ICARDA

Science for resilient livelihoods in dry areas

The Tools and Framework of the DryArc Interface

The Mapping Tool (MT)

Spatial Innovations for economically and ecologically viable solutions

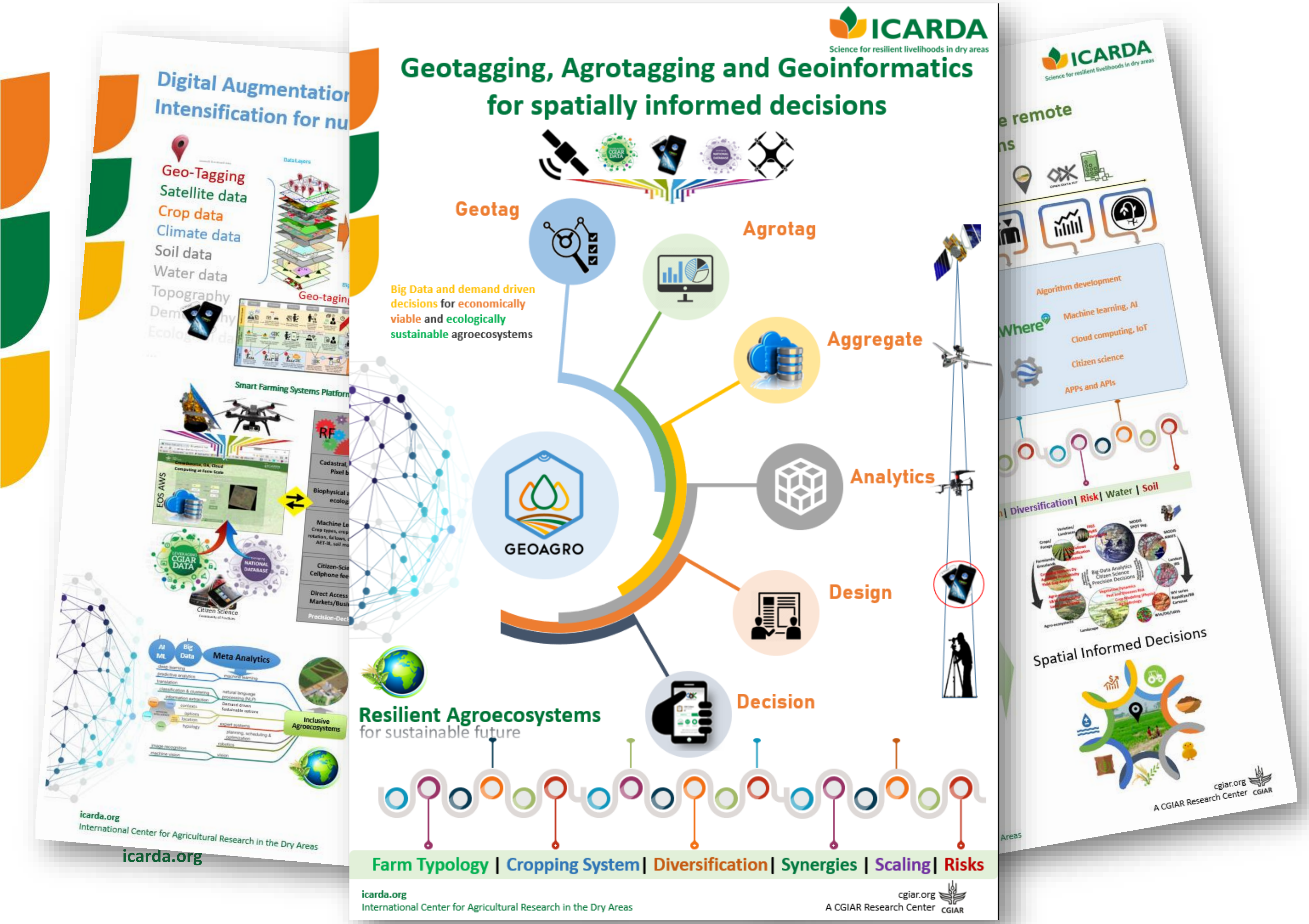
Chandrashekhar Biradar

First DryArc Workshop
25 Feb, 2019, Cairo, Egypt

GEOAGRO GBDX amazon web services Leaflet esri Google Earth Engine CGIAR

Platform for Big Data in Agriculture

CGIAR CSI Consortium for Spatial Information


ICARDA
Science for resilient livelihoods in dry areas
