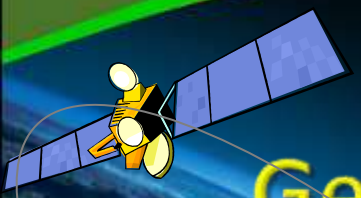
CGIAR

ICARDA
Science for Better Livelihoods in Dry Areas



Geoinformatics for nourishing drylands

Innovation, Investment, Intervention and Impact

ICARDA Geoinformatics
geoagro.icarda.org

ESRI UC MENA 2016
Nov 7-9, 2016
Dead Sea, Jordan

Spurring Geospatial Opportunities in Inclusive Agricultural Development

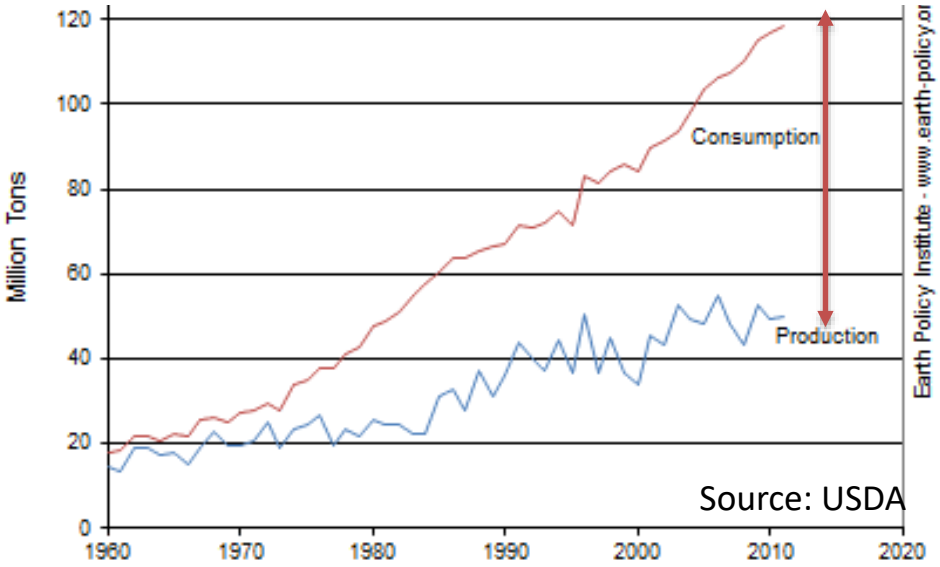
Drylands at a glance

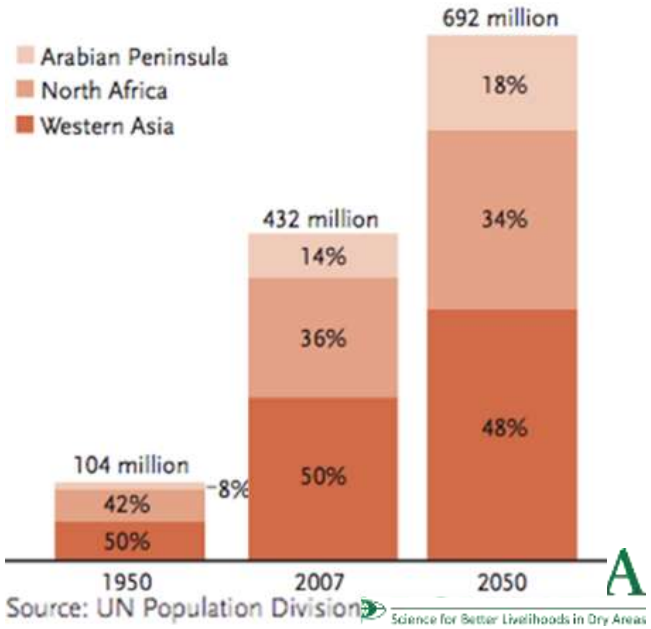
drylands in the developing countries

Global perspective

- Cover 41 percent of the Earth's surface
- Support 30 percent of the world's population
- Support 50 percent of the world's livestock
- Grow 44 percent of the world's food
- Home to 93 percent of the world's undernourished people
- Prevalent chronic poverty – with 400m living on < US$1 per day
- Drylands lose 23 ha per minute to drought and desertification – a loss of 20 million tons of potential grain production every year.

Grain Production and Consumption in MENA

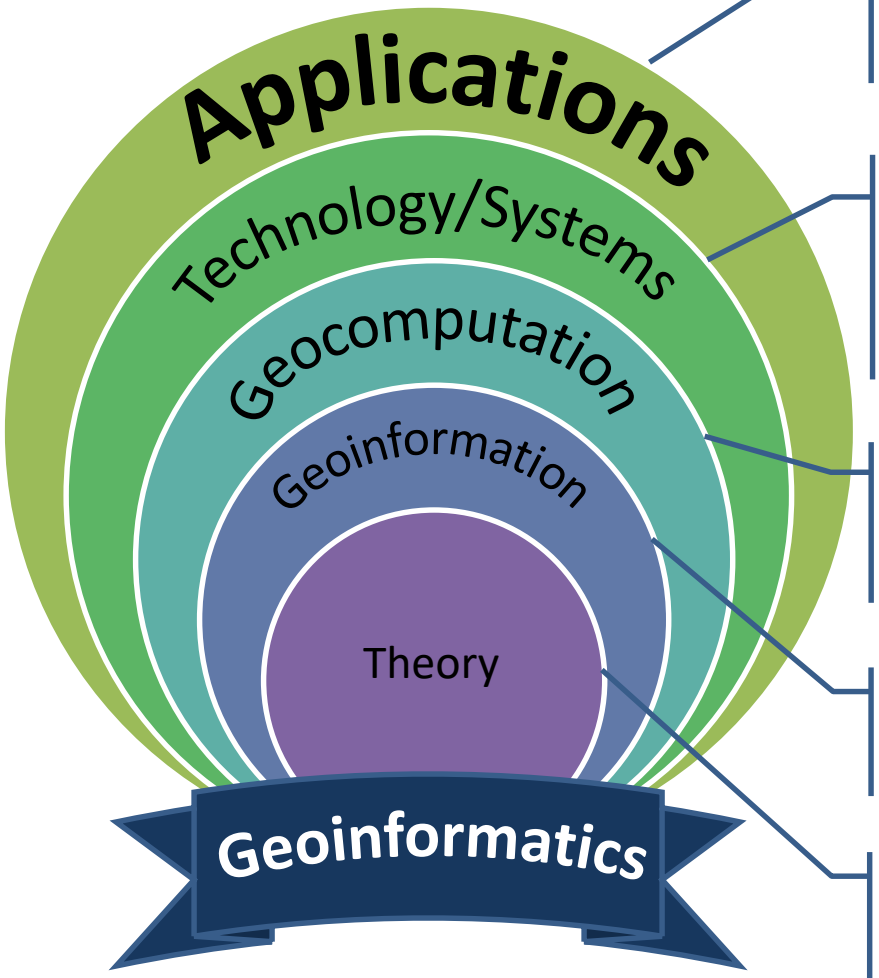




Geoinformatics

Science, Technology & Applications

GeSTA



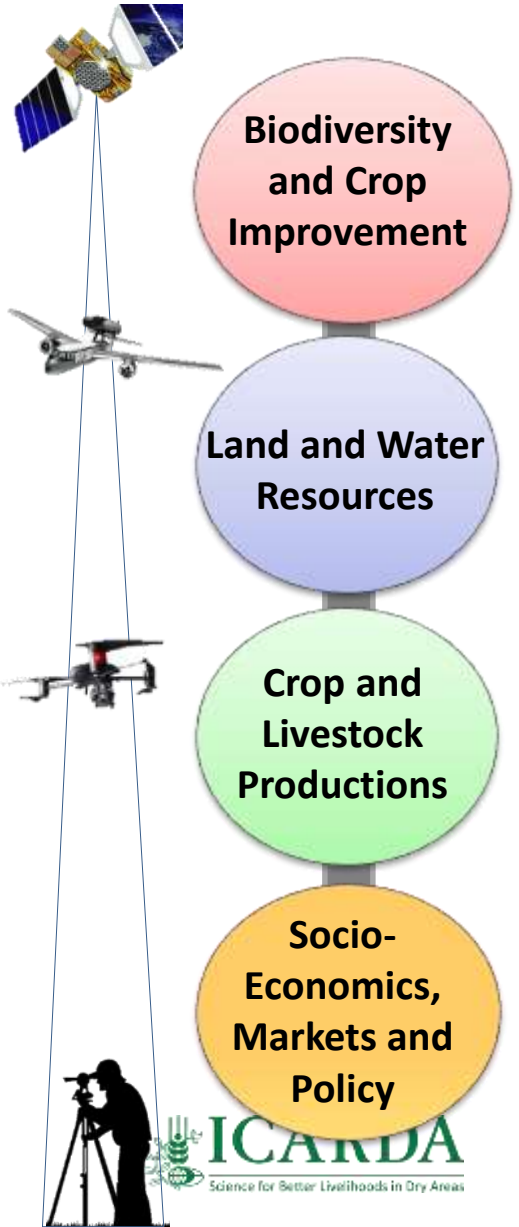
Agro-ecosystems
Environment
Climate Change

Remote Sensing
Navigation System
Spatial Decisions
Telecommunication

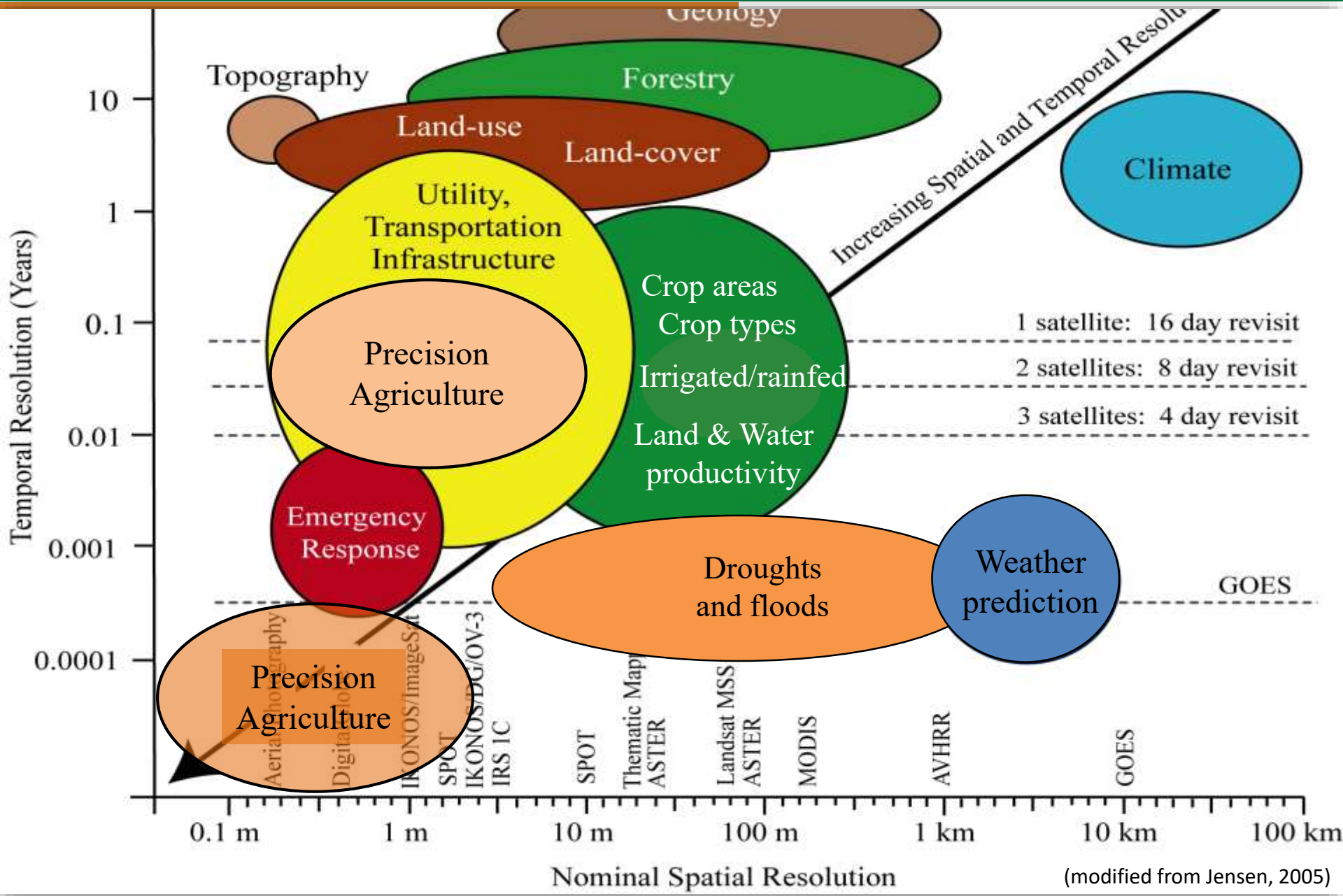
Comp. Geometry
Spatial Analysis
Spatial Data Mining

