfed (R). Farming system shares for rainfed production are an area weighted average of rainfed high input, rainfed low input and rainfed subsistence production. Shares of rain fed production are the sum of production under rain fed – high inputs, low inputs and subsistence and have been aggregated for this table only.

S5. Disaggregating the crop statistics by farming systems (*AdjCropHPY*$_{jlk}$)

To run the model requires disaggregate harvested area (*AdjCropH*$_{jk}$) and yield (*AdjCropY*$_{jk}$) for each of the four farming systems. Harvested area by farming system *l* (*AdjCropH*$_{jlk}$) was calculated as follows:

i. National (ADM0) harvested area (*H*) statistics

$$AdjCropH_{jlk_0} = AdjCropH_{jk_0} \times Percent_{jlk_0}$$

ii. Sub-national (ADM1 or ADM2) harvested area (*H*) statistics

$$AdjCropH_{jlk} = AdjCropH_{jk} \times Percent_{jlk_1}, \forall k = k_1, k_2 \quad if \; \exists \; Percent_{jlk_1}$$
$$AdjCropH_{jlk} = AdjCropH_{jk} \times Percent_{jlk_0}, \forall k = k_1, k_2 \quad if \; \nexists \; Percent_{jlk_1}$$

Yields by farming system *l* were more complicated to calculate. These computations used the farming system shares (*Percent*$_{jlk}$) and the yield conversion factors (αIRR_{jk0}, αHLR_{jk0}) to calculate an *AdjCropY*$_{jlk}$ variable for both national and subnational yield *AdjCropY*$_{jk}$ statistics. The relevant yield conversion factors included yield ratios for irrigated versus rainfed systems (αIRR_{jk0}) and rainfed – high versus rainfed – low systems (αHLR_{jk0}). In many instances we used expert judgement to define these factors. Occasionally data was available from reported statistics or field trials (e.g., rainfed – high input/low input ratios were calculated from trials that compared yields with fertilizer applications to those without). Additionally, some yield conversion factors were applied from similar crops (e.g., lentil factors used for ‘other pulses’) or from similar agro-ecological zones and similar countries (e.g., the same factor was used for all humid tropics areas in SSA).

Table S6 Yield conversion factors by select crops and countries

Country	Farming system	Wheat	Rice	Maize	Barley	Pearl Millet	Small Millet	Sorghum	Other Cereal	Potato	Sweet Potato	Yams	Cassava	Other Root
Brazil	I	2.0	2.4	-	-	-	-	-	-	1.1	1.2	1.2	-	-
Brazil	R	3.6	1.1	2.7	3.5	-	-	2.3	2.7	3.6	3.2	3.2	3.4	3.4
China	I	1.3	1.2	1.3	1.2	1.5	1.5	1.2	1.3	1.4	1.3	1.3	-	-
China	R	1.6	3.1	2.0	2.0	3.1	3.1	1.6	2.0	1.6	1.1	1.1	2.0	2.0
Ethiopia	I	-	-	1.2	-	-	-	2.0	1.2	-	-	-	-	-
Ethiopia	R	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
France	I	1.3	1.8	1.1	1.7	-	-	1.7	1.1	1.3	-	-	-	-
France	R	1.3	-	1.3	1.3	-	-	1.3	1.3	1.2	-	-	-	-
Indonesia	I	-	1.5	2.4	-	-	-	-	2.4	-	-	-	-	-
Indonesia	R	1.6	3.1	2.0	2.0	3.1	3.1	1.6	2.0	1.6	1.1	1.1	2.0	2.0
India	I	2.4	1.9	2.1	2.9	3.8	3.8	4.4	2.1	1.4	1.3	1.3	-	-

Country	Farming system	Wheat	Rice	Maize	Barley	Pearl Millet	Small Millet	Sorghum	Other Cereal	Potato	Sweet Potato	Yams	Cassava	Other Root
India	R	1.6	3.1	2.0	2.0	3.1	3.1	1.6	2.0	1.6	1.1	1.1	2.0	2.0
Nigeria	I	-	2.8	-	-	-	-	-	-	-	1.9	1.9	-	-
Nigeria	R	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Turkey	I	1.5	1.8	1.3	1.3	1.2	1.2	1.5	1.3	1.4	-	-	-	-
Turkey	R	1.5	1.8	1.3	1.3	1.2	1.2	1.5	1.3	1.4	-	-	-	-
USA	I	1.9	-	1.2	1.8	-	-	1.8	1.2	1.9	-	-	-	-
USA	R	2.3	-	1.5	1.6	-	-	1.6	1.5	-	-	-	-	-

Source: Developed by authors using data from the FAO's (2002) *World Agriculture: Towards 2015/30* report and expert judgment.

Note: Farming systems – irrigated (I) lists factor for irrigated vs. rainfed; rainfed (R) lists factor for rainfed high vs. rainfed low.

In order to disaggregating crop yield by farming systems, the following were assumed to hold:

- The observed yield ($AdjCropY_{jk}$), by definition, was the average of input-specific yields weighted by area:

$$\begin{aligned} AdjCropY_{jk} = {} & Percent_{jIk} \times AdjCropY_{jIk} + Percent_{jHk} \times AdjCropY_{jHk} \\ & + Percent_{jSk} \times AdjCropY_{jLk} \\ & + \left(1 - Percent_{jIk} - Percent_{jHk} - Percent_{jSk}\right) \times AdjCropY_{jLk}, \forall k = k_0, k_1 \end{aligned} \quad \text{(A-1)}$$

- Weighted rainfed yield, by definition, was equal to the sum of weighted rainfed – high, weighted rainfed – low yield and weighted subsistence yield (subsistence has cancelled out below):

$$\begin{aligned} & \left(1 - Percent_{jIk}\right) \times AdjCropY_{jRk} \\ & = Percent_{jHk} \times Yield_{jHk} \\ & + \left(1 - Percent_{jIk} - Percent_{jHk}\right) \times AdjCropY_{jLk}, \forall k = k_0, k_1 \end{aligned} \quad \text{(A-2)}$$

- By definition of αIRR_{jk_0}:

$$AdjCropY_{jIk} = \alpha IRR_{jk_0} \times AdjCropY_{jRk}, \forall k = k_0, k_1 \quad \text{(A-3)}$$

- By definition of αHLR_{jk_0}:

$$AdjCropY_{jHk} = \alpha HLR_{jk_0} \times AdjCropY_{jLk}, \forall k = k_0, k_1 \quad \text{(A-4)}$$

Given the four equations listed above, we can define the following term:

$$\beta_{jk} = \left(Percent_{jHk} \times \alpha HLR_{jk_0} + 1 - Percent_{jIk} - Percent_{jHk}\right) \times \frac{\alpha IRR_{jk_0}}{1 - Percent_{jIk}}, \forall k = k_0, k_1. \quad \text{(A-5)}$$

Equations A-1 – A-5 were then used to calculate statistical yields by crop j and input l. Depending on the values of $Percent_{jIk_0}$, αHLR_{jk_0} and β_{jk_0}, there were three cases for calculating these yields:

Case 1: $Percent_{jIk_0}$ <> 100 or (αHLR_{jk_0} <> 0 and β_{jk_0} <> 0):

- The national (ADM0) yield (Y) statistics were equal to

$$AdjCropY_{jLk_0} = \frac{AdjCropY_{jk_0}}{Percent_{jIk_0} \times \beta_{jk_0} + Percent_{jHk_0} \times \alpha HLR_{jk_0} + 1 - Percent_{jIk_0} - Percent_{jHk_0}};$$

$$AdjCropY_{jHk_0} = \alpha HLR_{jk_0} \times AdjCropY_{jLk_0};$$

$$AdjCropY_{jIk_0} = \beta_{jk_0} \times AdjCropY_{jLk_0};$$

$$AdjCropY_{jSk_0} = AdjCropY_{jLk_0}.$$

- The sub-national (ADM1 or ADM2) yield (Y) statistics were equal to

$$AdjCropY_{jLk} = \frac{AdjCropY_{jk}}{Percent_{jIk} \times \beta_{jk} + Percent_{jHk} \times \alpha HLR_{jk} + 1 - Percent_{jIk} - Percent_{jHk}}, \forall k = k_1, k_2;$$

$$AdjCropY_{jHk} = \alpha HLR_{jk_0} \times AdjCropY_{jLk}, \forall k = k_1, k_2;$$

$$AdjCropY_{jIk} = \beta_{jk_1} \times AdjCropY_{jLk}, \forall k = k_1, k_2;$$

$$AdjCropY_{jSk} = AdjCropY_{jLk}, \forall k = k_1, k_2.$$

Case 2: $Percent_{jIk_0} = 100$ (i.e., no rainfed agriculture)

- National (ADM0) yield (Y) statistic

$$AdjCropY_{jIk_0} = AdjCropY_{jk_0};$$

$$AdjCropY_{jHk_0} = AdjCropY_{jLk_0} = AdjCropY_{jSk_0} = 0.$$

- Sub-national (ADM1 or ADM2) yield (Y) statistics

$$AdjCropY_{jIk} = AdjCropY_{jk};$$

$$AdjCropY_{jHk} = AdjCropY_{jLk} = AdjCropY_{jSk} = 0, \forall k = k_1, k_2.$$

Case 3: $\alpha HLR_{jk_0} = 0$ and $\beta_{jk_0} = 0$

- National (ADM0) yield (Y) statistic

$$AdjCropY_{jHk_0} = \frac{(1 - Percent_{jIk_0}) \times AdjCropY_{jk_0}}{\left(1 - Percent_{jIk_0} + \alpha IRR_{jk_0} \times Percent_{jIk_0}\right) \times Percent_{jHk_0}};$$

$$AdjCropY_{jIk_0} = \frac{\alpha IRR_{jk_0} \times Percent_{jHk_0} \times AdjCropY_{jHk_0}}{(1 - Percent_{jIk_0})}.$$

- Sub-national (ADM1 or ADM2) yield (Y) statistics

$$AdjCropY_{jHk} = \frac{(1-Percent_{jIk})\times AdjCropY_{jk}}{(1-Percent_{jIk}+\alpha IRR_{jk_0}\times Percent_{jIk})\times Percent_{jHk}}, \forall k = k_1, k_2;$$

$$AdjCropY_{jIk} = \frac{\alpha IRR_{jk_0}\times Percent_{jHk}\times AdjCropY_{jHk}}{(1-Percent_{jIk})}, \forall k = k_1, k_2.$$

The farming system-specific yields were further modified if they fell outside the lower and upper bounds of acceptable yields for each crop and farming system. These minimum ($MinYield_{jlk}$) and maximum ($MaxYield_{jlk}$) yields were calculated by crop j, farming system l and administrative unit k. The minimum yield (for any farming system) was equal to one-tenth of the average adjusted yield:

$$MinYield_{jlk} = 0.1 \times AdjCropY_{jk}, \forall k = k_0, k_1$$

The maximum yield were either equal to the average adjusted yield or two or three times its value, depending on the farming system:

$$MaxYield_{jIk} = 3 \times AdjCropY_{jk}, \forall k = k_0, k_1$$

$$MaxYield_{jHk} = 2 \times AdjCropY_{jk}, \forall k = k_0, k_1$$

$$MaxYield_{jLk} = AdjCropY_{jk}, \forall k = k_0, k_1$$

$$MaxYield_{jSk} = MaxYield_{jLk}, \forall k = k_0, k_1$$

The resulting minima and maxima used in SPAM2010 were $MinYield_{jlk}$ and $MaxYield_{jlk}$ and they were reported at ADM0 and AMD1 levels only.

S6. Generating physical area

For each crop in a country we needed to establish how often it was harvested per year on the same area, or if it was grown simultaneously with other crops. If data existed on the area harvested per season s ($SeasHarvArea_{jlks}$), then it was used to calculate the relevant cropping intensity for that particular crop j, farming system l and administrative unit k. If statistics on seasonal areas were not available, then expert judgment was used to estimate cropping intensities. Cropping intensities by crop j, farming system l and administrative unit k were calculated as follows:

i. National (ADM0) and sub-national (ADM1) statistics for $l = I, H, L$

$$CropIntensity_{jlk} = \frac{\sum_s SeasHarvArea_{jlks}}{\max\limits_{i \in SUR_k}\left(SeasHarvArea_{jlks}\right)}, \forall l = I, H, L\ \forall k = k_0, k_1 \quad if\ \exists\ SeasHarvArea_{jlks}$$

$$CropIntensity_{jlk} \text{ based on expert judgement}, \forall l = I, H, L\ \forall k = k_0, k_1 \quad if\ \nexists\ SeasHarvArea_{jlks}$$

ii. National (ADM0) and sub-national (ADM1) statistics for subsistence farming systems, $l = S$

$$CropIntensity_{jSk} = CropIntensity_{jLk}, \qquad \forall l = S\ \forall k = k_0, k_1$$

Physical area (A) by crop j, farming system l and administrative unit k was then calculated using the relevant harvested area ($AdjCropH_{jk}$) and cropping intensity ($CropIntensity_{jlk}$):

$$AdjCropA_{jlk} = \frac{AdjCropH_{jlk}}{CropIntensity_{jlk}}$$

Cropping intensity values were generally one in temperate and cool climates, and for crops which had long growing periods, like sugar cane or oil palm. Cropping intensities were larger than one for irrigated crops like cereals, especially in Asia, and areas with bimodal rain regimes. Vegetables typically also have higher cropping intensities. The terms of irrigation/rainfed in the current study indicates to farming systems rather than to seasons. It means that the value of cropping intensity for a I farming system indicates for a year around situation, regardless of the dry/wet seasons. The calculation of cropping intensity is based on the statistics in a few selected sampling areas: cropping intensity = harvested area / cropland area, and the values are further adjusted by expert judgements. Table S11 lists cropping intensities for crop groups in a few countries.