Geotagging, Agrotagging and Geoinformatics
for spatially informed decisions
Geotag
Agrotag
Aggregate
Analytics
Design
Decision
Big Data and demand driven decisions for economically viable and ecologically sustainable agroecosystems
GEOAGRO
Resilient Agroecosystems
for sustainable future
Farm Typology | Cropping System | Diversification | Synergies | Scaling | Risks
icarda.org
International Center for Agricultural Research in the Dry Areas
cgiar.org
A CGIAR Research Center
Digital Augmentation
Intensification for nu
Geo-Tagging
Satellite data
Crop data
Climate data
Soil data
Water data
Topography
Smart Farming Systems Platform
Meta Analytics
Inclusive Agroecosystems
icarda.org
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Algorithm development
Machine learning, AI
Cloud computing, IoT
Citizen science
APPs and APIs
Where
Diversification | Risk | Water | Soil
Spatial Informed Decisions
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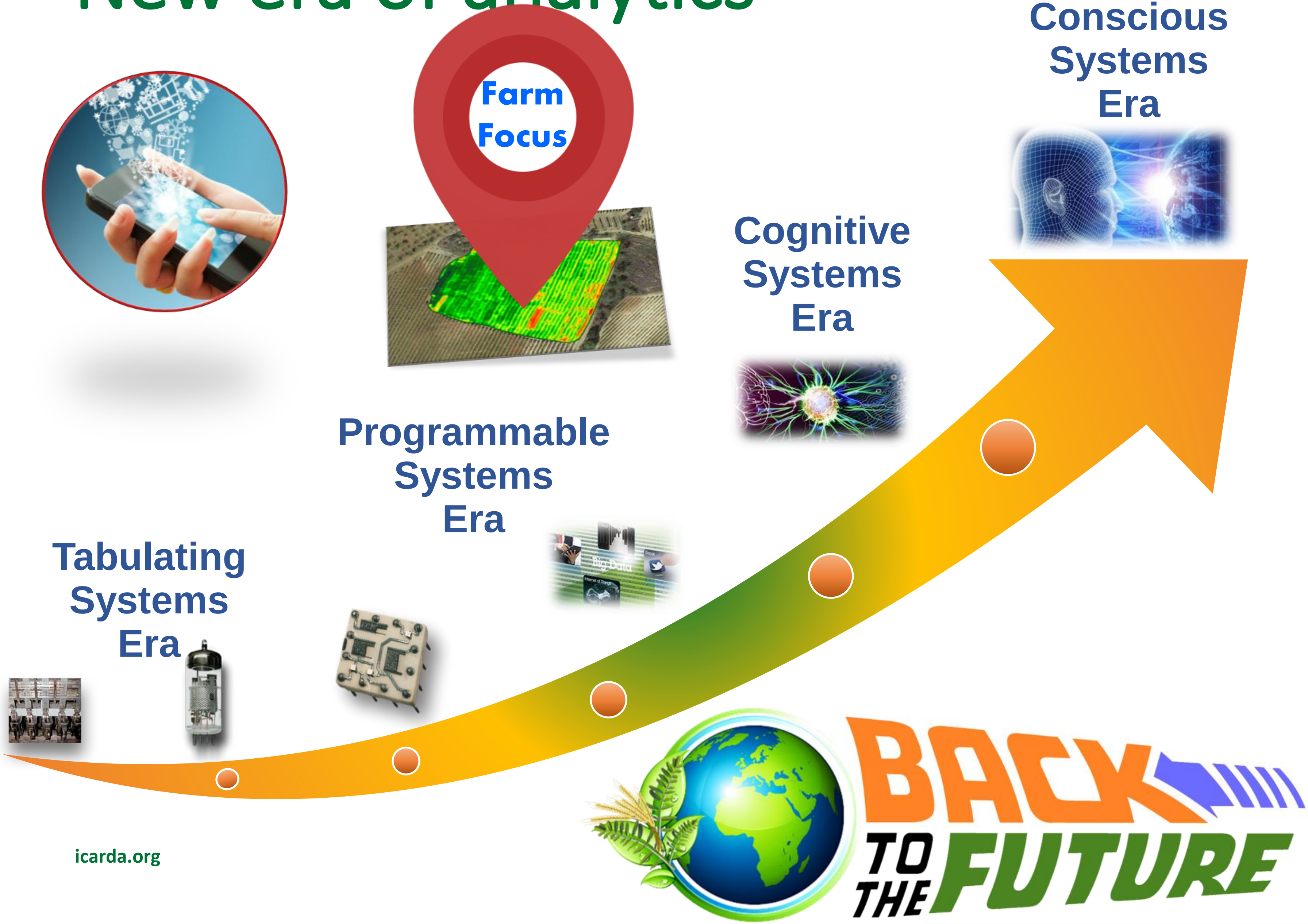
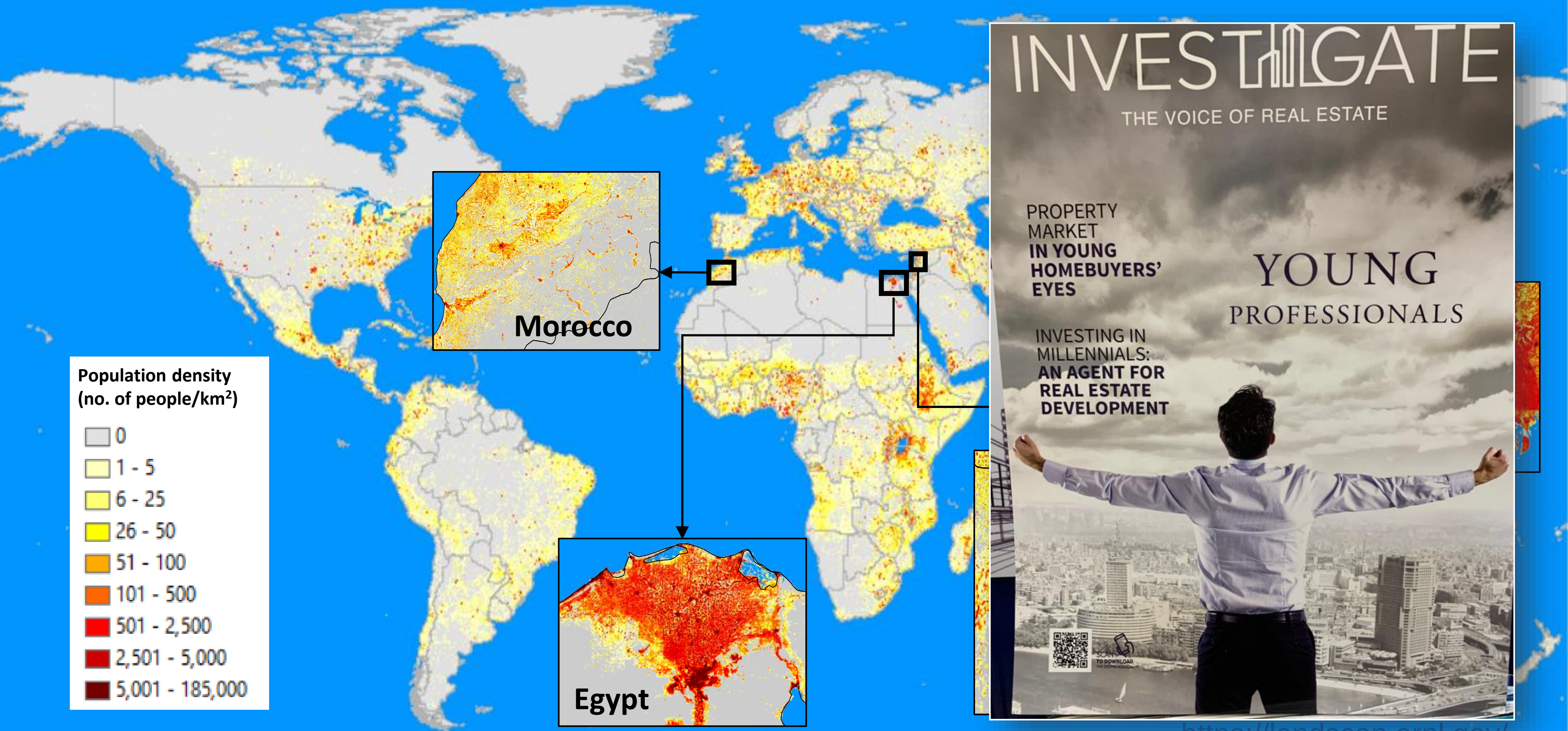
New era of analytics