Spatial Database
Maps & Attributes

Spatial Models
Spatial Algorithms
Spatial Reasoning



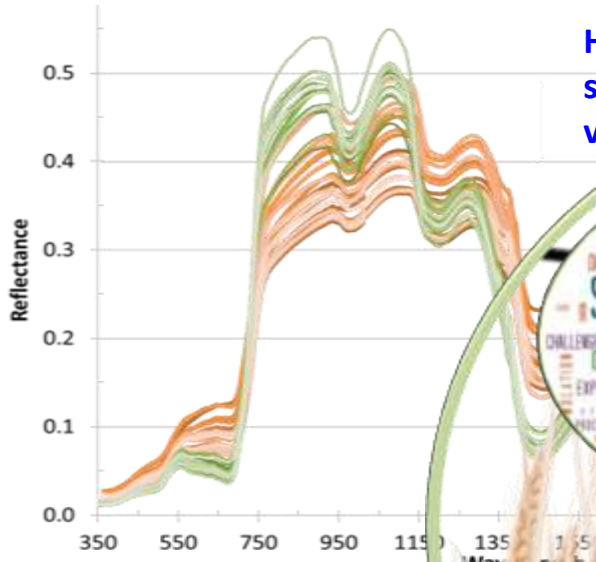
Spatio-Temporal Resolution vs. Applications



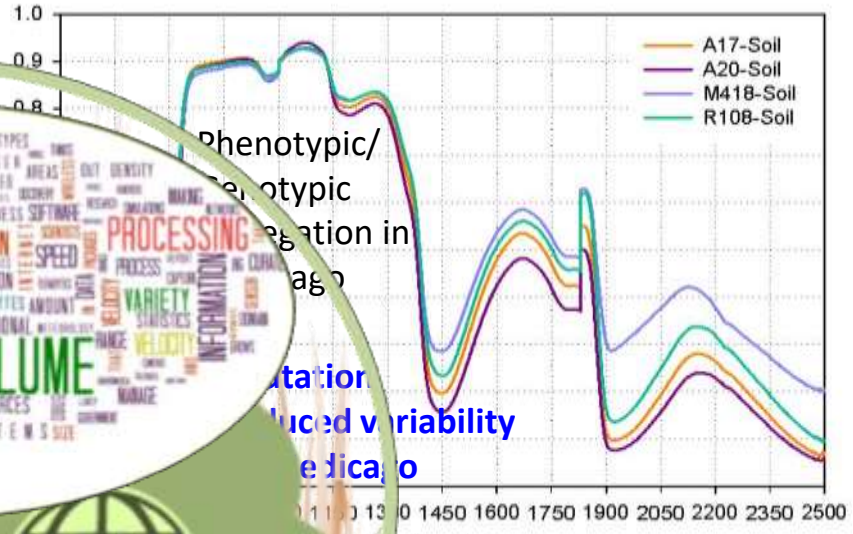
(modified from Jensen, 2005)

Advanced Sensors and Tools: Hyperspectral, Multispectral, Thermal, Ultraspatial

Big Data + ICT=GeSTA



HyperSpectral signature of 20 Wheat varieties



Phenotypic/
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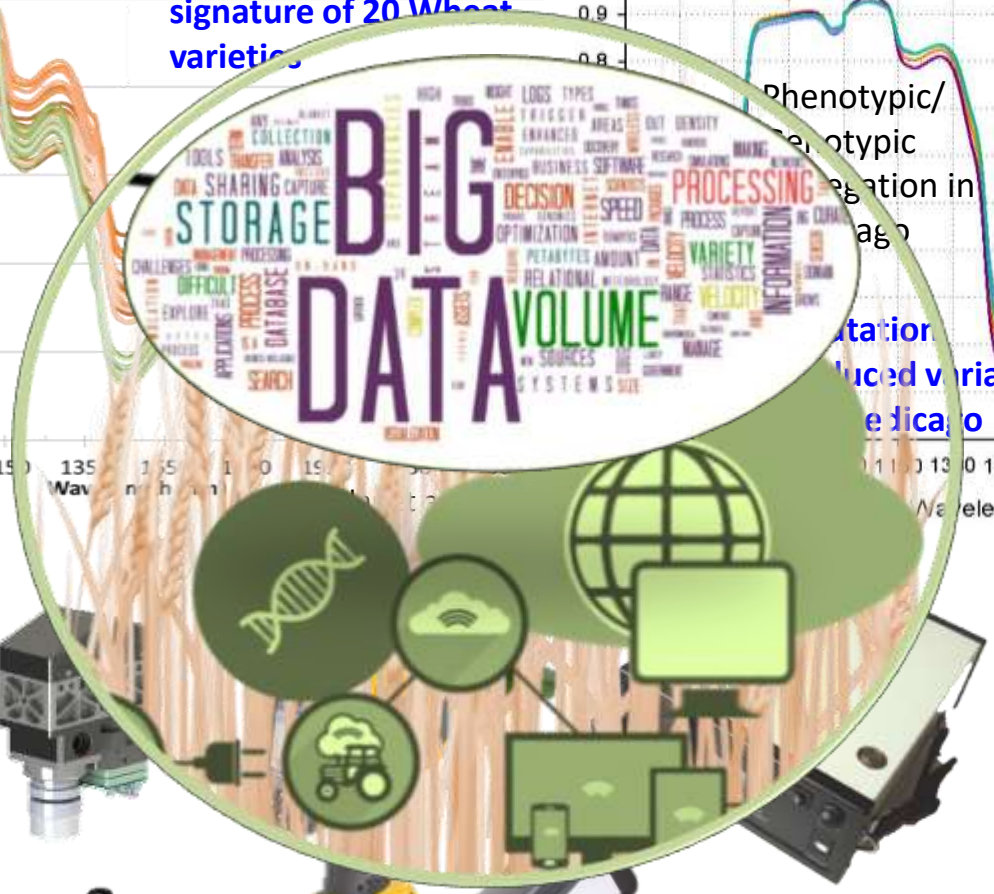
(Biradar et al., 2012)



Portable spectral devices

ICARDA Geo-Cyberinfrastructure Facility

High Speed Geo-Computing and Archiving

Computing Servers

Large Format HR printing and scanning

2xCPU (12 Cores)
512 GB RAM
Linux
GeoAg1

8 Cores CPU
32 GB RAM
Win 2012
GeoAg2

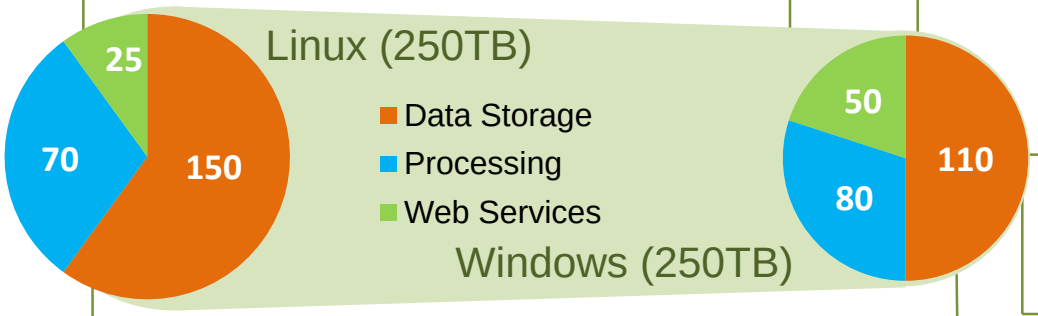
12 Cores CPU
48 GB RAM
Win 2012
GeoAg3

124 CPU
224 GB RAM
MSHPC2012
HPC

AgUAV
[HperSpectral, Opticla, TIR*]

Field Equipment

[Hyperspectral, HH2, SE-3500, NDVI Camera, Green Seeker, GPS Cameras, HH GPSUs, Field Data Kits, etc.]



Centralized Storage & Access

GLOBAL
REGIONAL
NATIONAL
LOCAL

Geospatial Data Gateways

Terminal Devices

Data Portals

Map Server

Hosted in UK

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Science for Better Livelihoods in Dry Areas

EO Matrix at Farmscape to Landscape

Example of One Sensor in each Platform/Scale

	Platforms	Ground/*in-situ*		Airborne		Spaceborne				
	Mode	Hyperspectral	Multispectral	Optical	LiDAR	Optical			LiDAR	SAR
RS data characteristics	Sensor	ASD FieldSpec	M× Camera	APs/UAVs	Lidar	WorldView-2	Landsat	MODIS	ICESat*	PALSAR
	Spectral	350-2500nm	4 bands	3-4 bands	1264nm	8 bands	7 bands	7/36 bands*	1264 & 532nm	L band
	Spatial resolution	0.1-1.5m	0.1-0.2m	1-m	20 - 80cm	0.46m Pan; 1.84m MS	15m Pan; 30m MS	250m, 500m, 1000m MS	70m	10m, 20m, 100m
	Swath	1-4m	2-10m	--	1-2km	16.4km	185km	2330km		35-250km
	Revisit	--	--	3-year	--	1.1 days	16 days	1 day	91 days	46 days
Biophysical	Plant biomass	×	×		×	×	×	×		×
	Plant height				×				×	×
	LAI, fPAR, LST	×	×			×	×	×		
	NDVI, EVI, LSWI	×	×	×		×	×	×		
Biochemical	Erosion, Salinity	×	×	×	×	×	×	×		
	Soil moisture	×	×	×		×	×			×
	Chlolophyll	×	×	×		×	x	×		
	Nitrogen	×	×	×		×	×			
	Phosphorous	×	×			×				
	Plant water	×	×			×		×		
Production	GPP	×	×	×		×		×		
	NPP	×				×	×	×		
LULC	land cover/use	×	×	×		×	×	×		×
	phenology	×	×				x	×		×
	Irrigation	×	×	×		×	×	×		×
Terrain	DEM		×	×	×	×			×	×
	Derivatives		×	×	×				×	×
Scale	Tier 1 AOIs	×	×	×	×	×	×	×	×	×
	Tier 2 action sites	×	×	×			×	×	×	×
	Tier 3 AEZs	×	×	×				×	×	×
	Tier 4 Target			×				×		×

EOS in Agricultural RDO

Scaling Trade-on/offs
Farmscapes to Landscapes

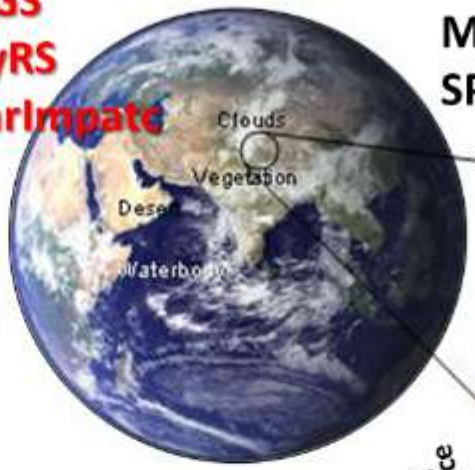
Varieties/
Landraces

FIGS
HyRS
VarImpatc

Crops/
Forage

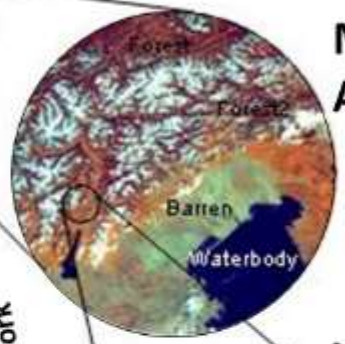
Crop Fallows
Intensification
feedstock

Farmlands/
Grasslands



MODIS
SPOT Veg.