Table S7 Cropping intensities by crop groups and selected countries

Country	Farming system	Cereals	Roots & Tubers	Pulses	Oil Crops	Sugar Crops	Fibre Crops	Stimulants	Fruits & Vegetables	Other Crops	All Crops
Brazil	I	1.03	1	1.19	1.01	1	1	1	1.04	1	1.03
Brazil	R	1.03	1.02	1.1	1.01	1	1	1	1.02	1	1.02
China	I	1.54	1	1	1	1	1.07	0	1	1	1.38
China	R	1.27	1	1	1	1	1	1	1.01	1	1.08
Ethiopia	I	1.43	1.19	1.41	1	1	1	1	1.27	1.81	1.3
Ethiopia	R	1.31	1.29	1.46	1	1	1	1	1.61	1.81	1.29
France	I	1	1	1	1	1	1	1	1	1	1
France	R	1	1	1	1	1	1	0	1	0	1
Indonesia	I	1.97	0	1	1	1	0	0	1.01	0	1.8
Indonesia	R	1.72	1	1	1	1	1	1	1.01	1	1.15
India	I	1.44	1	1.01	1.04	1	1	0	1.02	1	1.3
India	R	1.13	1	1.07	1.06	1	1.06	1	1.01	1	1.08
Nigeria	I	1.1	1	0	0	1	1	1	2	1.1	1.39
Nigeria	R	1.04	1.07	1.01	1.12	0	1	1	1.5	1.16	1.09
Turkey	I	1	1	1	0	0	0	0	1	0	1
Turkey	R	1	1	1	1	1	1	1	1	1	1
USA	I	1.03	1	1	1.1	1	1	1	1.05	1	1.04
USA	R	1.14	1.12	1	1.1	1	1	1	1.02	1	1.12

Source: Developed by authors using data from national statistics and expert judgment.

Note: Farming systems – irrigated (I); rainfed (R). Cropping intensities for rainfed production are an area weighted average of rainfed high input, rainfed low input and rainfed subsistence cropping intensities.

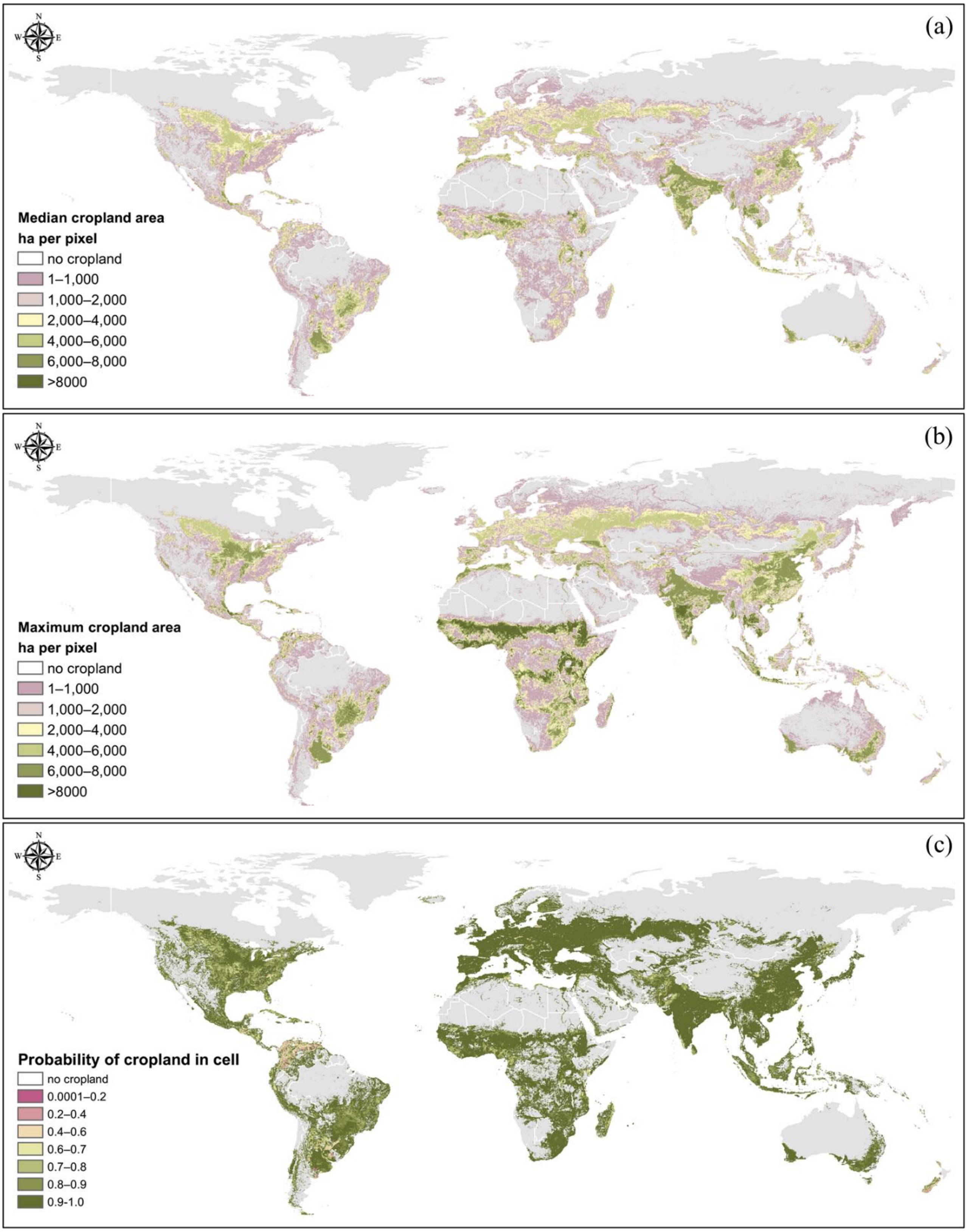
Cropping intensities are one of the instruments used to "force" the optimization to solve. If all of the cropland has been used within a grid, but there is still physical area unused within the allocation process, we can assume that the relevant harvested area did not properly account for intercropping or sequential cropping, and thus increase the cropping intensity. See Section 4.3 in the main text for further discussion on the interventions used to facilitate an allocation process solution if one has not been reached.

S7. Cropland extent

The CAAS-IFPRI cropland dataset fuses national and subnational statistics with multiple existing global-level land cover maps including GlobeLand30, CCI-LC, GlobCover 2009, MODIS C5 and Unified Cropland (Lu *et al.*, 2020). It reports three major parameters by 500×500m grid cells around year 2010: the median and maximum cropland percentage ($MedCropLand_i$ and $MaxCropLand_i$) and an estimate of the probability of cropland existence (i.e., greater than zero cropland) within a grid ($ProbCropLand_i$) for those measures. We aggregate these three parameters from 500 m grid cells to 5 arc-minute grid cells: $AggMedCropLand_i$, $AggMaxCropLand_i$ and $AggProbCropLand_i$ (Figure S1).

Differences between median and maximum cropland estimates reveal the extent to which the various sources used in generating the cropland surface differ in their measure of cropland. The maps of median (Figure S1a) and maximum (Figure S1b) cropland show the respective statistics on the estimated share of cropland per grid across all data sources. The probability of cropland (Figure S1c) gives a grid by grid indication of the degree of agreement between the various sources used in the hybrid map regarding the existence of cropland.

Figure S1 Median cropland percentage (a), maximum cropland percentage (b) and probability of cropland (c).



Source: Developed using data from Lu *et al.* (2020).

S8. Crop suitability

For allocation purposes we apply three of GAEZ's water regime/input level combinations: irrigated water/high input levels, rainfed water/high input levels and rainfed water/low input levels. The latter water regime/input level combination was used to represent both rainfed – low and subsistence farming systems. GAEZ's suitability index ($SuitIndex_{ijl}$) was used to estimate the suitable area for grid i, crop j and input l via the following formula:

$$SuitArea_{ijl} = SuitIndex_{ijl} \times Area_i \times \lambda$$

Where $Area_i$ is the physical area in grid i and λ is a discount factor.

The suitability index categorized as "very suitable land" represents land estimated to be able to achieve 80% – 100% of maximum attainable yield. In order to remain conservative on our estimation of very suitable land, and lesser suitability ratings, we choose a discount factor (λ) of 0.8. The major crops surveyed by GAEZ include most of the SPAM2010 crops – those not included were assigned values from similar GAEZ crops. Table S8 details these relationships. Suitable areas for maize irrigated, rainfed – high and rainfed low farming systems are mapped in Figure S2.

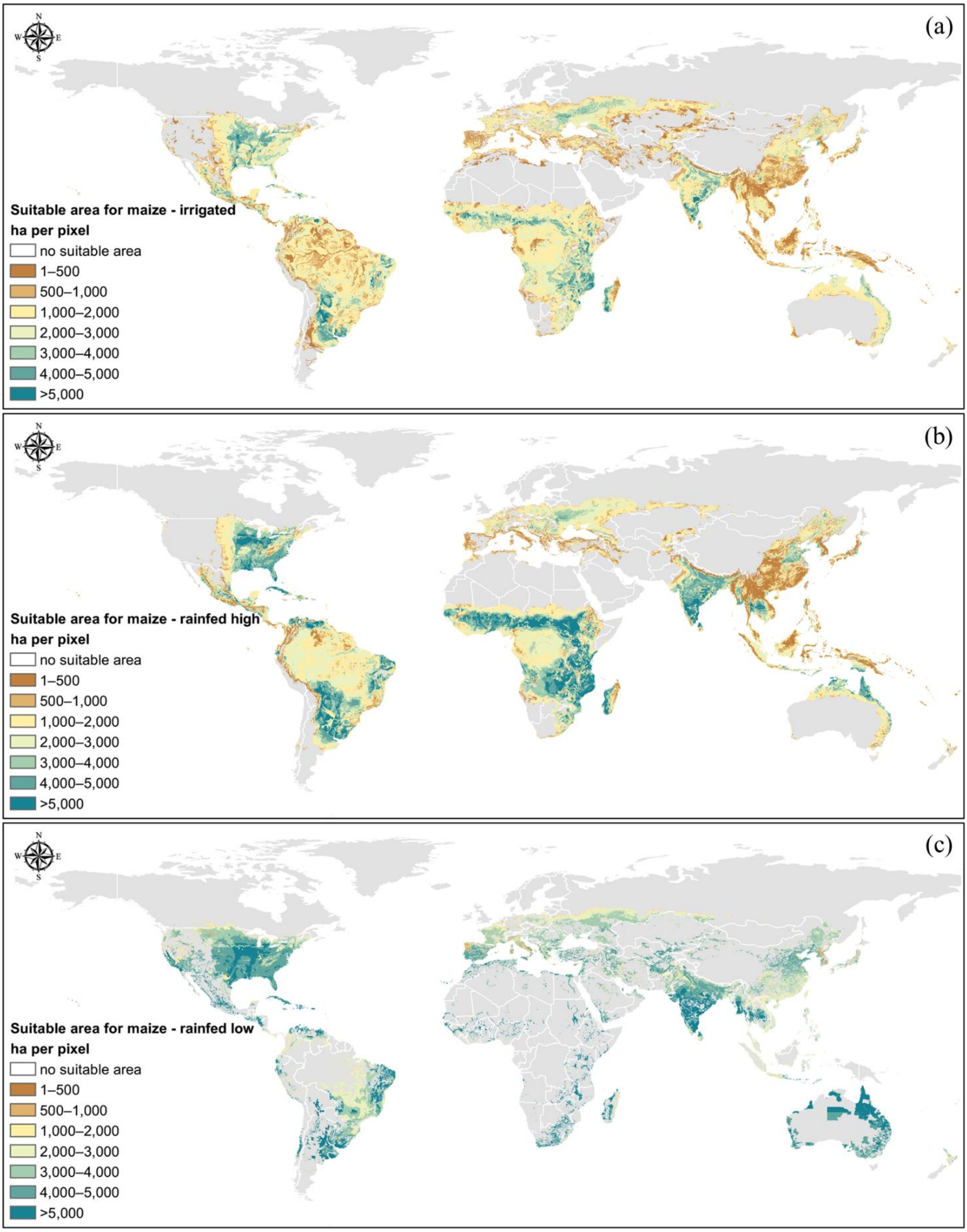
Table S8 Concordance between GAEZ crops and SPAM2010 crops

ID	SPAM2010 Crop	GAEZ Crop
1	Wheat	Wheat
2	Rice, Rainfed	Dryland rice
2	Rice, Irrigated	Wetland rice
3	Maize	Maize
4	Barley	Barley
5	Pearl Millet	Pearl millet
6	Small Millet	Foxtail millet
7	Sorghum	Sorghum
8	Other Cereals	Oat
9	Potato	White potato
10	Sweet Potato	Sweet potato
11	Yams	Yam and Cocoyam
12	Cassava	Cassava
13	Other Roots	Yam and Cocoyam
14	Bean	Phaseolus bean
15	Chickpea	Chickpea
16	Cowpea	Cowpea
17	Pigeon Pea	Pigeonpea
18	Lentil	Chickpea

ID	SPAM2010 Crop	GAEZ Crop
19	Other Pulses	Chickpea
20	Soybean	Soybean
21	Groundnut	Groundnut
22	Coconut	Coconut
23	Oilpalm	Oil palm
24	Sunflower	Sunflower
25	Rapeseed	Rape
26	Sesame seed	Rape
27	Other Oil Crops	Olive
28	Sugarcane	Sugarcane
29	Sugarbeet	Sugar beet
30	Cotton	Cotton
31	Other Fibre Crops	Flax
32	Arabica Coffee	Coffee
33	Robusta Coffee	Coffee
34	Cocoa	Cacao
35	Tea	Tea
36	Tobacco	Tobacco
37	Banana	Banana/Plantain
38	Plantain	Banana/Plantain
39	Tropical Fruit	Banana/Plantain
40	Temperate Fruit	Maize
41	Vegetables	Onion
42	Rest of Crops	Maize

Source: Developed using data from GAEZv3.0 (Fischer *et al.*, 2012).