Changing demography and diets

It's estimated nearly 1.5 billion people will be on "move" in next 5-10 years time

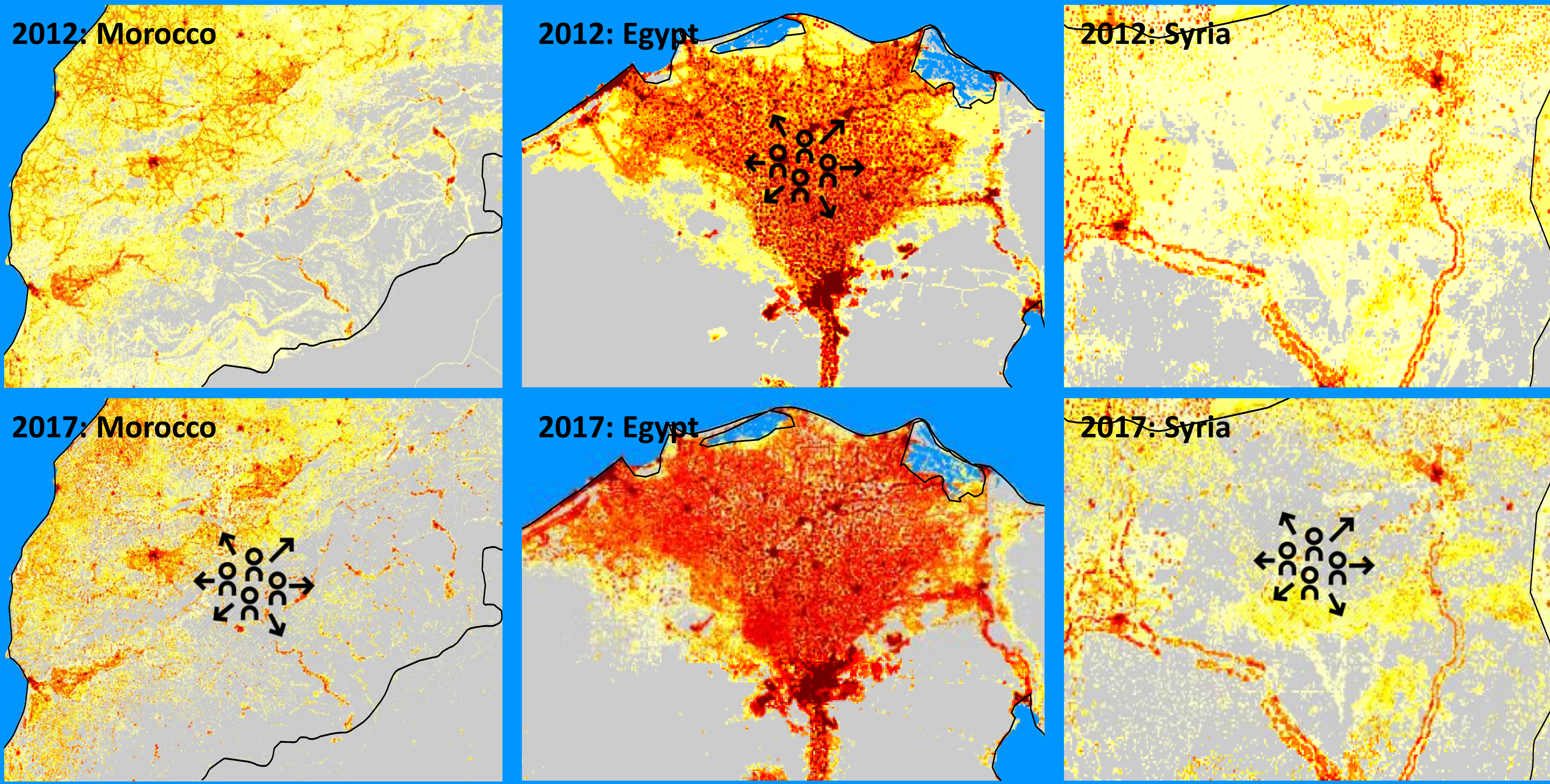
Agricultural areas
Drylands and degraded areas