MODIS
AWiFS



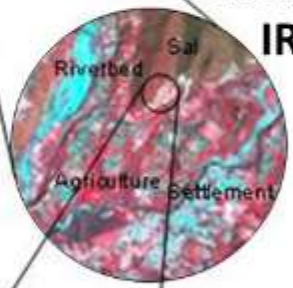
Cropping Systems Dy
Ag Water Productivity
Yield Gap Analysis

Algorithms
Automation
Right space-time

Big-Data Analytics
Citizen Science
Precision Decisions

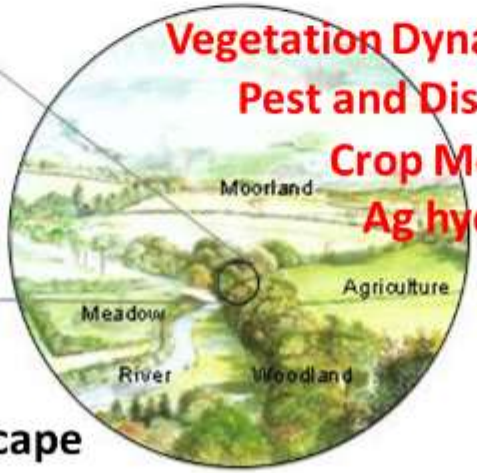
Machine learning
Artificial intelligence
Neural network

Landsat
IRS



Agro-ecosystems
L&W Productivity
Land Use Change

Vegetation Dynamics
Pest and Diseases Risk
Crop Modeling (Physio)
Ag hydrology



Agro-ecosystems

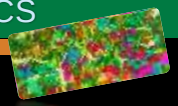
Landscape

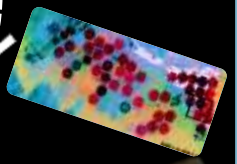
WV series
RapidEye/BB
Cartosat

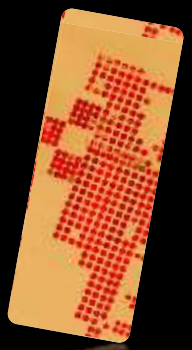
WVs/DG/UAVs

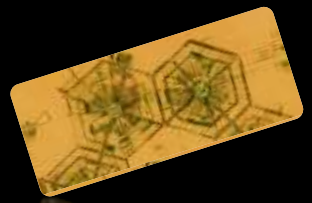
Earth Observation Systems for Agro-Ecosystem Research

ACTIVE SATELLITE SENSORS AND CHARACTERSTICS









Very High Resolution (Up to - 1 m)

Satellite Sensors	Resolution			Swath (km)
	Spatial (m)*	Temporal (days)	Spectral (Bands)	
GEOEYE-1	1.65 (0.41)	1	B, G, R, IR, P	15.2
IKONOS	3.2 (0.82)	14	B, G, R, IR, P	11.3
PLEIADES-1A	2 (0.5)	1	B, G, R, IR, P	20
PLEIADES-1B	3 (0.5)	1	B, G, R, IR, P	20
Quick Bird	2.4 (0.6)	3.5	B, G, R, IR, P	16.5
WorldView-1	(0.4)	1.2	P	17.6
WorldView-2	1.8 (0.4)	1.2	P, C, B, G, Y, R, RE, IR (2)	16.4
CARTOSAT-2	1	5	P	9.6
CARTOSAT-2a	<1	4	P	9.6
CARTOSAT-2B	<1	4	P	9.6
SKYSAT-1	2 (0.9)	<1 (hourly)	B, G, R, IR, P	8
KOMPSAT-3	2.8 (0.7)	14	B, G, R, IR, P	16.8
KOMPSAT-2	4 (1)	14	B, G, R, IR, P	15
OrbView-3	4 (1)	3	B, G, R, IR, P	14

High Resolution (1 to 5 m)

Satellite Sensors	Resolution			Swath (km)
	Spatial (m)*	Temporal (days)	Spectral (Bands)	
CARTOSAT-1	(2.5)	5	P	30
FORMOSAT-2	8 (2)	1	B, G, R , IR, P	24
SPOT-5	5, 20 (2.5, 5)	2-3	G, R, IR, SW, P	60 to 80
SPOT-6 (1.5)	6 (1.5)	2-3	B, G, R , IR, P	60
RapidEye	5	1	B, G, R, RE, IR	77
RESOURCESAT-1	5.8	5	G, R, IR	23, 70
GOKTURK-2	10, 20 (2.5)	2.5	B, G, R, IR, SW, P	20
TH-2	10 (2)		B, G, R, IR,P	60
EROS-A	(1.8)	2.1	P	14
Theos	15 (2)	3	B, G, R, IR	96
BEIJING-1	32 (4)	1	R G, IR	600
PROBA/HRC	18, 34 (5)	7	18	15

Medium resolution (5 - 30 m)

Satellite	Multispectral resolution (m)	B, s	Swath width (km)
ASTER (15m)			
VNIR (Visible Near Infrared)	15	VIR (4)	60
SWIR (Shortwave Infrared)	30	SW (6)	60
TIR (Thermal Infrared)	60	TIR (5)	60
CBERS - 2			
WFI	260	R, IR	890
CCD	20	B, G, R, IR	113
IRMSS	(2.7)	P-	27
LANDSAT 5TM -7ETM	30 (14.8)	B, G, R, IR, SW1, TIR, SW2, P	185
Nigeriasat-X	22	G, R, IR	-
Resourcesat-2/Liss-III	23.5	R, G, IR, SW	141
Deimos-1	22	G, R, IR	600
UK-DMC-2/SLIM6	22	G, R, IR	638
BILSAT-1	26 (12)	R, B, G, IR, P	640
Nigeriasat-1	32	G, R, IR	640
ALSAT-1	32	G, R, IR	640
UK-DMC/EC (DMC)	32	G, R, IR	600
EO-1/ALI-MS	30	B (2), G, R, IR (3), SW (2), P	37
EO-1/ Hyperion	30	220 bands	7,7
ASTER (15m)	15, 30, 90	G, R, IR (2) SW(6), TIR (4)	60
LANDSAT 7ETM+	30m (14.5)	B, G, R, IR, SW (2), TIR, P	185
SPOT-4	20 (10)	G, R, IR, SW, P	60
SPOT-3	20 (10)	G, R, IR+P	60
JERS-1	24 (18)	G, R, IR, IR	75
SPOT-2	20 (10)	G, R, IR	60
SPOT-1	20 (10)	G, R, IR	60
Landsat 5/MSS	80	G, R, IR, IR	185
Landsat 5/TM	30, 120	B, G, R, IR, SW, SW, TIR	185
RESURS-01-1	45	G, R, IR	600

Low or Medium resolution

Satellite	Multispectral resolution (m)	B, s	Swath width (km)
Landsat 8	30 (14.8)	P, C, B, G, R, IR, SW (3)	185
VIIRS	375, 750	22b, s	3000
ASAR	(12.5)	VV 1	5 - 406
MERIS	300	15 b, s	1150
Metosat MSG			
GERB	40000	7	-
SEVIRI	1000, 3000	12	-
SPOT5/VEGETATION 2	1000	B, R, IR, SW (4)	2250
MODIS	250, 500, 1000	36	2330
SPOT4/VEGETATION 1	1000	B, R, IR, SW (4)	60
IRS-1D/ WiFS	188	R, IR (2)	774
Orbview-2/ SeaWiFS	1130	B(2), G (3), IR (8)	2800
IRS-1C/ WiFS	188	R, IR (2)	810
RESURS-01-1/ MSU-S	240	G, R, IR (3)	600
RESURS-01-1/ MSU-SK	170, 600	R, G, IR(2), TIR	600
ResourceSat/AWiFS	56	R, G, IR, SW	740
Landsat 2/ MSS	80	G, R, IR, IR	183
Landsat 2/ RBV	80	G, R, IR	183
Landsat 1/ MSS	80	G, R, IR, IR	183
Landsat 1/ RBV	80	G, R, IR	183

Radar Satellites

Satellite	Bands	Band (Polarity)	Swath width (km)
Sentinel-1			10, 40, 30, 100,
COSMO-SKYMED 4	1, 5, 15, 30, 100	X-B (HH, VV, HV, VH)	200
TanDEM-X	1, 3, 16	X-B (HH, VV, HV, VH)	1500
COSMO_SKYMED 2	1, 5, 15, 30, 100	X-B (HH, VV, HV, VH)	10, 40, 30, 100, 200
RADARSAT 2	3, 8, 12, 18, 25, 30, 40, 50, 100	C-B (HH, HV, VH, VV)	5 - 500
COSMO-SKYMED 1	1, 5, 15, 30, 100	X-B (HH, VV, HV, VH)	10, 40, 30, 100, 200
Terra SAR-X	1, 3, 16	X-B (HH, VV, HV, VH)	1500
ALOS (PALSAR)	10, 20, 30, 100	L-B (HH, VV, HH, HV, VH)	70
ENVISAT (ASAR)	12.5	C-B (VV)	5 - 406
RADARSAT 1 (SAR)	8,25, 30, 35, 50, 100	C-B (HH)	50 - 500
ERS 2 (AMI)	25	C-B (VV)	100
ERS 1 (AMI)	25	C-B (VV)	100

*=Resolution in parenthesis is panchromatic

+=Bands: B-Blue, G-Green, R-Red, IR-Infra Red, C-Coastal blue, Y-Yellow, SW-Shortwave Infrared, M-Mid infrared, P-Panchromatic, H-Horizonal, V-vertcial

ICARDA

Science for Better Livelihoods in Dry Areas

Integrated Earth Observation System

Thematic foci

Multi-sensor and multi-scale observations of carbon (biomass, yield), water (WUE, WPM), and surface energy fluxes (G×E, stress) at pixel to landscape scales

Productivity of Croplands, Grasslands,
Livestock and Trees Based Systems
Quantification of Traits/integrated Breeding
Land Degradation and Desertification
Extreme Events, Climate Change and Resilience