Figure S2 Suitable area in irrigated (a), rainfed–high (b) and rainfed–low (c) farming systems.



Source: Developed using data from GAEZv3.0 (Fischer *et al.*, 2012).

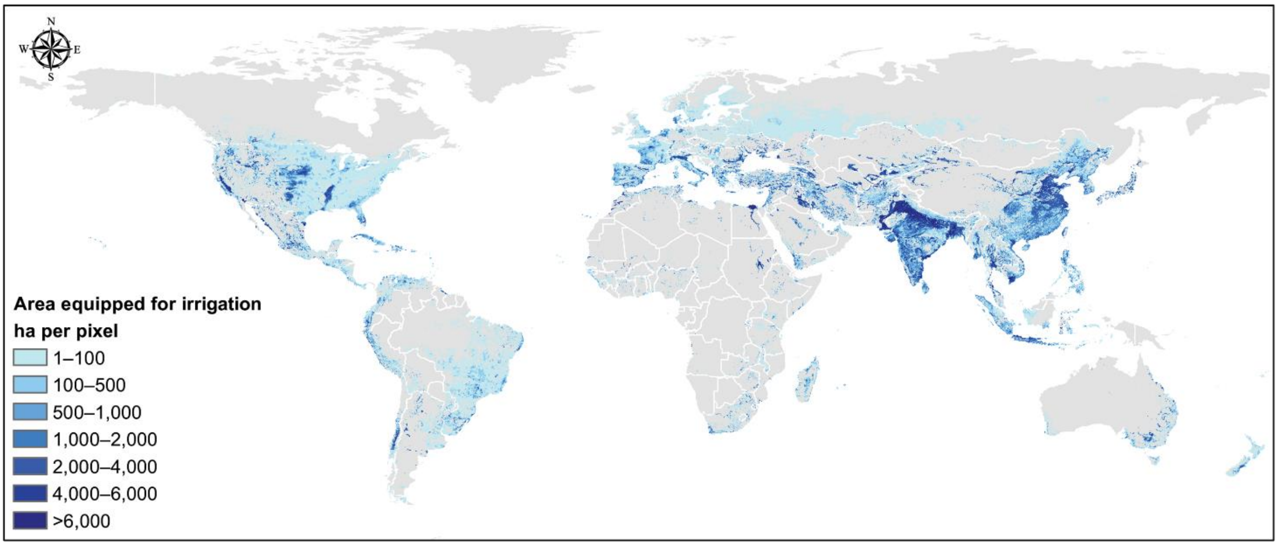
Note: Suitable area equals the GAEZ's suitability index multiplied by grid size and a discount factor (set to 0.8).

S9. Irrigated area

Coupled with the cropland information described above, geo-referenced data on the share of irrigated area within a grid is used to estimate the extent of irrigated cropland per grid. The Land and Water Division of FAO and the University of Frankfurt jointly developed the Global Map of Irrigation Areas (GMIA) version 5.0, which estimates the amount of area equipped for irrigation ($IrrArea_i$) at a 5 arc-minute resolution around the year 2005 (Siebert *et al.*, 2013). $IrrArea_i$ is mapped in Figure S3.

MIRCA (Portmann *et al.*, 2010) can provide crop-specific irrigated area, whereas GMIA cannot. We use GMIA to derive information on irrigation equipped area mainly because MIRCA is for 2000. In fact the SPAM team has collaborating and discussing with MIRCA team for a long time. SPAM modelling technique is very different from MIRCA's and we don't want to bring their modelling errors into SPAM. Instead, we used GMIA (MIRCA also used it) and derived some of irrigation input parameters from MIRCA. Anderson *et al.* (2015) compared MIRCA and SPAM and had a good discussion on that.

Figure S3 Area equipped for irrigation (5 arc-minute resolution)



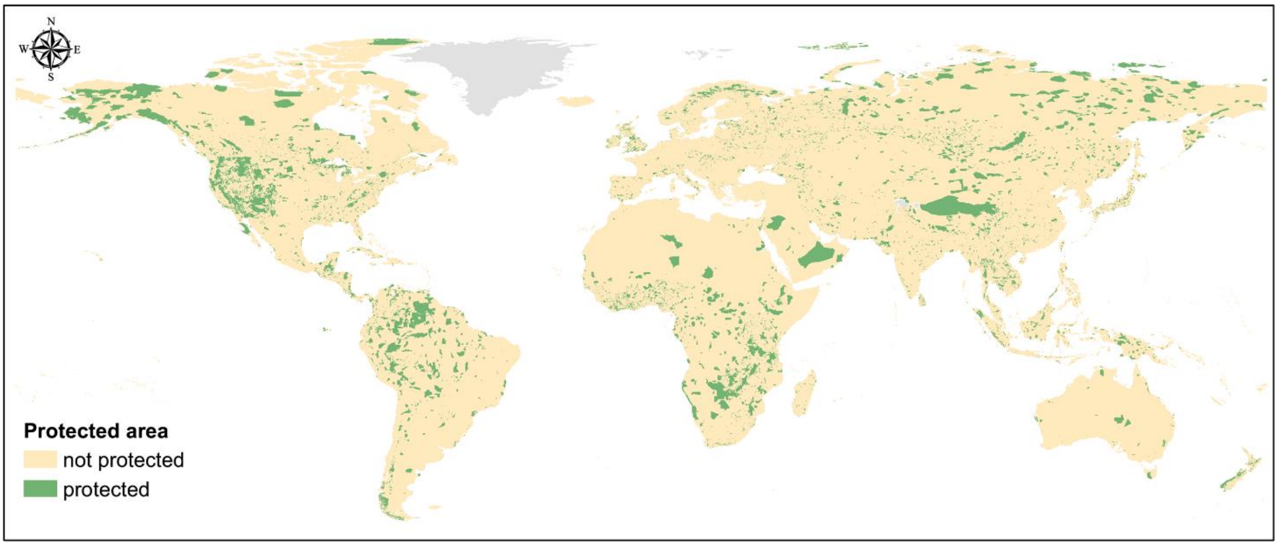
Source: GIMAv5.0 (Siebert *et al.*, 2013).

S10. Protected area

Protected areas are designated by the World Database on Protected Areas 2003 from the International Union for Conservation of Nature, and include both international and national definitions: (a) international designation of protected areas are areas designated or proposed through international or regional conventions, and (b) national designations are proposed at the national or sub-national level.

The data, originally in a polygon format ($Protect_{shape}$), was converted to 5 arc-minute grids ($Protect_i$) using GIS software. Protected areas are mapped in Figure S4.

Figure S4 Protected areas (5 arc-minute resolution)

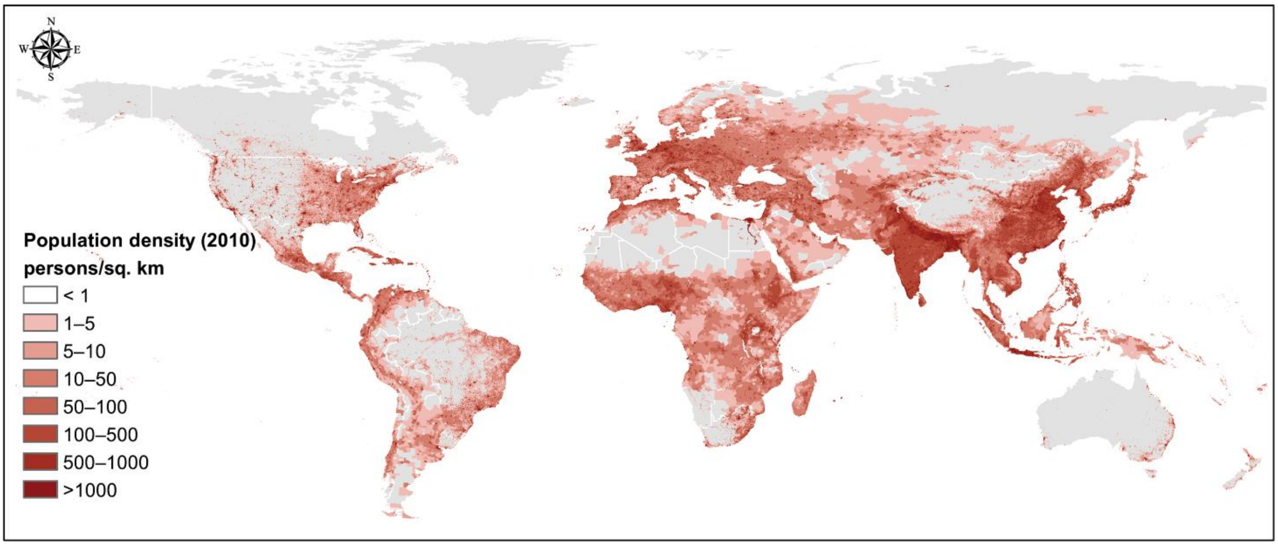


Source: Developed by authors using data from the World Database on Protected Areas (Deguignet *et al.*, 2014).

S11. Accessibility

The population count from the Gridded Population of the World database (GPWv4.0) (CIESIN, 2016) a 30 arc-second resolution is applied to calculate the population density at 5 arc-minute resolution for SPAM2010 (Figure S5). When it overlays with cropland data, rural population ($AggRurPop_i$) will be selected where population grids intersect with cropland grids.

Figure S5 Population density (persons/km2) (5 arc-minute resolution)



Source: Developed by authors using data from GPWv4.0 (CIESIN, 2016).

A measure of market accessibility ($Access_i$) was created from the grid-level estimates of rural population using the following equation:

$$\begin{array}{ll} Access_i = 0 & if\ AggRurPop_i < MinPop_{k_0} \\ Access_i = 0 & if AggRurPop_i > MaxPop_{k_0} \\ Access_i = \sqrt{AggRurPop_i - MinPop_{k_0}} & Otherwise \end{array}$$

where rural population densities were constrained by the maximum ($MaxPop_{k0}$) and minimum ($MinPop_{k0}$) rural population densities within a country. Table S9 shows the maximum and minimum rural population densities for select countries. These max-min cutoffs were determined by expert judgment.

Table S9 Minimum and maximum rural population densities in select countries

	Rural Population Density	
Country	Minimum	Maximum
	(people/km^2)	

	Rural Population Density	
Country	Minimum	Maximum
Brazil	5	1,000
China	5	600
Ethiopia	5	250
France	5	1,000
Indonesia	5	2,000
India	5	2,000
Nigeria	10	300
Turkey	5	1,000
United States	5	350

Source: Developed by authors.

S12. Crop revenue

According to the assumption of risk aversing and profit maximizing, crop revenure (*Rev*) would substantially influence farmers' decisions on selecting crops. In SPAM2010, we assume *Rev* is a function of crop prices (*Price*), crop potential yield (*PotYield*) and market accessibility (*Access*):

$$Rev_{ijl} = Price_j \times Access_{ij} \times PotYield_{ijl}$$

We adopt the crop-specific prices ($Price_j$) from FAO's Gross Production Value. Prices for crop aggregates (e.g., tropical fruit) are calculated as a weighted average from FAO world totals (Table S10).

Table S10 SPAM2010 crop prices (constant 2009-2011 Int $)

ID	SPAM2010 Crop	International Price
		(constant 2004-2006 Int $/mt)
1	Wheat	157.8
2	Rice	278.7
3	Maize	141.7
4	Barley	119.0
5	Pearl Millet	181.5
6	Small Millets	181.5
7	Sorghum	153.8
8	Other Cereals	135.9
9	Potato	168.8
10	Sweet Potato	75.5
11	Yams	255.0
12	Cassava	104.5
13	Other Roots And Tubers	200.9
14	Bean	601.4
15	Chickpea	484.1
16	Cowpea	335.8
17	Pigeon Pea	534.2
18	Lentil	408.4
19	Other Pulses	279.4
20	Soybean	274.3
21	Groundnut	451.1
22	Coconut	110.6
23	Oilpalm	65.7
24	Sunflower	275.2
25	Rapeseed	280.6
26	Sesame Seed	676.9
27	Other Oilcrops	639.0

ID	SPAM2010 Crop	International Price
28	Sugarcane	32.8
29	Sugarbeet	43.0
30	Cotton	330.0
31	Other Fibre Crops	385.3
32	Coffee Arabica	1,074.4
33	Coffee Robusta	1,074.4
34	Cocoa	1,038.5
35	Tea	1,063.5
36	Tobacco	1,592.8
37	Banana	281.6
38	Plantain	206.5
39	Tropical Fruit	265.9
40	Temperate Fruit	520.1
41	Vegetables	279.1
42	Rest Of Crops	1,316.5

Source: Developed by authors using price data from FAO's (2012) gross value of production.