https://landscan.ornl.gov/

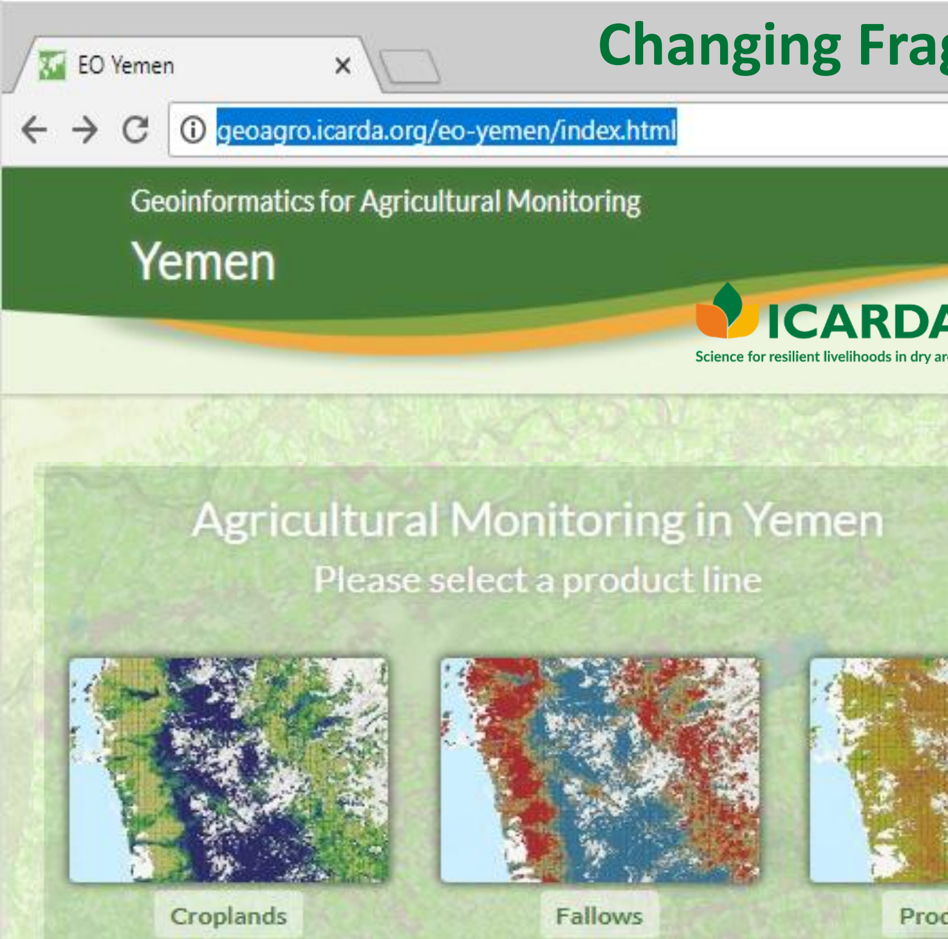
Changing demography and diets

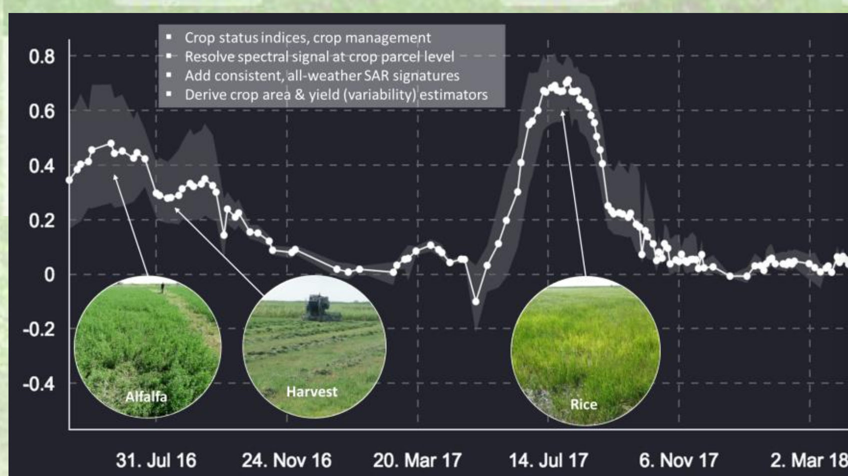
Migration and aggregated expansion