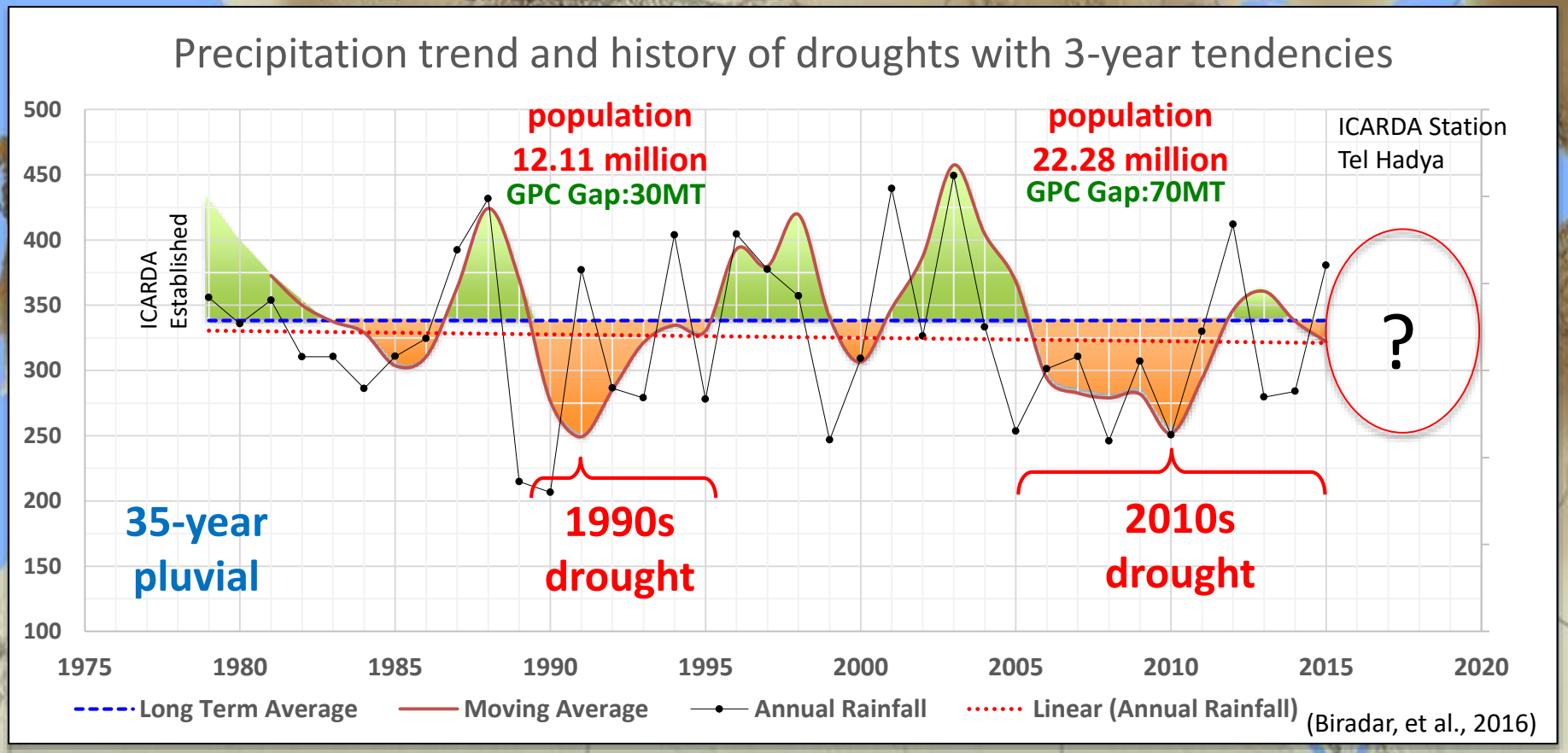
ICARDA
Science for Better Livelihoods in Dry Areas

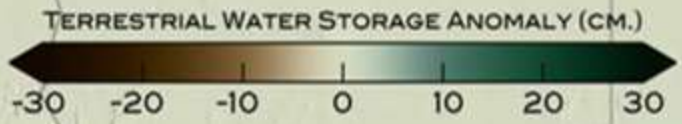
Droughts in Drylands

and the consequences and conflicts

Drought in middle east is worst of past 900 years

Conflicts and migration

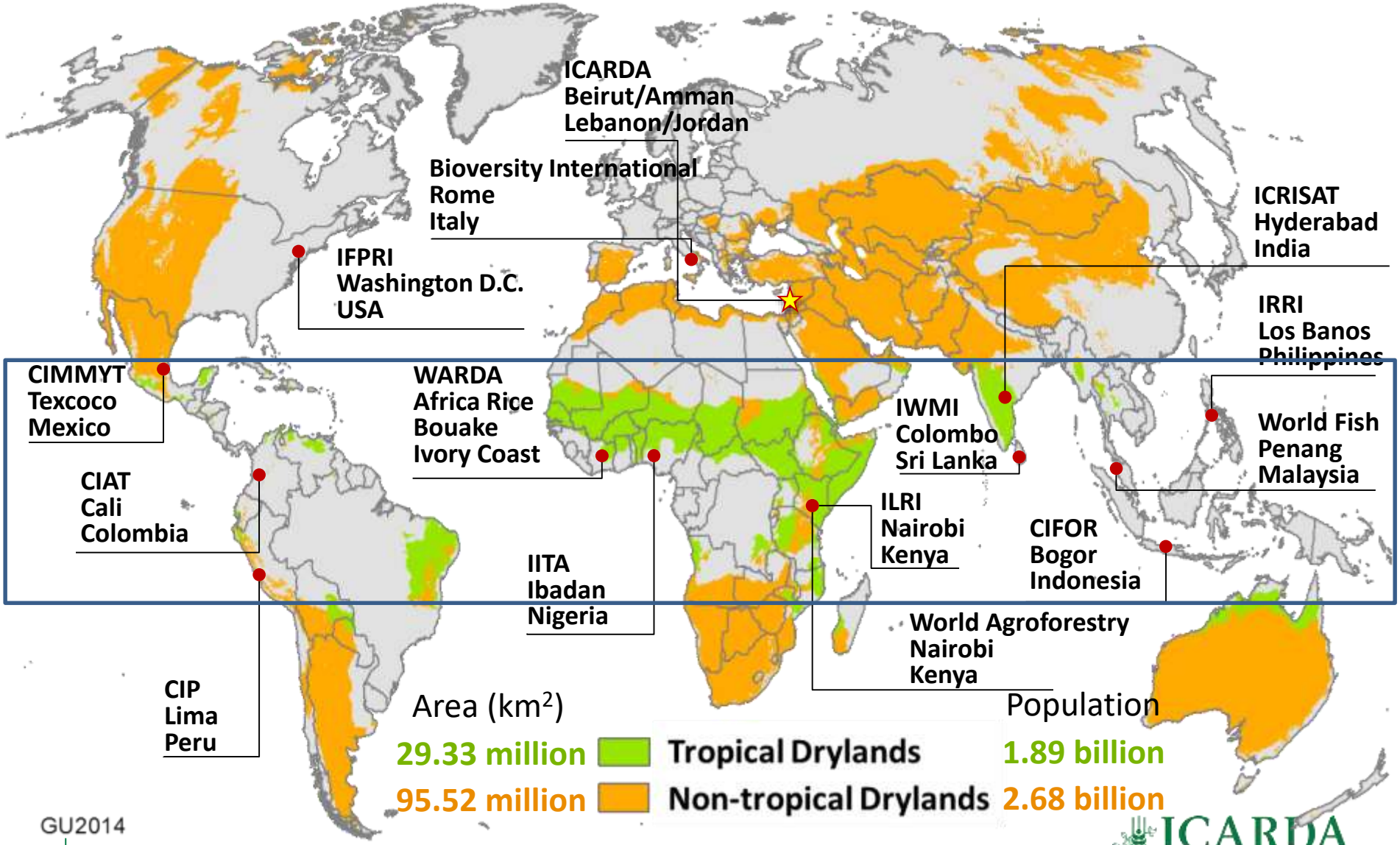




Source: NASA, 2016

Global Drylands and CGIAR

tropical and non-tropical drylands



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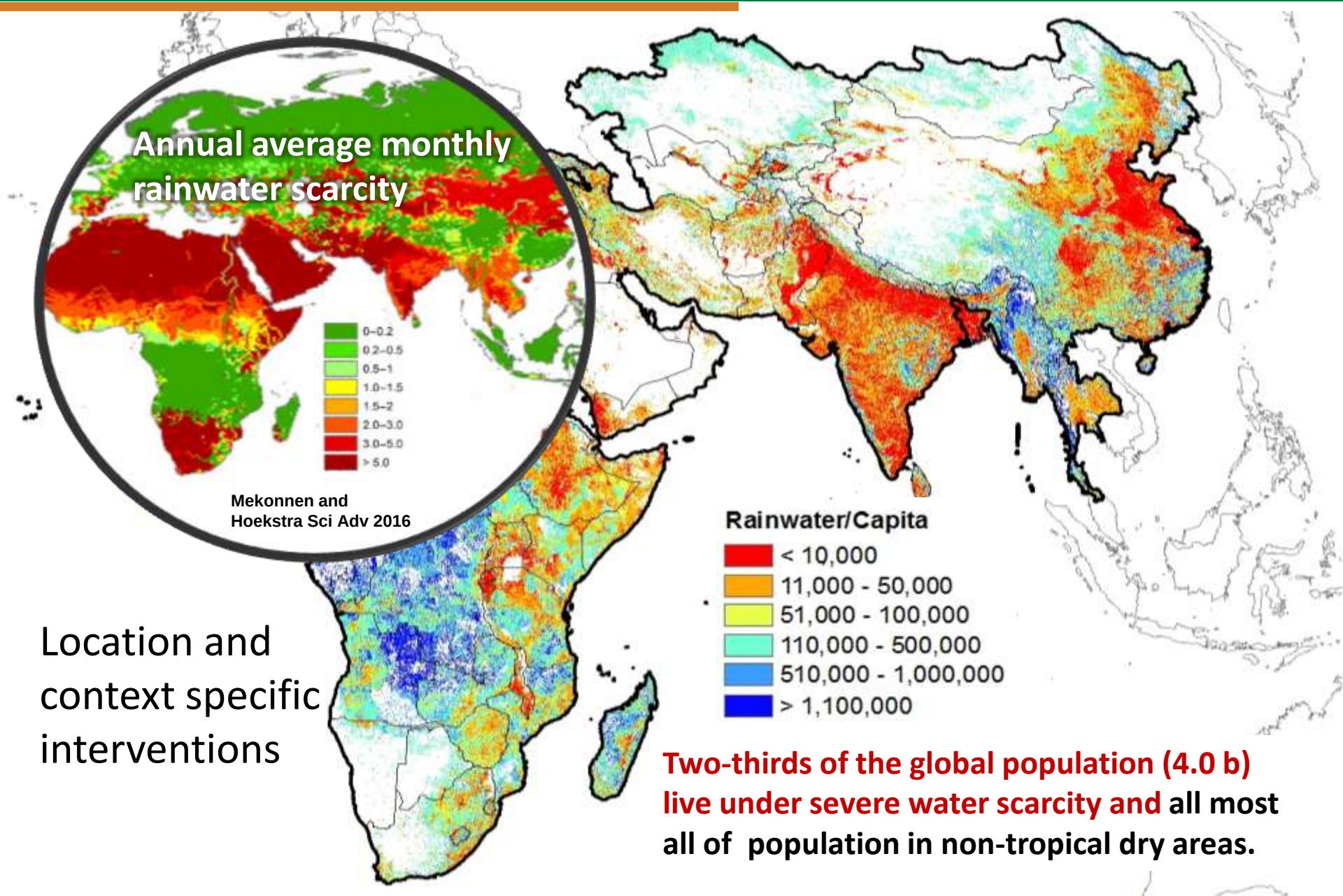
Science for Better Livelihoods in Dry Areas