Note: Prices of pearl and small millet were set equal. Prices of Arabica and Robusta coffee were set equal.

We estimate the crop-specific potential yield ($PotYield_{ijl}$) as a composite measure of yield based on GAEZ. In addition to estimates of suitability indices by grid, GAEZ also published data on potential dry weight yields by grid i, crop j and farming system l ($PotDryYield_{ijl}$). To run SPAM2010 requires that this variable be measured in terms of harvested weight, which was derived by dividing the respective dry matter yield by crop-specific conversion factors provided by GAEZ in their Model Documentation (Fischer *et al.*, 2012). If a crop-specific conversion factor was not available for a particular crop or crop aggregate, it was assigned from a similar "stand-in" crop as follows:

$$OthFact_{j_1,j_2} = \frac{\sum_{t=2009}^{t=2011} FAOCropY_{j_1 t}}{\sum_{t=2009}^{t=2011} FAOCropY_{j_2 t}}$$

$$TotFact_{j_2} = GAEZfactor_{j=j_1} \times OthFact_{j_1,j_2}$$

where $GAEZact_j$ is the dry-to-harvested weight yield conversion factor and $FAOCropY_j$ is the 2009 – 2011 average FAO statistic on world yield by crop j. Table S11 lists the GAEZ factors to convert dry matter yields to harvested yields. Potential harvested yield ($PotHarvYield_{ijl}$) for grid i, crop j and farming system l was then calculated as follows:

$$PotHarvYield_{ijl} = \frac{PotDryYield_{ijl}}{TotFact_j}$$

Then, the potential yield ($PotYield_{ijl}$) is calculated as follows:

$$PotYield_{ijl} = AdjCropY_{jlk} \times \frac{PotHarvYield_{ijl}}{AvgPotHarvYield_{jlk}}, \qquad \forall k \in (k_0, k_1, k_2)$$

and

$$AvgPotHarvYield_{jlk} = \frac{\sum_{i \in k}\left(PotHarvYield_{ijl} \times AdjSuitArea_{ijl}\right)}{\sum_{i \in k} AdjSuitArea_{ijl}}, \quad \forall k \in (k_0, k_1, k_2)$$

Table S11 Conversion factors to calculate harvested yield from dry matter yield

ID	SPAM2010 Crop	GAEZ Crop	GAEZ Factor	Other Factor	Total Factor
1	Wheat	Wheat	0.88	1.00	0.88
2	Rice	Dryland rice/Wetland rice	0.90	1.00	0.90
3	Maize	Maize	0.87	1.00	0.87
4	Barley	Barley	0.88	1.00	0.88
5	Pearl Millet	Pearl millet	0.90	1.00	0.90
6	Small Millets	Foxtail millet	0.90	1.00	0.90
7	Sorghum	Sorghum	0.88	1.00	0.88
8	Other Cereals	Oat	0.88	1.00	0.88
9	Potato	White potato	0.25	1.00	0.25
10	Sweet Potato	Sweet potato	0.30	1.00	0.30
11	Yams	Yam and Cocoyam	0.35	1.00	0.35
12	Cassava	Cassava	0.35	1.00	0.35
13	Other Roots and Tubers	Yam and Cocoyam	0.35	1.00	0.35
14	Bean	Phaseolus bean	1.00	1.00	1.00
15	Chickpea	Chickpea	1.00	1.00	1.00
16	Cowpea	Cowpea	1.00	1.00	1.00
17	Pigeon Pea	Pigeonpea	1.00	1.00	1.00
18	Lentil	Chickpea	1.00	1.00	1.00
19	Other Pulses	Chickpea	1.00	1.00	1.00
20	Soybean	Soybean	0.90	1.00	0.90
21	Groundnut	Groundnut	0.67	1.00	0.67
22	Coconut	Coconut	0.18	1.00	0.18
23	Oilpalm	Oil palm	0.23	1.00	0.23
24	Sunflower	Sunflower	0.90	1.00	0.90
25	Rapeseed	Rape	0.90	1.00	0.90
26	Sesame Seed	Rape	0.90	0.26	3.44
27	Other Oilcrops	Olive	0.22	1.00	0.22
28	Sugarcane	Sugarcane	0.10	1.00	0.10
29	Sugarbeet	Sugar beet	0.14	1.00	0.14
30	Cotton	Cotton	0.35	1.00	0.35
31	Other Fibre Crops	Flax	0.90	1.00	0.90
32	Coffee Arabica	Coffee	0.35	1.00	0.35
33	Coffee Robusta	Coffee	0.35	1.00	0.35
34	Cocoa	Cacao	0.50	1.00	0.50

35	Tea	Tea	0.30	1.00	0.30
36	Tobacco	Tobacco	0.45	1.00	0.45
37	Banana	Banana/Plantain	0.35	1.00	0.35
38	Plantain	Banana/Plantain	0.35	1.00	0.35
39	Tropical Fruit	Banana/Plantain	0.35	0.76	0.46
40	Temperate Fruit	Maize	0.87	1.92	0.45
41	Vegetables	Onion	0.15	0.96	0.16
42	Rest of Crops	Maize	0.87	0.26	3.32

Source: Developed by authors using data from GAEZv3.0 (Fischer *et al.*, 2012) and own-calculations.

Note: Column "GAEZ Factor" lists the factors from GAEZv3.0 to convert from dry matter to harvested crop; Column "Other Factor" was a second factor introduced by the authors to convert a "borrowed" yield (e.g., from maize, to be used with temperate fruit); Column "Total Factor" was the final factor by which GAEZ yields were divided to arrive at SPAM2010 yields: GAEZ Factor/Other Factor.

S13. Adjusting areas

We first adjust the grid-level data on cropland, irrigated area and suitable area before calculating the priors of physical area, in order to satisfy the constraints at the administrative unit level. These constraints are:

(i) that the total land in crops must be greater than or equal to the sum of area equipped for irrigation;

(ii) that statistical physical area summed over all crops and farming systems must be less than or equal to the sum of cropland;

(iii) that irrigated statistical physical area summed over all crops must be less than or equal to the sum of area equipped for irrigation; and

(iv) that statistical physical area must be less than or equal to the suitable area per crop and farming system.

In many cases these conditions are not met.

In many cases these conditions are not met due to the different sources of the data, inaccuracies, different times of measurement, different scales, inconsistencies in classification, and various other reasons. Therefore, we make adjustments following a hierarchy of "credibility" that we defined in decreasing order of importance:

(i) statistical data;

(ii) cropland;

(iii) area equipped for irrigation; and

(iv) suitable area.

This is because statistical data was not changed, except in the unusual case when a model run failed to yield a solution, and only after all other modification options were exhausted. The general approach to the grid-level area adjustments was to upscale each variable so that they matched the statistical totals reported for the smallest available administrative unit, checking back that the corresponding totals at higher administrative units also continued to align. If scaling was not enough, we would calculate the missing amounts, and depending on the control parameters $condAg_i$ and $condSuit_i$, distributed those amounts equally to grids which could still be expanded (up to total grid area). In a further step we could unconditionally increase areas of cropland, equipped for irrigation or suitable area by a given percentage to try and satisfy the conditions. If constraints were not met after these new adjustments, the specific problem was noted and manual adjustments of other parameters were made to resolve any area discrepancies, guided by expert judgment. Cropland area is worthy of special mention, since not all cropland in an administrative unit was necessarily used within the allocation model. To choose how much cropland would be used in each administrative unit, the grids of cropland for that unit were sorted by the reliability factor ($ProbCropLand_i$) in descending order. Then the cropland was added up until it reached the physical area statistical value. Any excess grids (those with the lowest probabilities) were discarded from the SPAM2010 cropland surface.

In the processing phase, we first introduce the γ parameter which represents a relaxation factor for land constraints from sources less reliable than the statistical offices. Initially, the γ parameter is set to 5% for all of the three measures of gridded area. Adjusting γ may have some effect on the model's ability to solve if there were enough grids which did not yet have 100 percent cropland, suitable area or irrigated area (see "Temporary Irrigation Step 1", "Temporary Cropland Step 6" and "Temporary Suitable Area Step 1"). We have another adjustment option in this pre-processing phase which is to relax the conditions on irrigated area, cropland and suitable area when assigning area to grids with zero reported irrigation, cropland or suitable area (see the equation conditions in "Temporary Irrigation Step 2", "Temporary Cropland Step 7" and "Temporary Suitable Area Step 2"). This adjustment could further relax the more restrictive "AND" condition to the less restrictive "OR" condition, and effectively allows zero values to be substituted with non-zero values. The details are written as:

- *Temporary Cropland Step 1*: Set cropland as median cropland value

$$T1CropLand_i = AggMedCropLand_i$$

- *Temporary Cropland Step 2*: Adjustment of cropland for irrigation

  If $T1CropLand_i < IrrArea_i$,

$$T2CropLand_i = IrrArea_i$$

  If $T1CropLand_i \geq IrrArea_i$,

$$T2CropLand_i = T1CropLand_i$$

- *Temporary Cropland Step 3*: Adjustment of cropland with additional cropland to satisfy physical area statistics

  If $\sum_{i\in k} T2CropLand_i < \sum_j \sum_l AdjCropA_{jlk}$,

$$T3CropLand_i = \min[AggMaxCropLand_i, PixelArea_{i\in k}], \qquad \forall k = k_0, k_1, k_2$$

  Otherwise

$$T3CropLand_i = T2CropLand_i$$

- *Temporary Cropland Step 4*: Only use cropland grids with highest probability

i. Sort grids ($i \in k_0$) by $AggProbCropLand_i$ from largest to smallest

ii. Sum grids (in order of sort) until sum of cropland is equal to (or slightly greater than) the total physical area. Mark remaining cells for deletion.

iii. Begin with ADM0, then ADM1, then ADM2 statistics. Note: Cells marked for deletion at an administrative level but not marked for deletion at a lower administrative level are retained. For example, if a cell is marked for deletion at an ADM0 level, but not at an ADM1 level, then the cell is kept for the remainder of the analysis.

If $\sum_{i\in k} T3CropLand_i \geq \sum_j \sum_l AdjCropA_{jlk}$,

$$T4CropLand_i = T3CropLand_i, \qquad \forall k = k_0, k_1, k_2$$

Otherwise

$$T4CropLand_i = Mark\ for\ Deletion$$

Delete all $T4CropLand_i$ grids marked for deletion

- *Temporary Irrigation Step 1*: Scale irrigation area to reflect physical area

If $\sum_{i\in k} IrrArea_i < \sum_j AdjCropA_{jIk}$,

$$T1IrrArea_i = \min\left[IrrArea_i \times \frac{\sum_j AdjCropA_{jIk}}{\sum_{i\in k} IrrArea_i} \times (1+\gamma), PixelArea_{i\in k}\right], \qquad \forall k = k_0, k_1, k_2$$

Otherwise

$$T1IrrArea_i = IrrArea_i$$

where γ normally starts at 5 percent, and is increased as necessary

- *Temporary Irrigation Step 2*: Adding irrigation to grids with zero irrigation

If $\sum_{i\in k} T1IrrArea_i < \sum_j AdjCropA_{jIk}$, and $T1IrrArea_i = 0$, and ($T4CropLand_i > 0$ AND $AggRurPop_i > 0$),

$$T2IrrArea_i = \min\left[\frac{\sum_j AdjCropA_{jIk} - \sum_{i\in k} T1IrrArea_i}{count_{i\in k}(T1IrrArea_i = 0)}, PixelArea_{i\in k}\right], \qquad \forall k = k_0, k_1, k_2$$

Otherwise

$$T2IrrArea_i = T1IrrArea_i$$

- *Temporary Cropland Step 5*: Adjustment of cropland for modified irrigation

If $T4CropLand_i < T2IrrArea_i$,

$$T5CropLand_i = T2IrrArea_i$$

Otherwise

$$T6CropLand_i = T4CropLand_i$$

- *Temporary Cropland Step 6*: Adjustment of modified cropland for statistics

If $\sum_{i \in k} T5CropLand_i < \sum_j \sum_l AdjCropA_{jlk}$ and $Protect_i = 0$,

$$T6CropLand_i = \min\left[T5CropLand_i \times \frac{\sum_j \sum_l AdjCropA_{jlk}}{\sum_{i \in k} T5CropLand_i} \times (1+\gamma), PixelArea_{i \in k}\right],$$

$$\forall k = k_0, k_1, k_2$$

Otherwise

$$T6CropLand_i = T5CropLand_i$$

if scaling only results in the addition of 10 ha, increase γ by a factor of 10 and repeat.