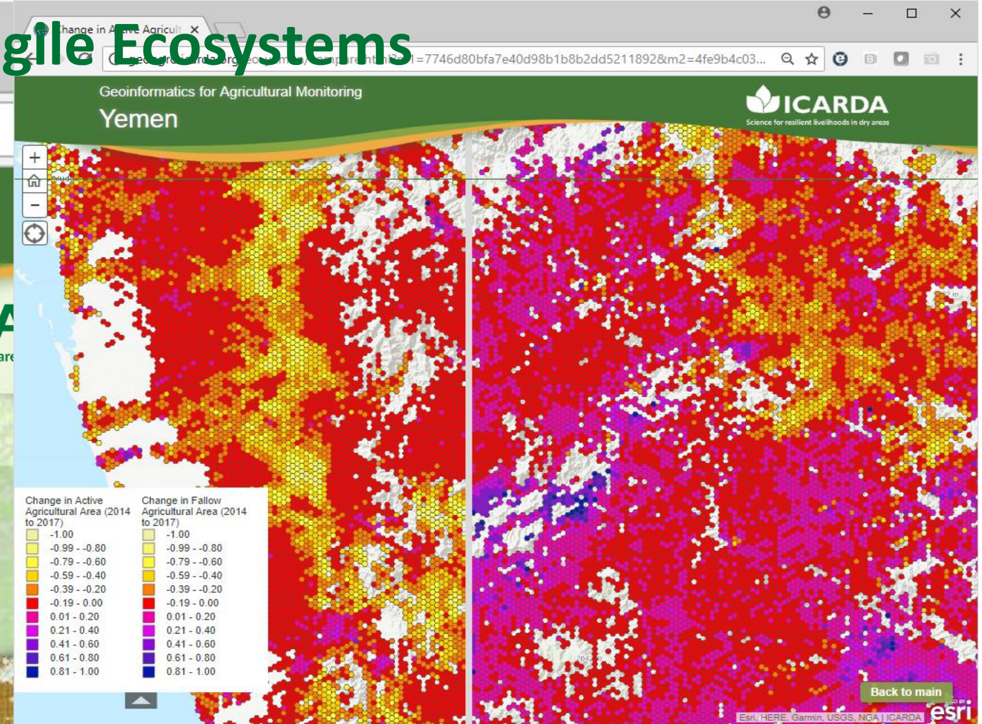


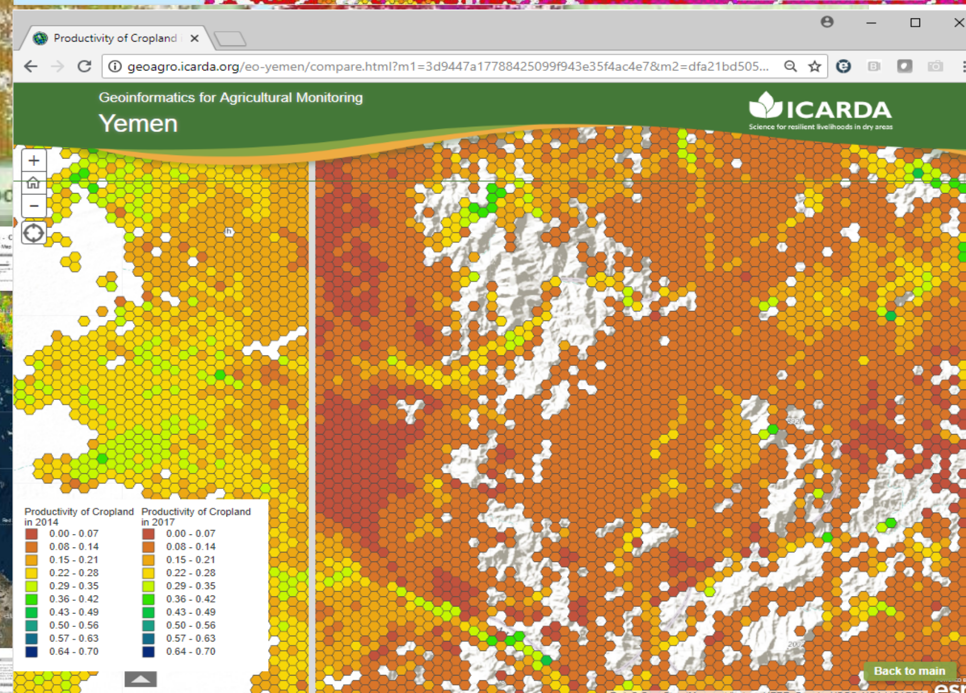
Shrinking in agriculture lands and expanding in urban landscapes