Green Water Resources

rainwater per capita (m^3/person/year)

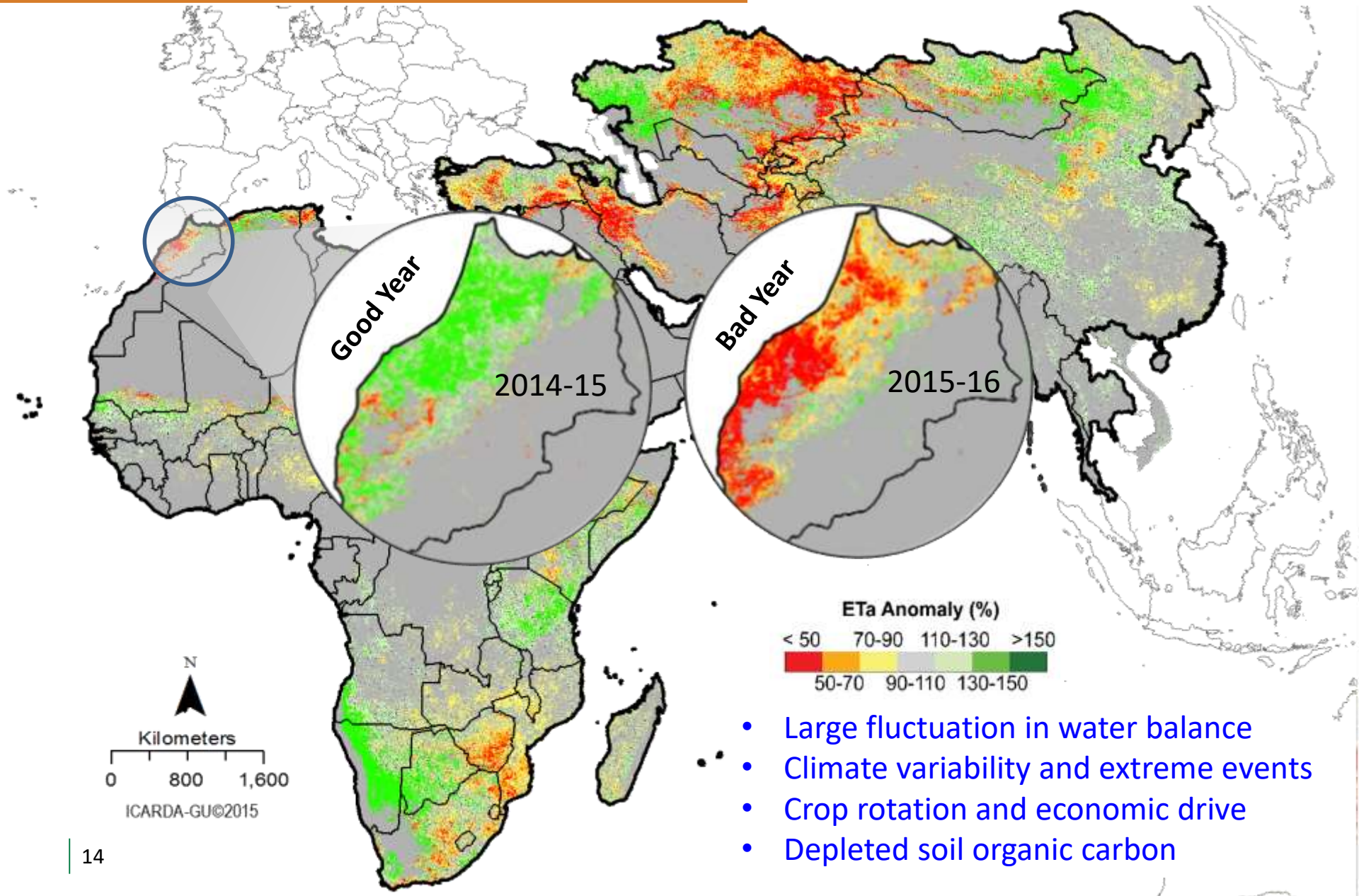


Location and context specific interventions

Two-thirds of the global population (4.0 b) live under severe water scarcity and all most all of population in non-tropical dry areas.

Changing Water Balance

Increasing deviation from long-term averages



- Large fluctuation in water balance
- Climate variability and extreme events
- Crop rotation and economic drive
- Depleted soil organic carbon

Inclusive-Integrated Agro-Ecosystems

Increased land and water productivity while safe guarding the environmental flows and ecosystem services

- more **crop** per **drop** -water is foci
- in a **inch of land** and a **bunch of crop** -multi dimensions -integrated systems

Knowledge based prioritization (space & time) better strategy for intervention, implementation and impact

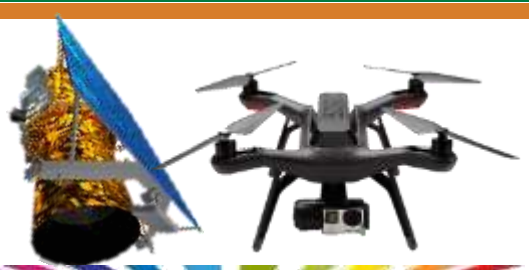
Eco-Crop Zoning
Water Use Efficacy
Conservation Practices
Adoption/Adaptation
Scaling Technology

- food and environmental security
- cooperative and collective actions
- trade, social security and stability

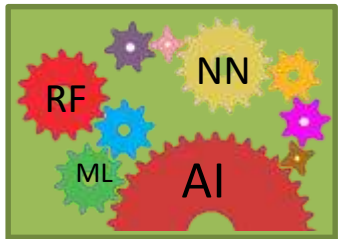
ICARDA
Science for Better Livelihoods in Dry Areas

Digital Agriculture Platform

Image Based, Open Source Precision Decision at Farm scales

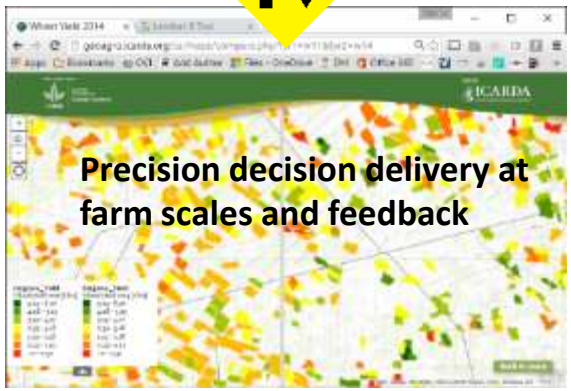


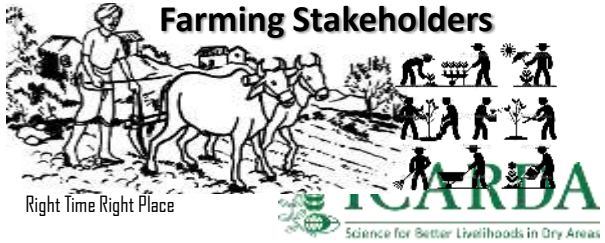
Citizen Science
Community of Practices

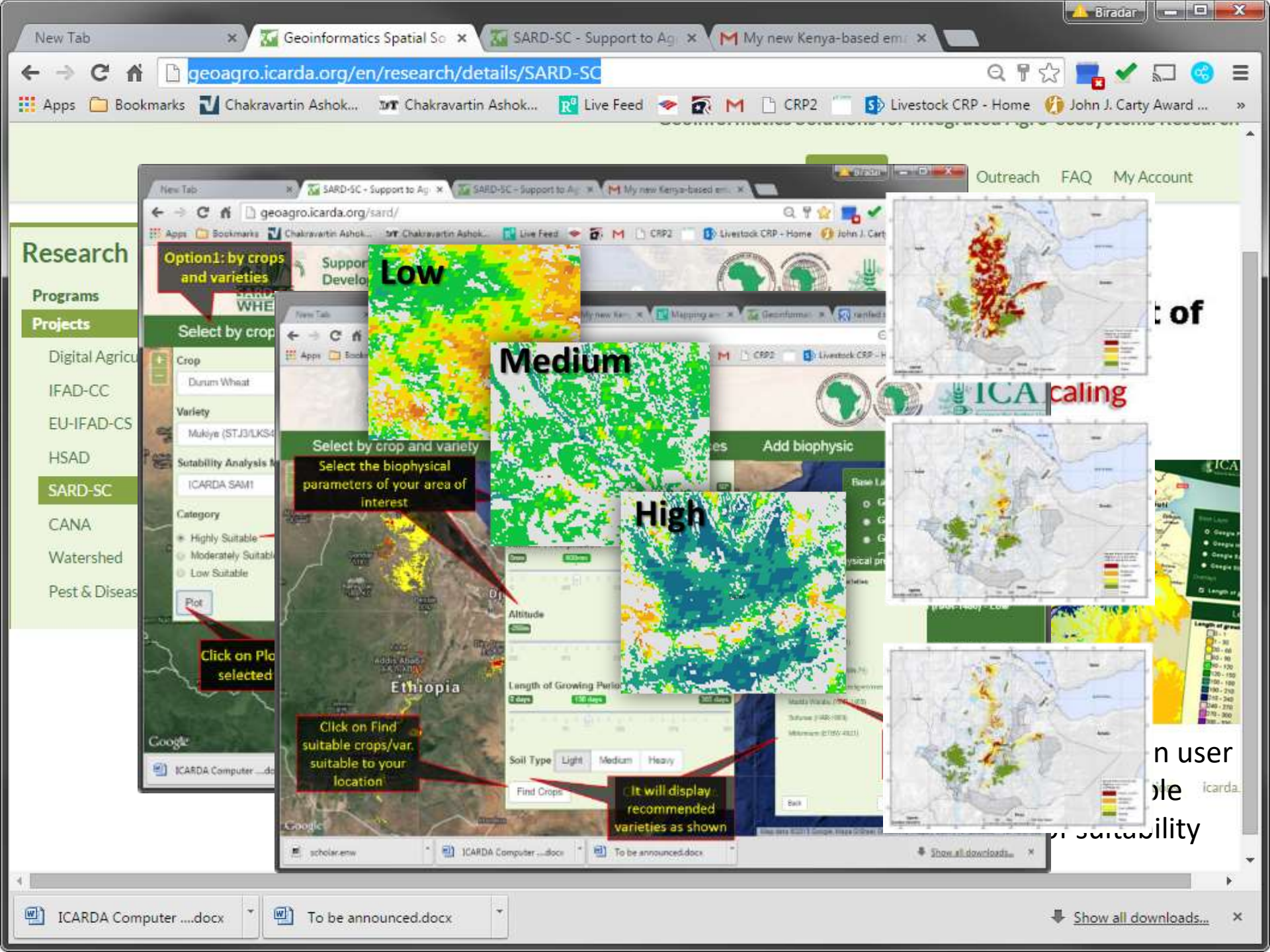


- Cadastral, Object & Pixel based
- Biophysical and socio-ecological
- **Machine Learning**
  Crop types, crop intensity, pattern, fallows, crop stress, AET-l8, soil moisture-SMAP
- Citizen-Science Cellphone feedback
- Direct Access and Markets/Trade
- Precision-Decision

Timely-Access-Application-Trading (TAAT)