- *Temporary Cropland Step 7*: Adding cropland to grids with zero cropland

If $\sum_{i \in k} T6CropLand_i < \sum_j \sum_l AdjCropA_{jlk}$, and $T6CropLand_i = 0$, and $Protect_i = 0$, and ($SuitArea_i > 0$ AND/**OR** $AggRurPop_i > 0$),

$$T7CropLand_i = \min\left[\frac{\sum_j \sum_l AdjCropA_{jlk} - \sum_{i \in k} T6CropLand_i}{count_{i \in k}(T6CropLand_i = 0)}, PixelArea_{i \in k}\right], \quad \forall k = k_0, k_1, k_2$$

Otherwise

$$T7CropLand_i = T6CropLand_i$$

- *Temporary Suitable Area Step 1*: Adjustment of suitable areas

If $\sum_{i \in k} SuitArea_{ijl} < AdjCropA_{jlk}$,

$$T1SuitArea_{ijl} = \min\left[SuitArea_{ijl} \times \frac{AdjCropA_{jlk}}{\sum_{i \in k} SuitArea_{ijl}} \times (1+\gamma), PixelArea_{i \in k}\right],$$

$$\forall j \forall l \forall k = k_0, k_1, k_2$$

Otherwise

$$T1SuitArea_{ijl} = SuitArea_{ijl}$$

- *Temporary Suitable Area Step 2*: Adding suitable area to grids with zero suitable areas

If $\sum_{i \in k} T1SuitArea_{ijl} < AdjCropA_{jlk}$, and $T1SuitArea_{ijl} = 0$, and ($T7CropLand_i > 0$, AND/**OR** $AggRurPop_i > 0$),

$$T2SuitArea_{ijl} = \min\left[\frac{AdjCropA_{jlk} - \sum_{i \in k} T1SuitArea_{ijl}}{count_{i \in k}(T1SuitArea_{ijl} = 0)}, PixelArea_{i \in k}\right], \quad \forall k = k_0, k_1, k_2$$

Otherwise

$$T2SuitArea_{ijl} = T1SuitArea_{ijl}$$

The final adjusted variables used in the model are

$$AdjCropLand_i = T7CropLand_i$$

$$AdjIrrArea_i = T2IrrArea_i$$

$$AdjSuitArea_{ijl} = T2SuitArea_i$$

If the model run has not yielded a solution any or all of the three variables can be readjusted unconditionally to

$$\overline{AdjCropLand_i} = \min\left[AdjCropLand_i \times \left(1 + \gamma_{1_{k_{SRU}}}\right), PixelArea_i\right]$$

$$\overline{AdjIrrArea_i} = \min\left[AdjIrrArea_i \times \left(1 + \gamma_{2_{k_{SRU}}}\right), PixelArea_i\right]$$

$$\overline{AdjSuitArea_{ijl}} = \min\left[AdjSuitArea_i \times \left(1 + \gamma_{3_{k_{SRU}}}\right), PixelArea_i\right]$$

S14. Adjusting entropy conditions

If the model does not solve after these area adjustments, we would relax constraints within the entropy optimization process on the availability of cropland (constraint ii), irrigated area (constraint iii) or suitable area (constraint iv), by increasing the percentage values (γ) in each cell of cropland, irrigated area or suitable area. These percentages can vary between area types, but cropland can only be increased if the cell is not classified as a protected area. Areas in each grid can only be increased up to the point that their sum does not exceed the grid size.

If the first entropy condition adjustment does not yield an optimal solution, and it is obvious from the control output that suitable areas were not satisfying the constraints, it is possible to selectively eliminate suitability constraints for individual crops – including all crops if necessary. This means that the allocation would be guided only by cropland, irrigated areas (and crop distribution if data was available), but not by crop suitability considerations.

S15. Adjust data harmonization rules

If the previous interventions failed to achieve a solution, the primary data used to create the constraints and priors may be problematic. To address this problem, countries were run at an ADM1 rather than an ADM0 level. This is only possible if the area and yield statistics are also available for all ADM1 units and all crops in the country in question. In the case of large countries, which are already run at an ADM1 level (e.g., the United States, Canada, China, Russia or India), the details for all ADM1 units were available with few exceptions (e.g. crops which were only grown in small quantities, or “rest of crops” which often were an aggregation of all other crops not reported individually). For other countries we relied on secondary information or own-estimates to complete the statistics. For example, the FAO reported that China grew oil palm, but the Chinese sources did not break down oil palm by ADM1 units. Further literature review revealed that oil palm was grown only in the Hainan province. Thus national totals for oil palm were all assigned to Hainan, while all other provinces were assigned zero oil palm production.

If additional information was not forthcoming, we applied some rules-of-thumb to assign crop production data to ADM1 units when only national data was available. For example, where required we often assigned crop aggregates to ADM1 units in the same shares as the sum of similar crops. Hence, the national value of “rest of crops” for some countries was allocated to ADM1 units using the same share as the sum of all other crops within each sub-national administrative unit. Or “other cereals” was assigned in the same proportion as the sum of all cereals for which there were data. However, the exact method of assigning national statistical totals to the relevant sub-national units was dependent on the crop, country and expert judgment. If a country is run at an ADM1 level, it is necessary to also have data on the farming system shares and cropping intensities at the same administrative level. Absent of existing ADM1 statistics on farming system shares and cropping intensities, we used the national level values. Table S12 summarizes the various interventions methods described above. Not all countries needed interventions, as can be seen in Table S13, which lists a subset of interventions for select ADM1 units.

Table S12 Points of interventions in spatial allocation process

Variable	Meaning	Values
Intervention Type 1		
γ	Increase the amount of cropland, suitable area or irrigated area by γ percent	$1 \le \gamma \le 100$
$condAg_i$	Conditionally assign positive area to $AdjCropLand_i = 0$ and $AdjIrrArea_i = 0$ by relaxing conditions from ($SuitArea > 0$ AND $AggRurPop_i > 0$) to ($SuitArea > 0$ OR $AggRurPop_i > 0$)	1 = *And*; 2 = *No*
$condSuit_{ijl}$	Conditionally assign positive area to $AdjSuitArea_{ijl} = 0$ by relaxing conditions from ($CropLand_i > 0$ AND $AggRurPop_i > 0$) to ($CropLand_i > 0$ OR $AggRurPop_i > 0$)	1 = *And*; 2 = *No*
Intervention Type 2		
$isAg_{k_{SRU}}$	Indicator variable to add more cropland	$0 = No;\ 1 = Yes$
$\gamma_{1_{k_{SRU}}}$	$\gamma_{1_{k_{SRU}}}$ percent to be added to $AdjCropLand_i$	$1 \le \gamma_{1_{k_{SRU}}} \le 100$
$isSuit_{k_{SRU}}$	Indicator variable to add more suitable area	$0 = No;\ 1 = Yes$
$\gamma_{2_{k_{SRU}}}$	$\gamma_{2_{k_{SRU}}}$ percent to be added to $AdjSuitArea_{ijl}$	$1 \le \gamma_{2_{k_{SRU}}} \le 100$
$isIrr_{k_{SRU}}$	Indicator variable to add more irrigated area	$0 = No;\ 1 = Yes$
$\gamma_{3_{k_{SRU}}}$	$\gamma_{3_{k_{SRU}}}$ percent to be added to $AdjIrrArea_i$	$1 \le \gamma_{3_{k_{SRU}}} \le 100$
$noSuit_{jk_{SRU}}$	Do not apply suitability constraints for All crops j OR Any crop $j = 1, 2, \ldots, 42$	1 = Apply Suitability; 2 = Do Not Apply Suitability
Intervention Type 3		
$CropIntensity_{jlk_{SRU}}$	Adjust cropping intensity up or down	$0 \le CropIntensity_{jlk_{SRU}} \le 3$
$Percent_{jlk_{SRU}}$	Adjust farming system share of harvested area up or down	$0 \le Percent_{jlk_{SRU}} \le 100$ and $\sum_l Percent_{jlk_{SRU}} = 100$
$CropHY_{jk_{SRU}t}$	Adjust statistics on harvested area and yield by changing unknown values ($CropHY_{jkt} = -999$) to a value greater than or equal to zero or vice versa	$CropHY_{jk_{SRU}t} \ge 0$

Source: Developed by authors.

Table S13 Subset of interventions for the first three ADM1 units in selected countries

Country	ADM1	FIPS1	Optimality	γ	$condAg$	$condSuit$	$isAg_{k_{SRU}}$	$\gamma_{1_{k_{SRU}}}$	$isSuit_{k_{SRU}}$	$\gamma_{2_{k_{SRU}}}$	$isIrr_{k_{SRU}}$	$\gamma_{3_{k_{SRU}}}$	$noSuit_{jk_{SRU}}$ [a]
				(%)	(flag)	(flag)	(flag)	(%)	(flag)	(%)	(flag)	(%)	(count)
Brazil	Acre	BR01	Locally	5	2	2	1	80	0	0	1	90	0
	Alagoas	BR02	Locally	5	1	1	0	0	1	40	0	0	0
	Amapa	BR03	Globally	5	1	1	0	0	0	0	0	0	0
China	Beijing	CH01	Globally	5	2	2	0	0	0	0	0	0	0
	Tianjin	CH02	Globally	5	2	2	0	5	0	5	0	5	0
	Hebei	CH03	Globally	5	2	2	0	0	0	0	0	0	0
Ethiopia	Addis Ababa	ET01	Globally	5	2	2	0	0	0	0	1	20	8, 15, 18
	Afar	ET02	Globally	5	2	2	0	5	0	5	0	5	0
	Amhara	ET03	Globally	5	2	2	0	0	0	0	0	0	10, 27, 31
Indonesia	Bali	ID01	Globally	5	2	2	0	0	0	0	1	20	0
	Bangka Belitung	ID02	Globally	5	2	2	0	0	0	0	1	50	0
	Banten	ID03	Globally	5	2	2	0	5	0	5	0	5	0
India	Andaman & Nicobar Island	IN01	Locally	5	2	2	1	30	0	0	0	0	0
	Andhra Pradesh	IN02	Globally	5	2	2	1	10	1	80	1	20	0
	Arunachal Pradesh	IN03	Locally	5	2	2	1	60	1	90	0	0	0
Russia	Adygeya Rep.	RS02	Globally	5	2	2	0	5	0	5	0	5	0
	Aginskiy Buryatskiy A. Okrug	RS03	Globally	5	2	2	0	5	0	5	0	5	0
	Altay Rep.	RS04	Globally	5	2	2	1	90	1	90	1	90	0
Turkey	Istanbul	TUZ1	Globally	5	2	2	1	90	1	90	1	90	0
	Bati Marmara	TUZ2	Globally	5	2	2	0	0	0	0	1	10	39
	Ege	TUZ3	Globally	5	2	2	0	0	0	0	0	0	39
USA	Alabama	US01	Globally	5	2	2	0	5	0	5	0	5	0
	Alaska	US02	Globally	5	2	2	1	10	1	10	0	0	0
	Arizona	US03	Globally	5	2	2	1	5	0	0	0	0	39
Brazil	Acre	BR01	Locally	5	2	2	1	80	0	0	1	90	0
	Alagoas	BR02	Locally	5	1	1	0	0	1	40	0	0	0
	Amapa	BR03	Globally	5	1	1	0	0	0	0	0	0	0

Source: Developed by authors.

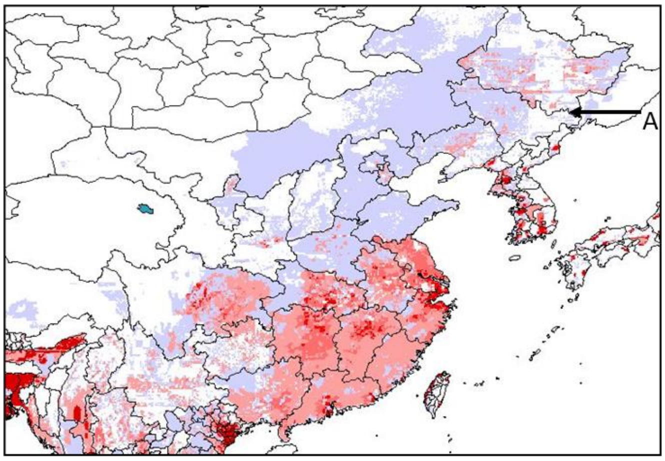
[a] Number of crops for which suitability constraints were deactivated. If entry equals “all” then suitability constraints for all crops were deactivated.

S16. Supporting documents for the qualitative validation process

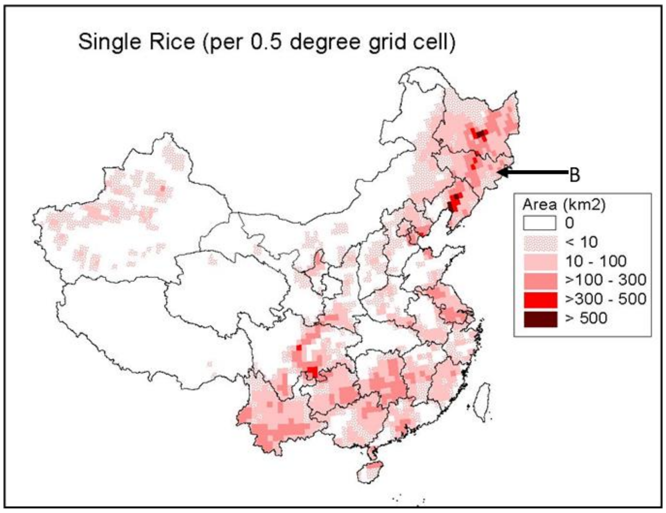
We build up a system through which we are able to send the crop maps to collaborators and users alike for comments or assessment. These collaborators mainly include IRRI, CIMMYT, IIASA and CAAS. We carried out field trips and workshops onsite or online where local experts were asked to confirm or validate the crop production maps by providing hand-written comments or posting comments online at the MapSPAM website. The SPAM maps were evaluated crop by crop, and country by country. As an example, some of rice map validation documents are presented below. Similar documentations can be found from the MapSPAM website.

<u>China:</u>

Generally, the cover for China appears to match the studies which we have found online (The light purple means lower value while the pink and red colors mean higher value in the upper figure), although the following map highlights some difference in the north eastern parts of the country between the DNDC study and our data:

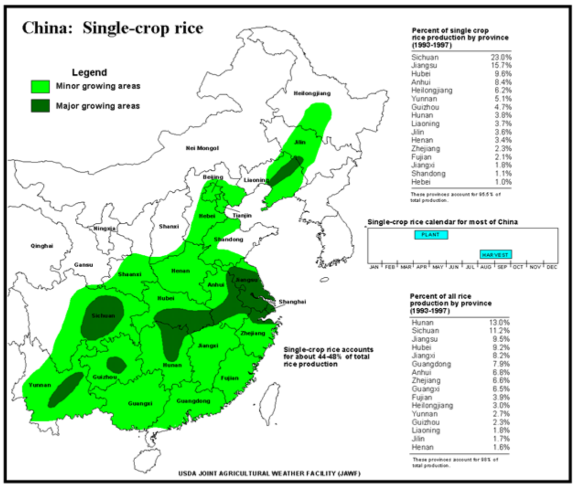


(1. SPAM Harvested Rice Area – China)

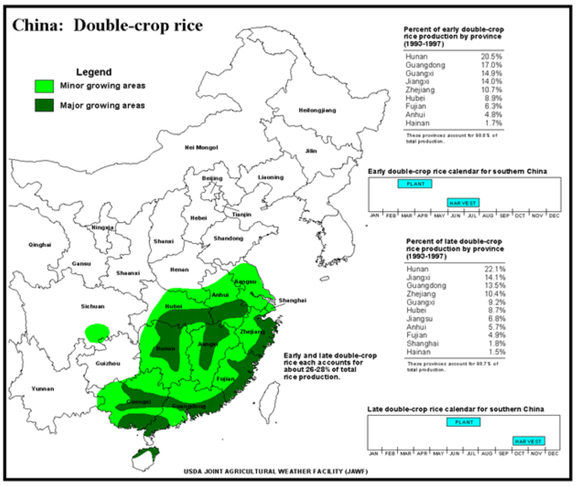


(2. Single crop Rice production-
http://www.dndc.sr.unh.edu/boles/d_jpeg/singlerice.jpg)

The comparison is fair accept for the area in the north Eastern part of the country indicated by the Arrows A and B on 1 and 2. This may be explained by the following two maps, which although crude, demonstrate that there is a significant difference between the double crop and single crop rice harvest in the North Eastern Part of the country:



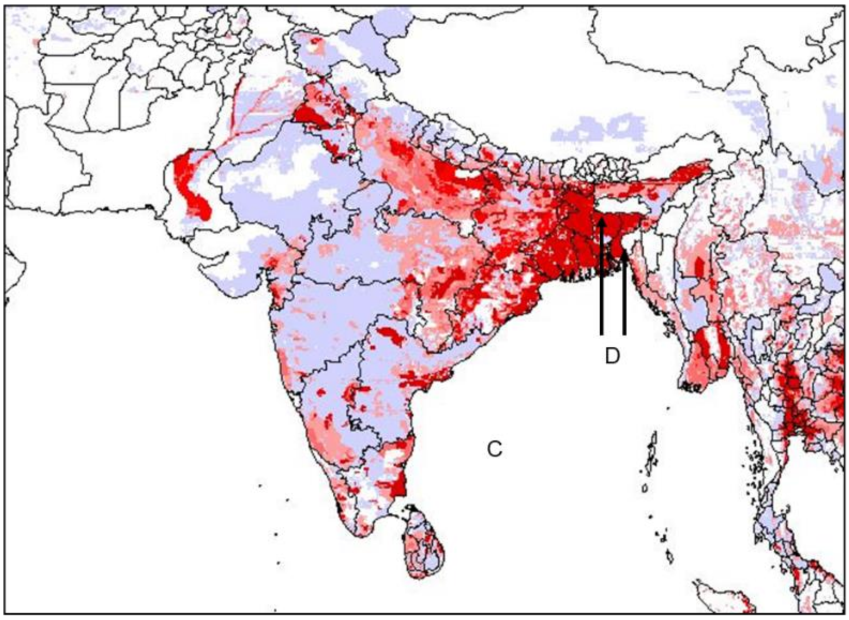
(3.http://www.usda.gov/oce/weather/pubs/Other/MWCACP/Graphs/chi/chisric.gif)



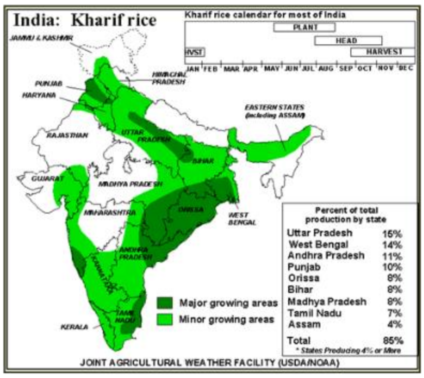
(4.http://www.usda.gov/oce/weather/pubs/Other/MWCACP/Graphs/chi/chidric.gif)

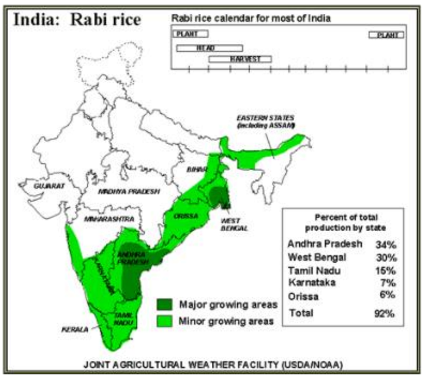
<u>India:</u>

We were unable to find any detailed studies of rice in India at Provincial or district level, but generally the data appears to correlate fairly well with the basic country level information that we found except for a few anomalies:



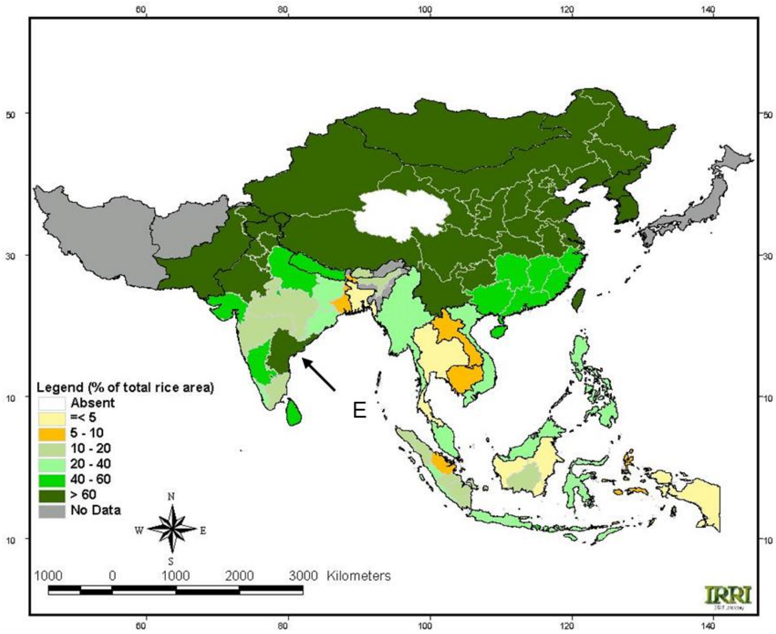
(6. SPAM Harvested Rice Area – India)





(7.http://www.usda.gov/oce/weather/pubs/Other/MWCACP/Graphs/ind/indk_ric.gif
8.http://www.usda.gov/oce/weather/pubs/Other/MWCACP/Graphs/ind/indr_ric.gif)

There are although several differences in the province indicated by Arrow C on 6, and the USDA maps are suggesting that our data should be showing significantly more production in this province, but data from a more accurate or detailed study would need to be found to confirm this either way. The following map for example shows the province in question (marked with Arrow E) to be one the highest producing province in India, which reinforces the USDA maps:

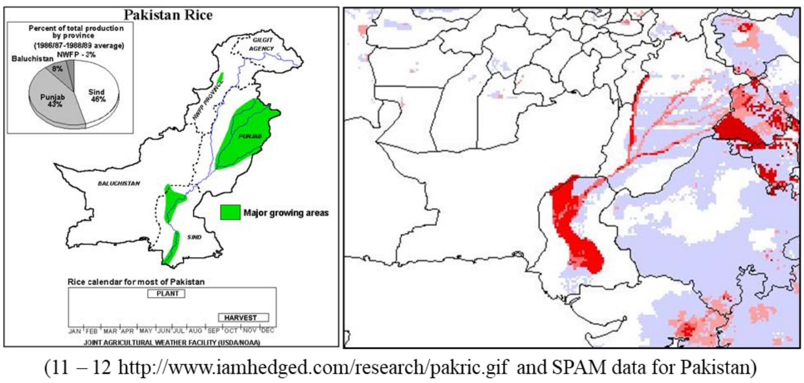


(9. http://www.knowledgebank.irri.org/gis/images/irw.jpg)

On 6 Arrow D indicates two Indian Provinces which are shown to have no data. Although the comparative studies we have found on these provinces is limited, 7 and 8 both suggest that there is rice production on the North side of the Bangladeshi border. Unfortunately, 9 also has no data on the areas in question.

Pakistan:

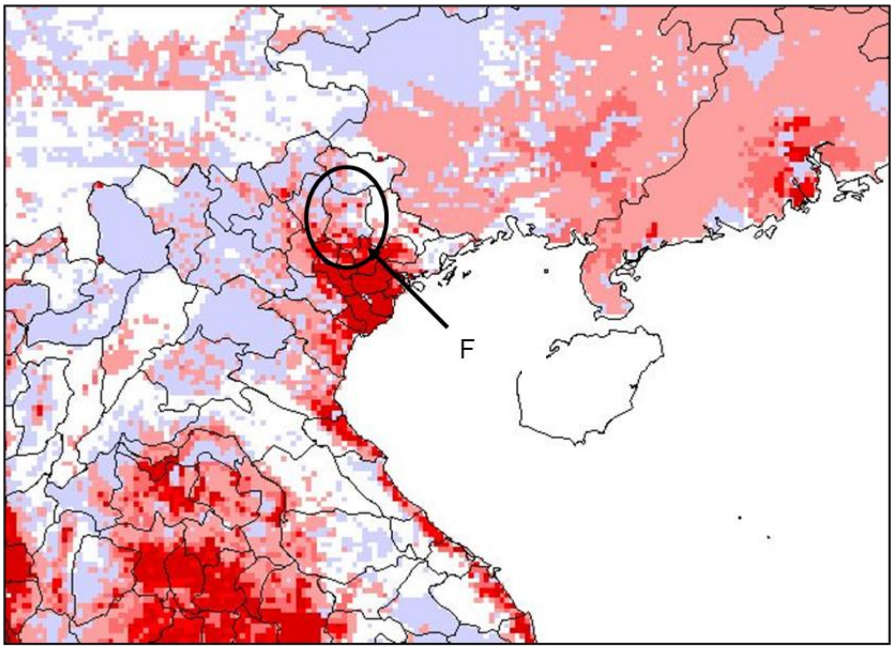
The SPAM data shows an interesting pattern in the growing areas of Pakistan. This is compared below with a very basic study in 11 by the FAO. It can be seen that the Rice production tracks the river and there are some strong similarities in the patterns, which both follow the river with similar clusters of production in the South. The striped blue lines which appear in the river tributaries in the North Eastern part of Part of Pakistan are an area which the FAO data suggests to be under intense Rice production. There is no real explanation for the horizontal lines in the SPAM data at that point which suggests an error. Again a more in depth study would likely need to be found to verify this.



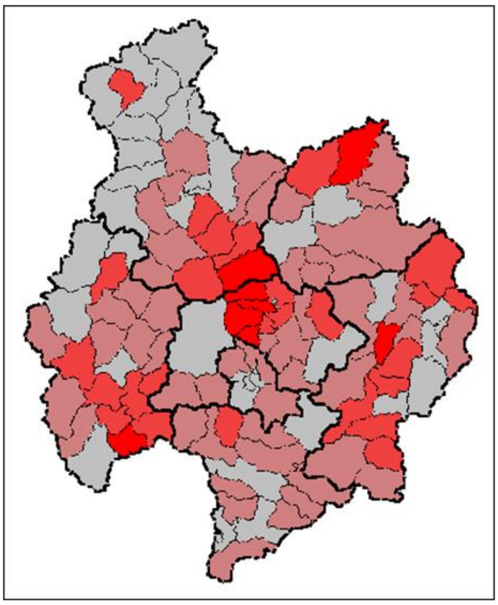
(11 – 12 http://www.iamhedged.com/research/pakric.gif and SPAM data for Pakistan)

Thailand, Cambodia and Vietnam:

One study which serves as a reference, was carried out on the Bac Kan Province of Vietnam, indicated by Arrow F on 13. It can be seen that the SPAM data even at this level is fairly accurate.