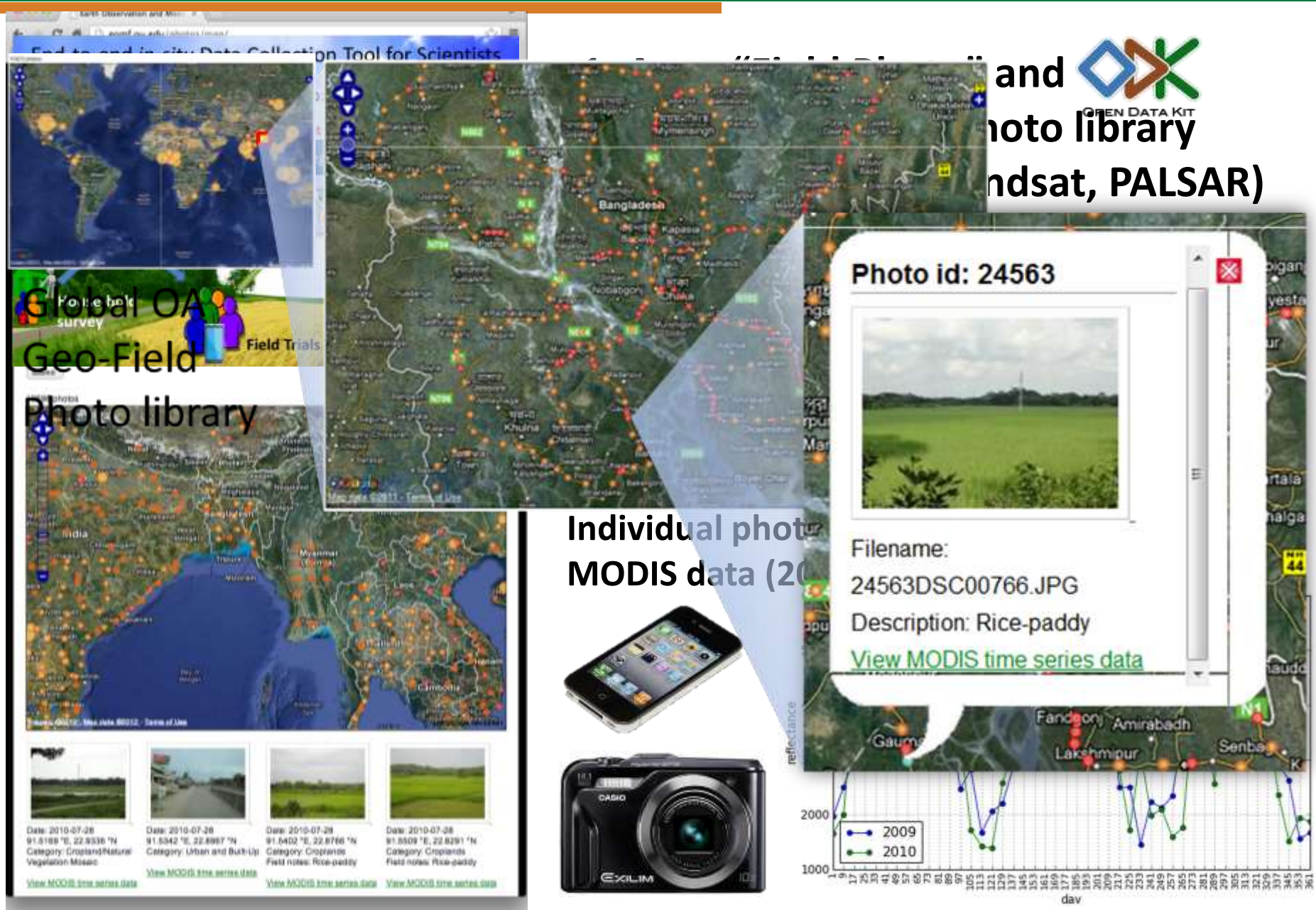





Option1: by crops and varieties
Select by crop
Low
Medium
High
Select by crop and variety
Select the biophysical parameters of your area of interest
Add biophysic
Click on Find suitable crops/var. suitable to your location
It will display recommended varieties as shown
Ethiopia
Research
Programs
Projects
Digital Agricu
IFAD-CC
EU-IFAD-CS
HSAD
SARD-SC
CANA
Watershed
Pest & Diseas
Outreach
FAQ
My Account
ICARDA Computer ....docx
To be announced.docx
Show all downloads...

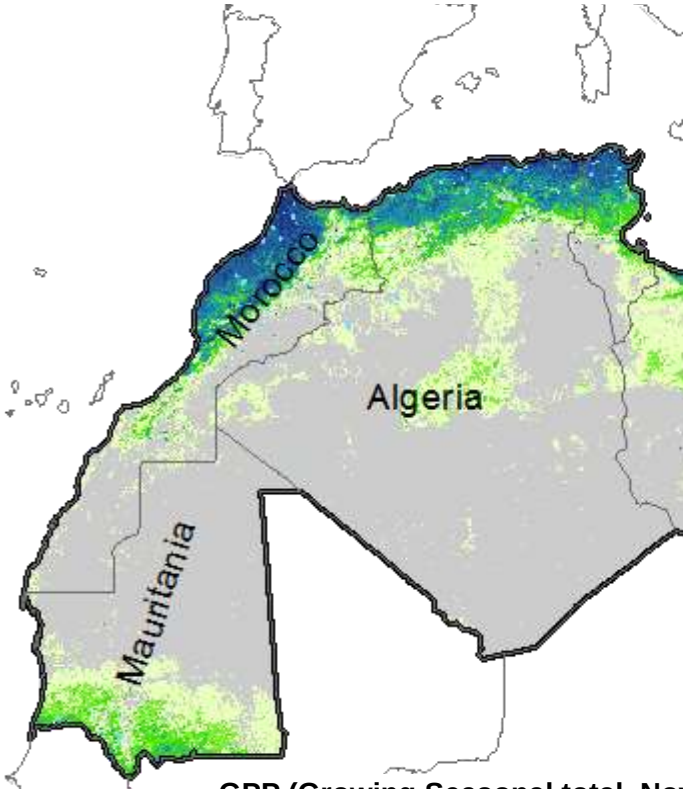
Citizen Science and Community RS

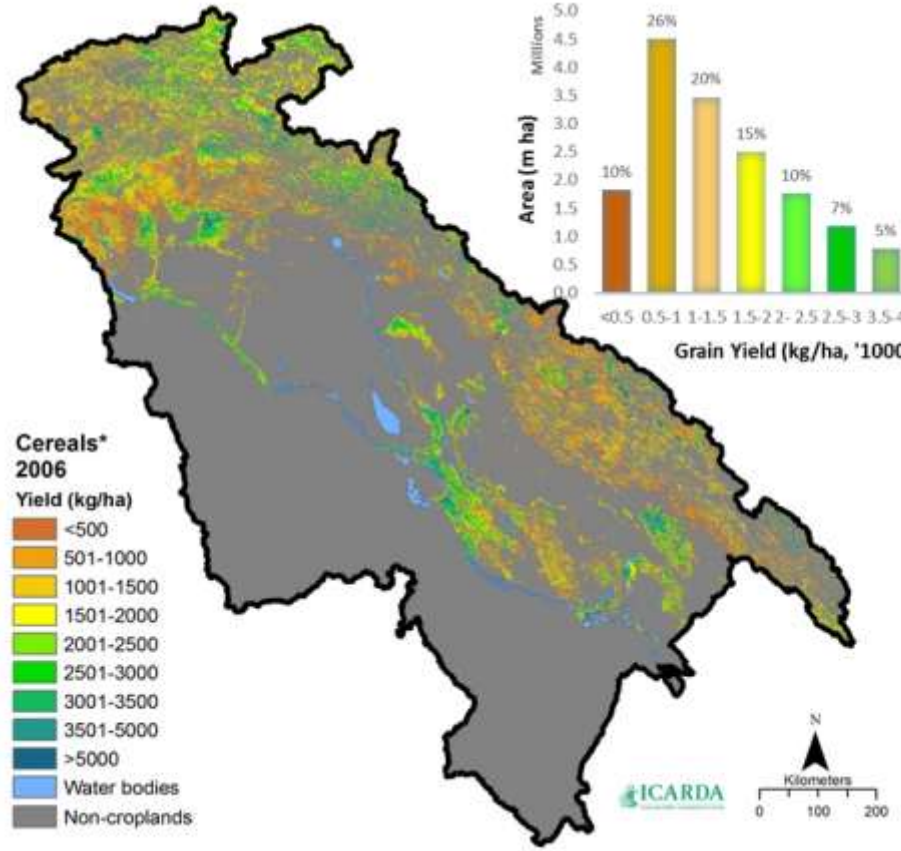
Field Data Collection



Quantification of Agricultural Productivity

Bridging the yield gaps





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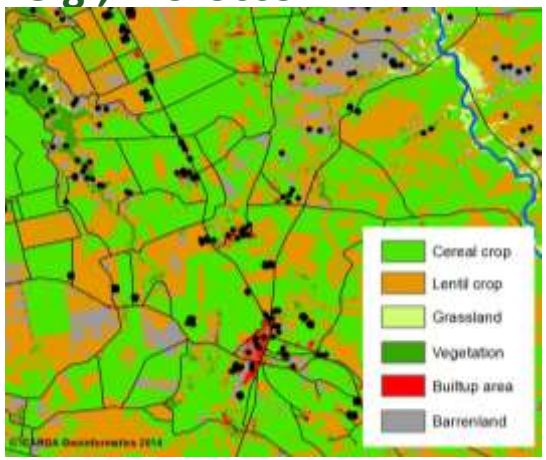
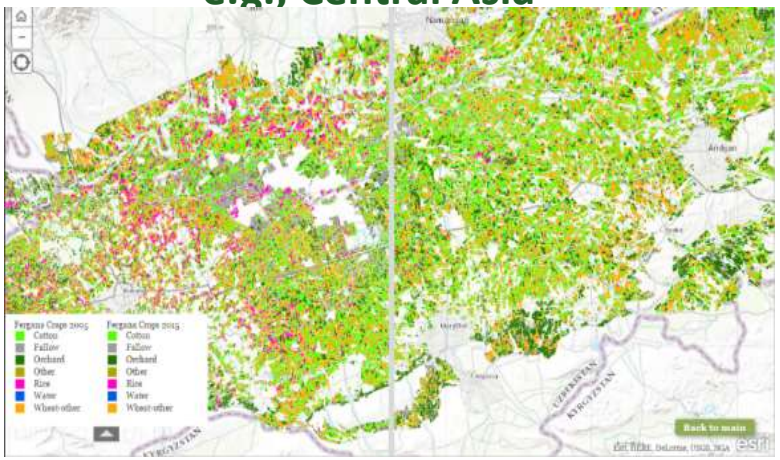
Crop types, sequence and productivity