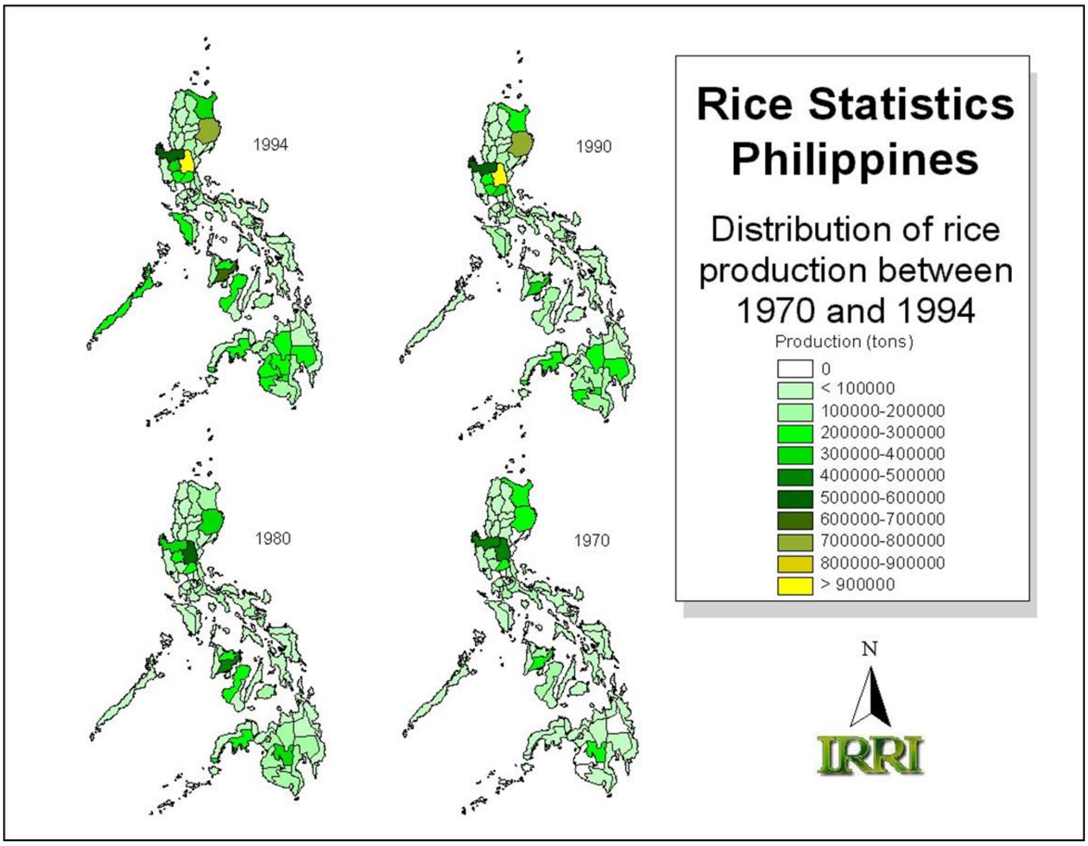
(13. SPAM data for Vietnam)



(14. Total Rice production per Capita, Bac Kan Province - http://www.knowledgebank.irri.org/sam/SAM/site_en/atlas_en/map_agricult001_en.html)

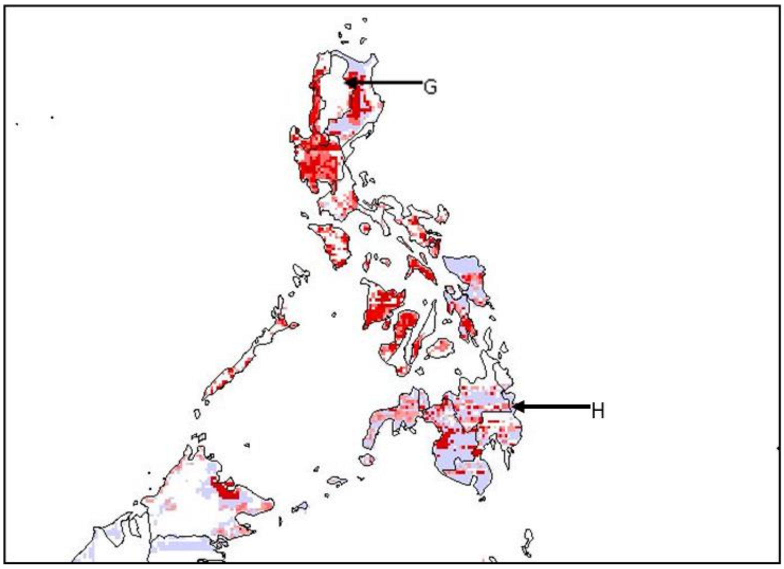
The Philippines:

The following study charts the changes of distribution of rice production in the main provinces of the Philippines over the last three decades.

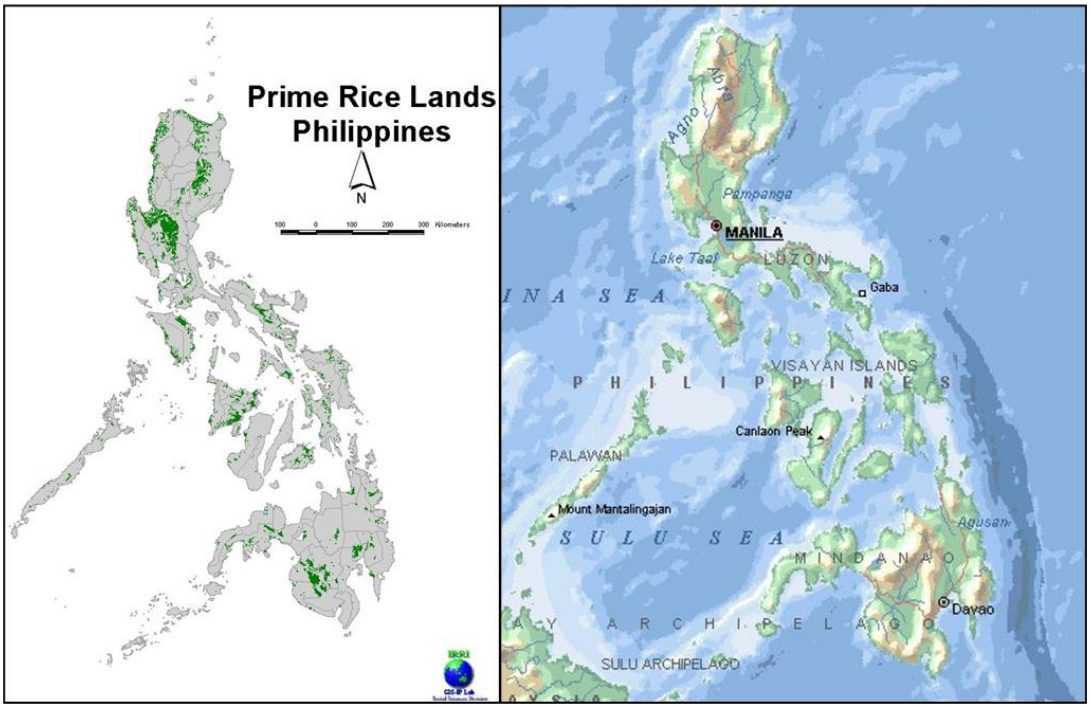


(15. http://www.knowledgebank.irri.org/gis/images/phprod.jpg)

When looking at the SPAM data below, it can clearly be seen that there is some unusual patterning especially in the south. The data from 15 clearly demonstrates that there should be a significant amount of Rice production in the South, but the SPAM data in 16 Below shows some unusual patterning which does not really hold any particular reference to the landscape:



(16. SPAM Data for the Philippines)



(17 – 18. Prime Rice Lands and Topography)

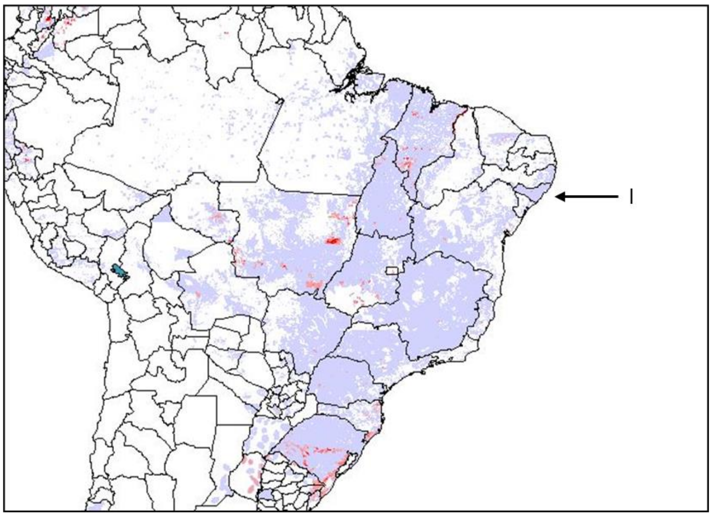
Generally the areas of the SPAM data showing higher levels of production correspond with Prime Rice Land areas shown in 17, but this data also reinforces the fact that the patterning on the Spam Data, should be more clustered, and the horizontal patterning does not correspond with any other available studies. The void in the northern part of the Philippines indicated by Arrow G corresponds to an area of highlands, and it can be seen also that the prime rice land run vertically along the sides of the mountainous region, which is correctly indicated by the red areas on the SPAM data, although the patterning again appears to be unusual.

The area indicated by arrow H for example is shown to be highlands, and 17 shows that the patterns of Prime

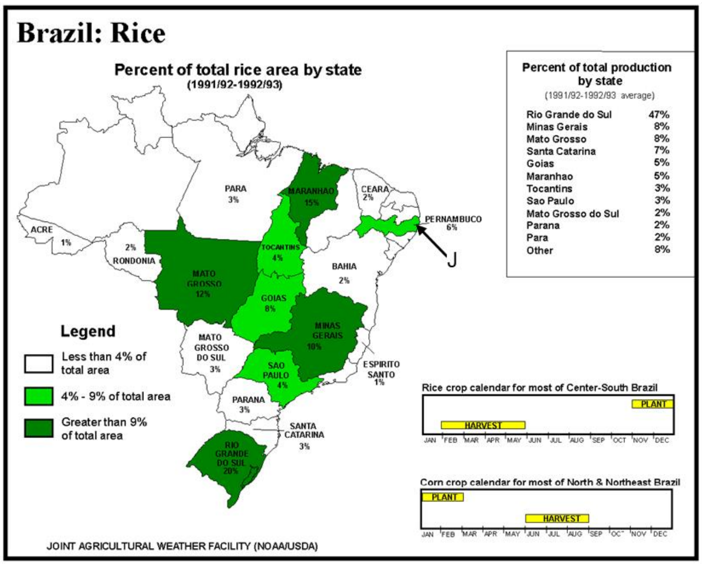
Rice areas corelate with the topography of the region. The SPAM data on the other hand appears to have no real correlation with the topography of the land or the patchy prime rice growing areas in this southerly part.

Brazil:

The following page shows the SPAM data compared with a broad provincial level study of rice production Brazil, comparative to other areas of the world, rice production is much lower here, but the provinces reported to have the highest production, from the FAO study, appear to correlate with the SPAM data. There is only one major exception, which is that the provinces marked with Arrows I and J appear to be completely contradictory. Otherwise, the only other observation is that areas abruptly change from higher to lower production along provincial boundaries as if the data was entered only as an average for each province, with the result that it looks remarkably like the FAO Provincial level Study.



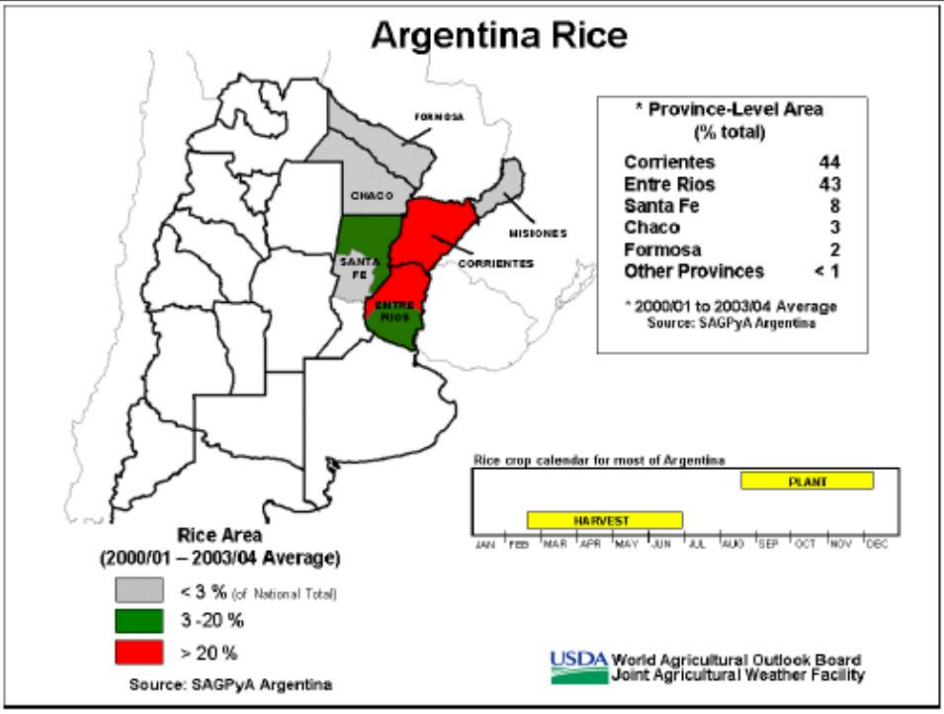
(19. SPAM data for Brazil)



(20. http://www.iamhedged.com/research/brzric.gif)

Argentina:

In Argentina for example the following USDA study (21) shows that rice production is highly concentrated in one very small part of the country.



Argentina Rice Production Statistics

Year (Marketing)	Area Harvested (1000 HA)	Milled Production (1000 MT)	Rough Production (1000 MT)	MILLING RATE (.9999)
1993	141	395	608	6,500
1994	184	602	926	6,500
1995	193	641	986	6,500
1996	224	783	1,205	6,500
1997	212	673	1,035	6,500
1998	289	1,078	1,658	6,500
1999	189	588	905	6,500
2000	151	567	872	6,500
2001	124	463	712	6,500
2002	133	467	718	6,500
1998 to 2002 Average	177	633	973	6,500

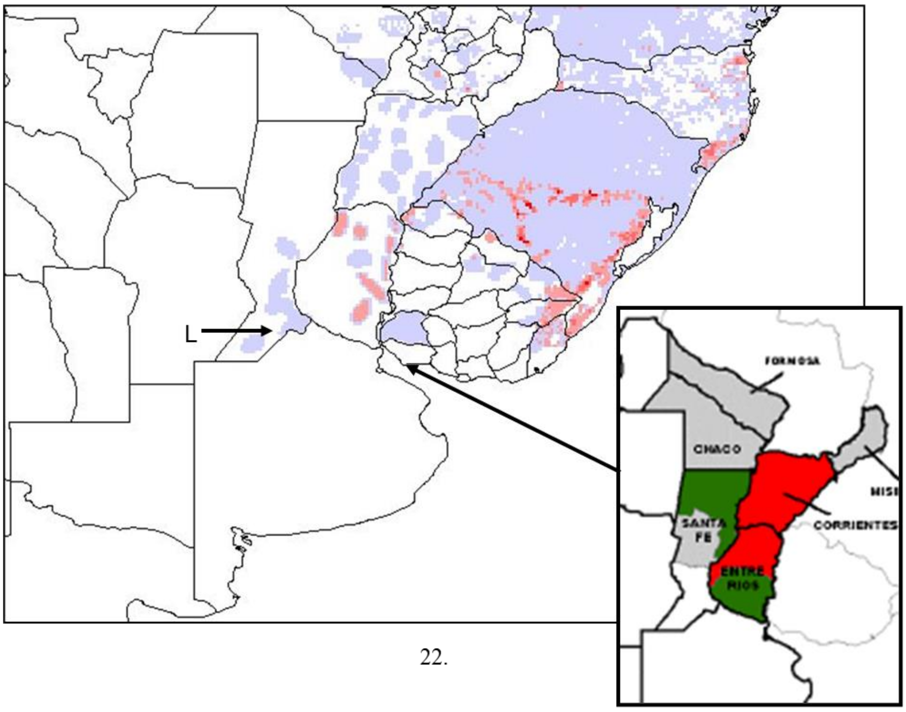
Rice conversion factor is 22.04 cwt per metric ton.

Official USDA production statistics are subject to change.

USDA World Agricultural Outlook Board
Joint Agricultural Weather Facility

(21.http://www.usda.gov/oce/weather/pubs/Other/MWCACP/Graphs/Argentina/ArgentinaRice.pdf)

The SPAM data for this region is particularly interesting for rice production, and specific circular patterning can be seen in the provinces surrounding the river mouth which is unlike any other patterning observed in the data set:



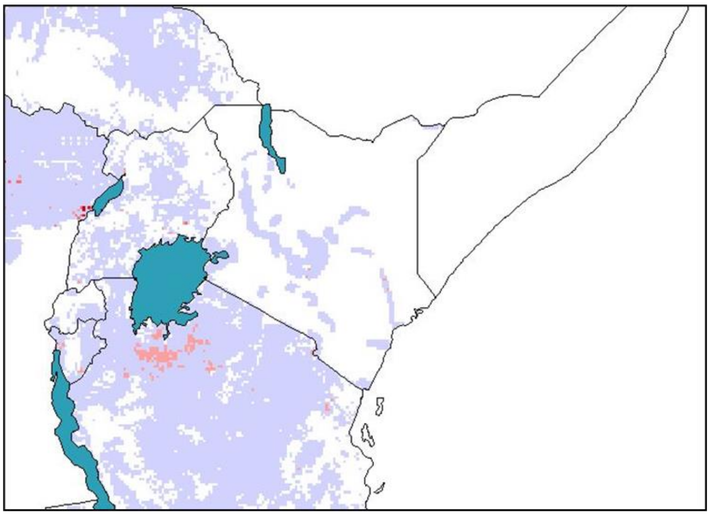
22.

A brief comparison of the data will reveal numerous anomalies between the two. The highest producing areas in the USDA study are the two marked in red which appear to correlate with the patterning which is shown in these provinces on the SPAM data. A brief examination of some topographical maps for the region have provided no reasonable explanation for the circular patterning.

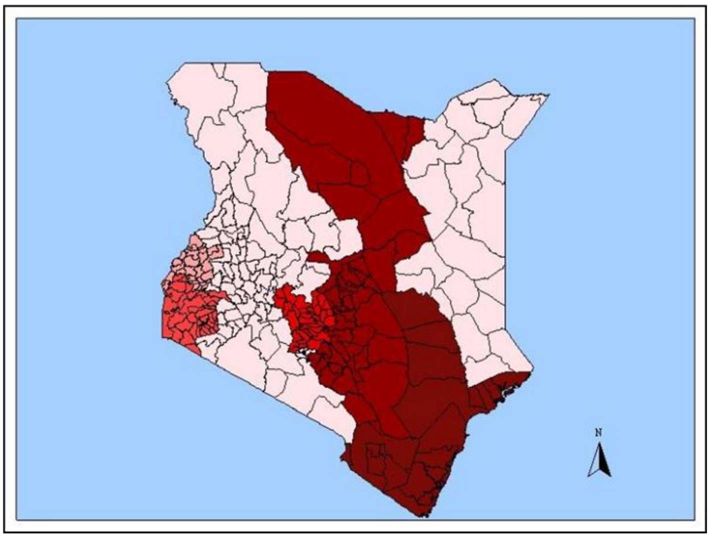
The North Eastern Province in the Iguazu falls areas is shown by the SPAM data to have no registered production, but USDA believe this province to be producing up to 3% of the country's output, now it may be that this is simply too low a level of production to register on the SPAM study, which seem to tie in with the fact that the other provinces marked in grey on the FAO study, except for the fact that the area marked with Arrow L shows production in the only area which the FAO study believes to have no production at all. Particularly noticeable because they have gone to the trouble of dividing the Santa Fe province into three different grades, with the specific purpose of showing that there is no significant production in the southerly part but 3-20 % of the country's total output in the north.

Kenya:

There appears to be little correlation between the SPAM data for Kenya and the Province level study we discovered. Some of the areas appear to correlate with the highest producing areas, but there is little evidence of the vertical band of production which can be seen in 24 but this may just be due to the fact that the production is too low for the SPAM model to recognize.



(23. SPAM data for Kenya, Country borders only)



(24. http://www.ilri.org/gis/search.asp?id=334)

S17. Confidence assessment

The confidence rating by users, local experts and collaborators is presented in Table S14. The rating is collected from the feedback and comments from users, local experts and collaborators. We combine all the information together to give a subjective rating on how confidence we, SPAM team, think of our final crop maps (both area and yield).

Table S14 Confidence rating by users, local experts and collaborators

COUNTRY NAME	**Confidence Category(1-highest, 5- lowest)**
Armenia	1
Angola	2
Argentina	1
Australia	2
Bangladesh	2
Bolivia	1
Benin	1
Brazil	1
Canada	2
China	1
Colombia	2
Ethiopia	1
Czech Republic	1
Germany	2
Indonesia	2
India	2
Israel	1
Italy	3
Japan	1
Kenya	1
Mexico	1
Nigeria	2
New Zealand	1
PAKISTAN	3
Poland	2
Russian Federation	1
Senegal	2
Spain	2
Sudan	2
Sweden	2
Turkey	1
United States of America	1
Yemen	3
Antigua and Barbuda	3

Afghanistan	2
Algeria	1
Azerbaijan	1
Albania	2
Austria	1
Bahrain	1
Barbados	2
Botswana	1
Belgium	2
Belize	1
Bosnia and Herzegovina	2
Myanmar	4
Belarus	2
Solomon Islands	2
Bhutan	2
Bulgaria	3
Brunei Darussalam	2
Burundi	2
Cambodia	2
Chad	4
Sri Lanka	2
Congo	3
Democratic Republic of Congo	3
Chile	3
Cameroon	3
Costa Rica	2
Central African Republic	2
Cuba	3
Cape Verde	2
Cyprus	3
Denmark	2
Djibouti	2
Dominica	3
Dominican Republic	3
Ecuador	3
Egypt	4
Ireland	2
Equatorial Guinea	2
Estonia	2
Eritrea	3
El Salvador	2
French Guiana	2
Finland	2
Fiji	3

France	2
Gambia	3
Gabon	2
Georgia	2
Ghana	1
Grenada	2
Guadeloupe	2
Greece	2
Guatemala	2
Guinea	4
Guyana	3
Haiti	4
Honduras	3
Croatia	1
Hungary	2
Iran (Islamic Republic of)	2
Ivory Coast	3
Iraq	3
Jamaica	3
Jordan	1
Kyrgyzstan	2
Dem People's Rep of Korea	2
Kiribati	1
Republic of Korea	1
Kuwait	2
Kazakhstan	2
Lao People's Democratic Republ	2
Lebanon	2
Latvia	2
Lithuania	2
Liberia	1
Slovakia	1
Lesotho	1
Luxembourg	1
Libyan Arab Jamahiriya	2
Madagascar	2
Martinique	2
Republic of Moldova	1
Mongolia	1
Montserrat	1
Malawi	3
Republic of Macedonia	3
Mali	3
Morocco	1

Mauritius	1
Mauritania	2
Malta	2
Oman	3
Maldives	2
Montenegro	1
Malaysia	2
Mozambique	3
New Caledonia	2
Niger	2
Vanuatu	2
Netherlands	1
Norway	1
Nepal	1
Suriname	3
Nicaragua	2
Paraguay	3
Peru	2
Panama	3
Portugal	1
Papua New Guinea	3
Guinea-Bissau	3
Qatar	1
Serbia	1
Romania	1
Philippines	2
Puerto Rico	2
Rwanda	2
Saudi Arabia	2
Saint Kitts and Nevis	2
Seychelles	2
South Africa	2
Slovenia	1
Sierra Leone	3
Singapore	1
Somalia	3
Saint Lucia	2
Syrian Arab Republic	2
Switzerland	1
United Arab Emirates	2
Trinidad and Tobago	3
Thailand	3
Tajikistan	3
Togo	2

Sao Tome and Principe	2
Tunisia	3
Timor-Leste	3
Turkmenistan	3
United Republic of Tanzania	2
Uganda	3
U.K. of Great Britain and Nort	2
Ukraine	3
Burkina Faso	2
Uruguay	2
Uzbekistan	2
Saint Vincent and the Grenadin	3
Venezuela	2
Viet Nam	3
Namibia	1
Swaziland	2
Zambia	2
Zimbabwe	3

Note: The confidence rating is raging from 1 to 5 categories (1 represents the highest accuracy or confidence, 5 the lowest).

Reference

Anderson, W., You, L., Wood, S., Wood-Sichra, U., and Wu, W., 2015. An analysis of methodological and spatial differences in global cropping systems models and maps, Global Ecology and Biogeography, 24, 180-191.

CIESIN, 2016. Gridded Population of the World, Version 4 (GPWv4): Population Count Adjusted to Match 2015 Revision of UN WPP Country Totals. Center for International Earth Science Information Network, Columbia University.

Deguignet, M., Juffe-Bignoli, D., Harrison, J., MacSharry, B., Burgess, N.D., Kingston, N., 2014. United Nations List of Protected Areas. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Fischer, G., Nachtergaele, F.O., Prieler, S., Teixeira, E., Tóth, G., Velthuizen, H.v., Verelst, L., Wiberg, D., 2012. Global Agro‐ecological Zones (GAEZ v3.0). IIASA/FAO, IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Lu, M., Wu, W., You, L., See, L., Fritz, S., Yu, Q., Wei, Y., Chen, D., Yang, P., Xue, B., 2020. A cultivated planet in 2010: 1. the global synergy cropland map. Submitted to the current journal.

Portmann, F.T., Siebert, S., Döll, P., 2010. MIRCA2000—Global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution data set for agricultural and hydrological modeling. Global Biogeochemical Cycles 24.

Siebert, S., Henrich, V., Frenken, K., Burke, J., 2013. Update of the digital global map of irrigation areas to version 5. Rheinische Friedrich-Wilhelms Universität, Bonn, Germany and FAO, Rome, Italy.

Wood-Sichra, U., Joglekar, A.B., You, L., 2016. Spatial Production Allocation Model (SPAM) 2005: Technical Documentation. HarvestChoice Working Paper. International Food Policy Research Institute (IFPRI) and St. Paul: International Science and Technology Practice and Policy (InSTePP) Center, University of Minnesota.