Mapping crop types, sequence and water use

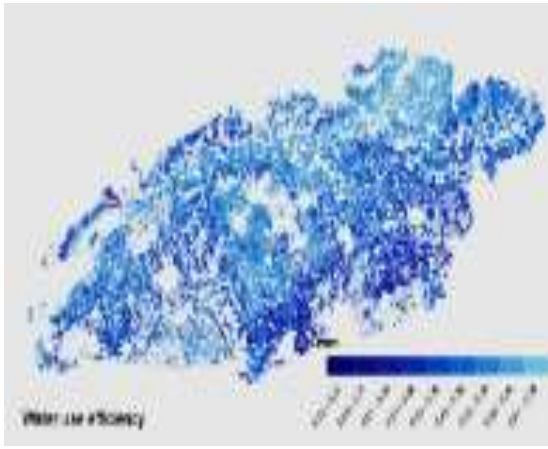
e.g., Morocco

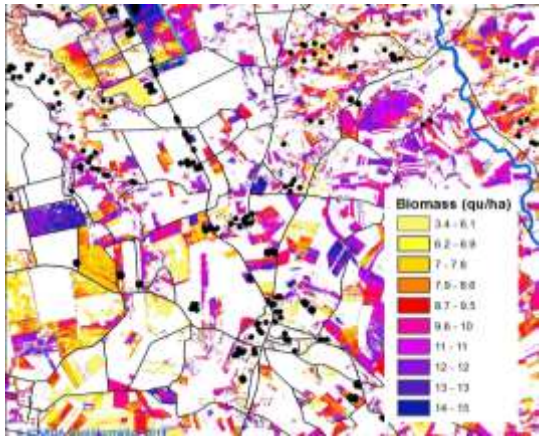


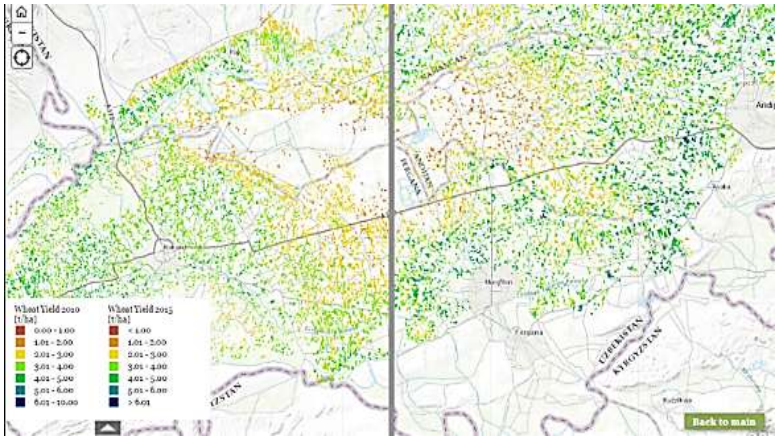
e.g., Central Asia

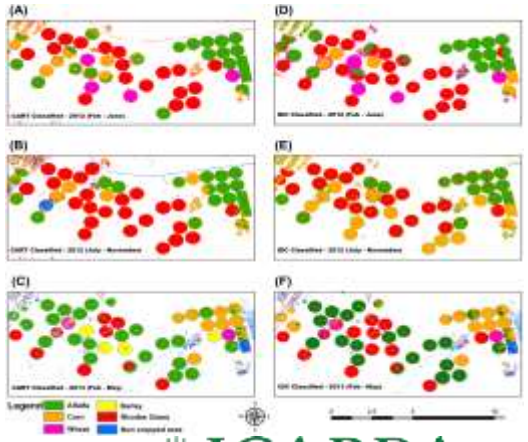


e.g., SA









Biradar et al., 2015; Low et al., 2016; Patil et al., 2016 ICARDA

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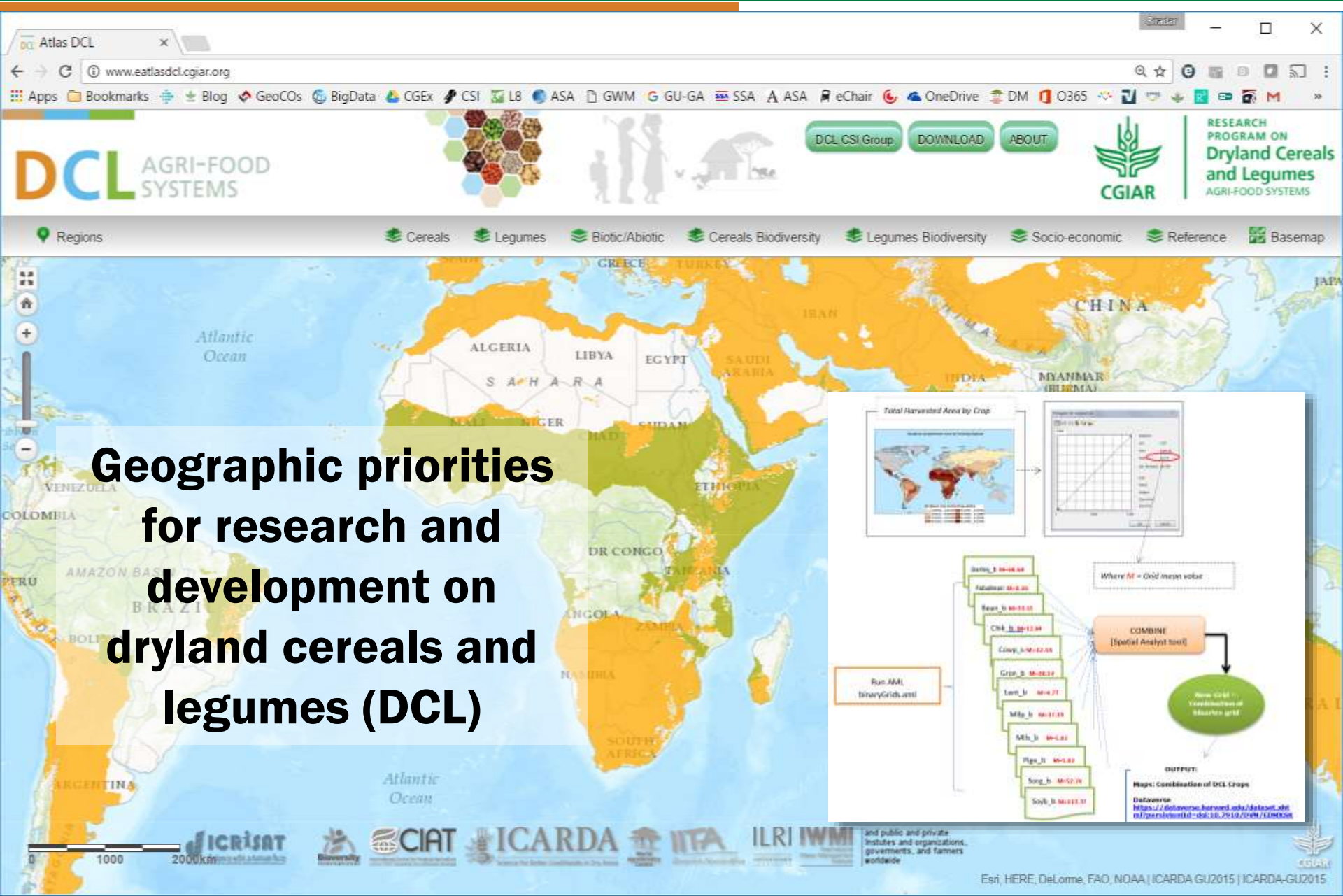
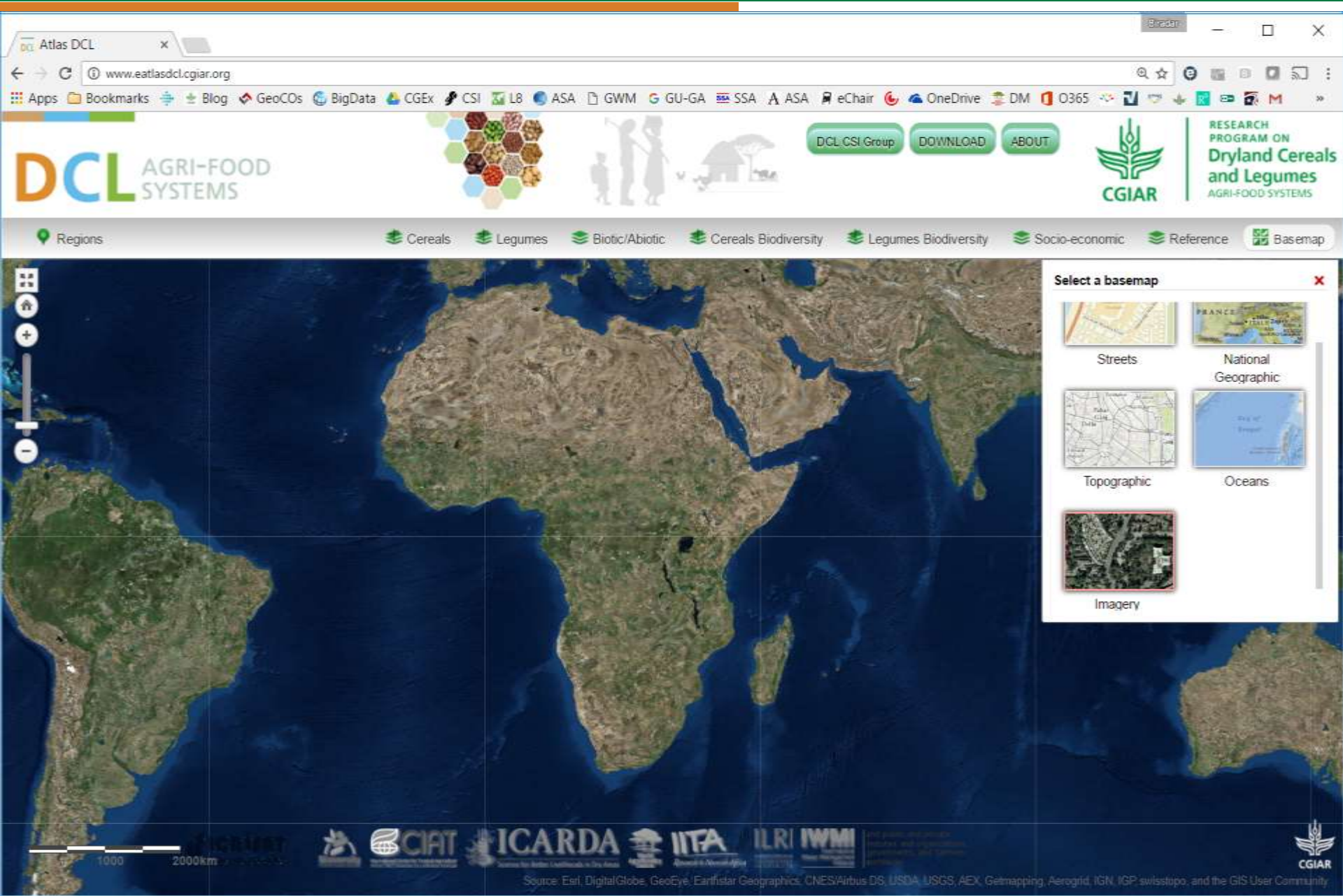
eAtlasDCL.cgiar.org

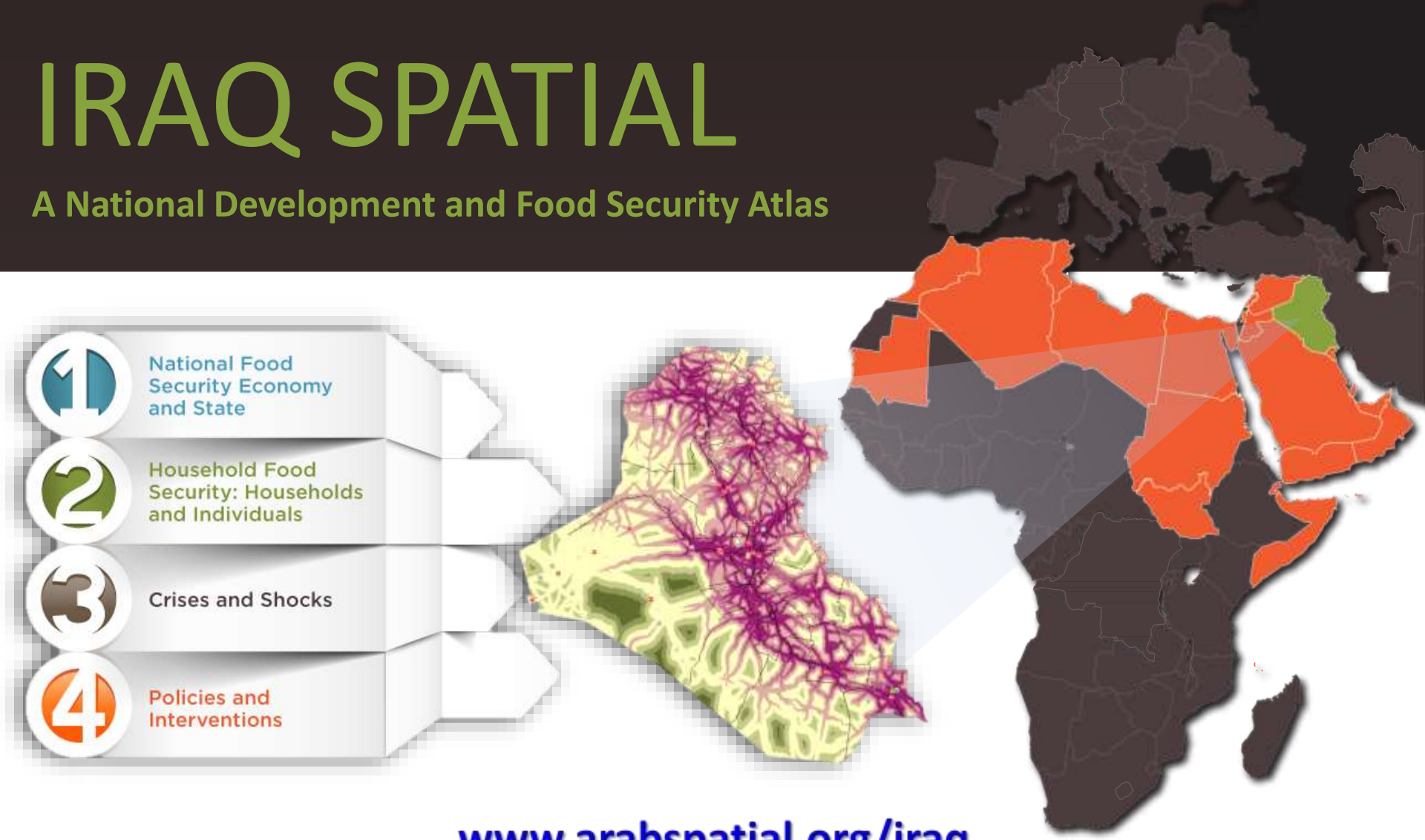


The DCL eAtlas www.eatlasdcl.cgiar.org



IRAQ SPATIAL

A National Development and Food Security Atlas



www.arabspatial.org/iraq

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IFPRI

USAID
FROM THE AMERICAN PEOPLE

Adoption and out scaling of Innovative Technologies:

e.g., Conservation Agriculture

- productivity
- employment
- enterprise

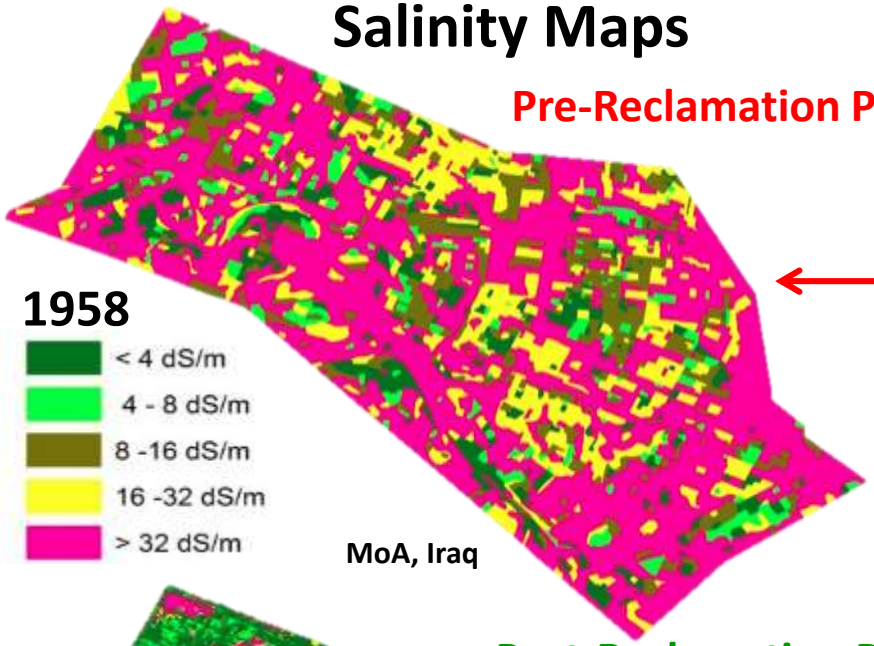
Suitability class	Area (km2)	Population	Density
Highly suitable	40,956	10,021,600	243
Medium suitable	28,870	5,081,674	174
Low suitable	24,083	2,929,224	122
Not suitable	576,076	9,471,688	16

Measuring Impact of Successful interventions

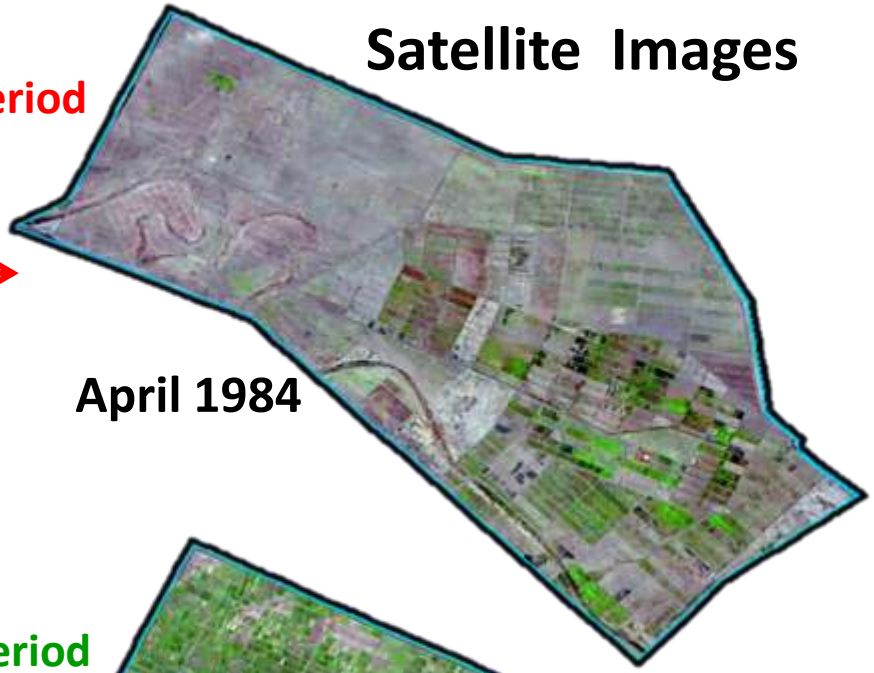
Soil Salinity, Dujaila, Iraq

Salinity Maps

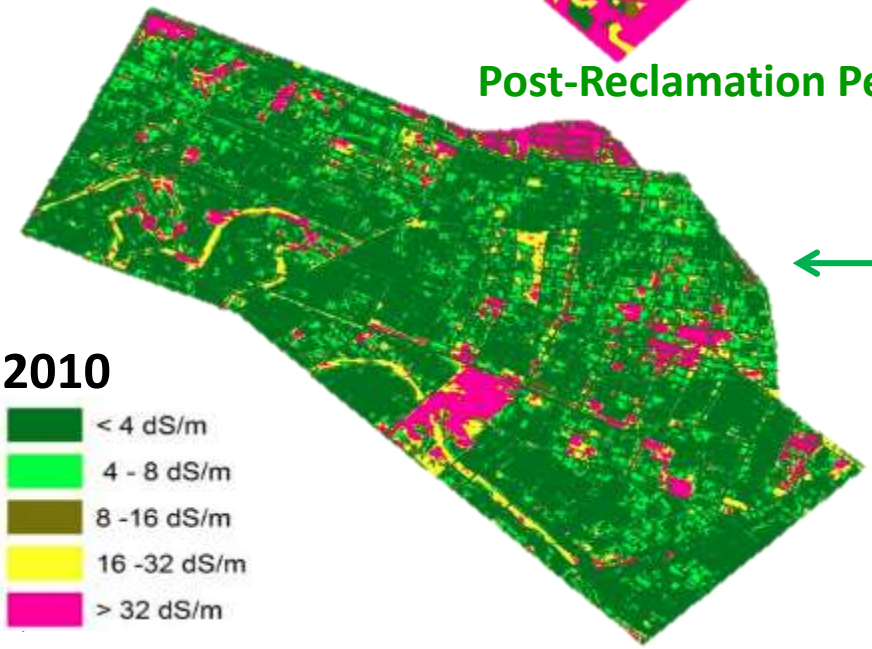
Pre-Reclamation Period

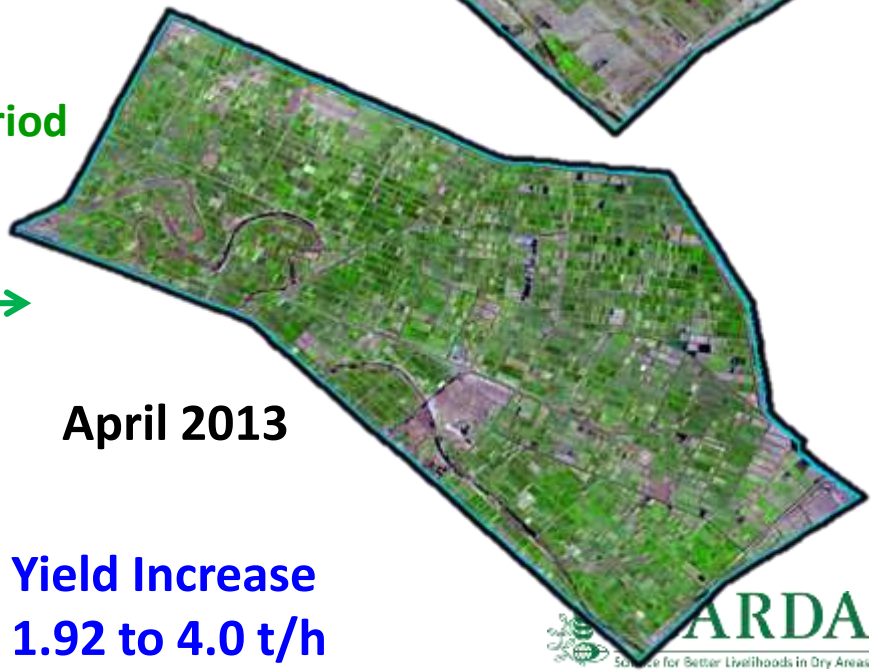


Satellite Images



Post-Reclamation Period





Yield Increase
1.92 to 4.0 t/h

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Geoinformatics in Sustainable Agro-Ecosystems

geoagro.icarda.org

- Ag-Intensification
- Digital Agriculture
- Wheat out-scaling
- CA Adoption
- Thematic Research
- Cereals-Legume System
- Pests & Disease Risks
- Land Degradation
- Crop modelling
- Watershed management
- Climate Change
- System Modelling
- Big-data Analytics

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