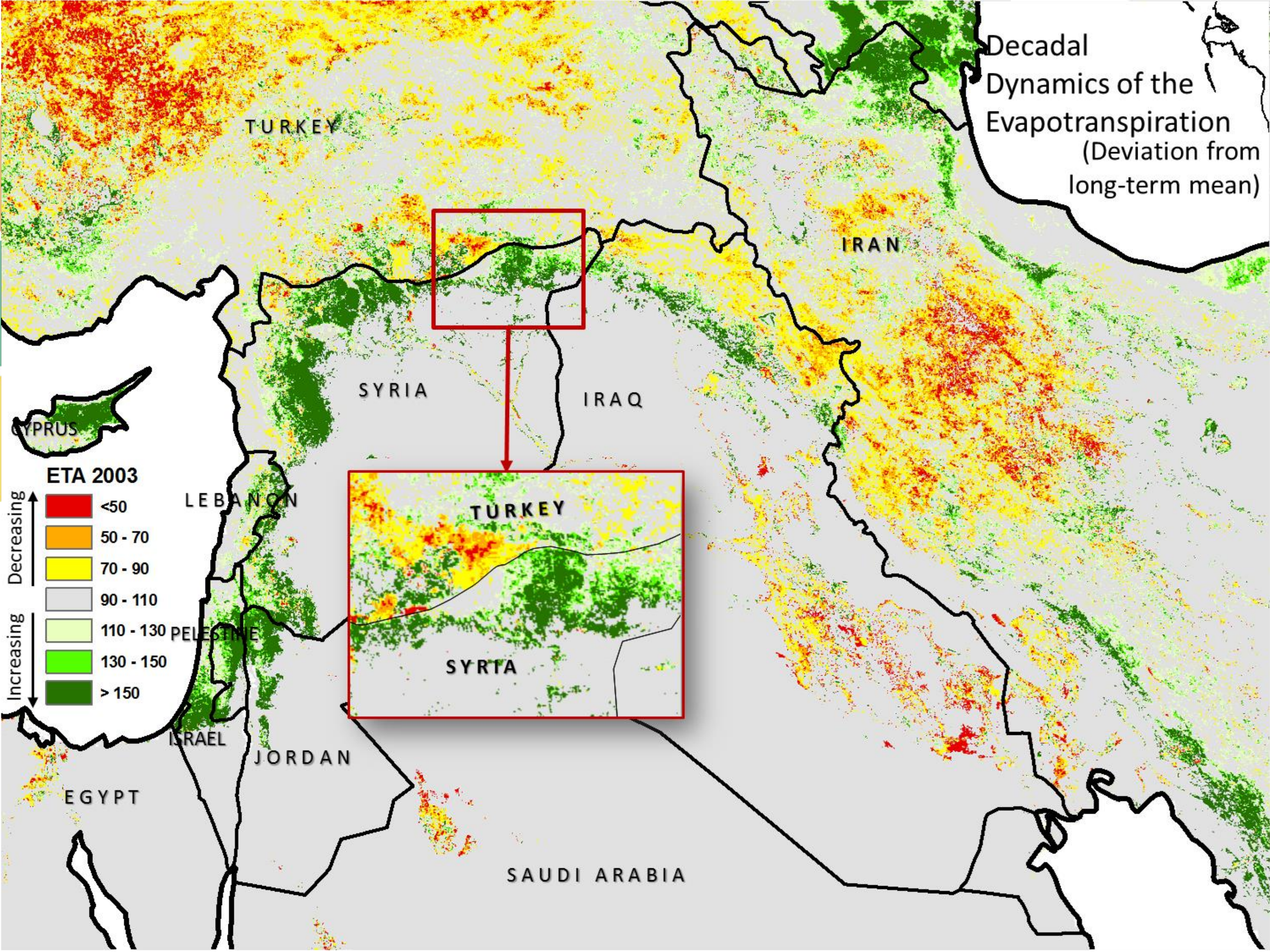
Changing Fragile Ecosystems

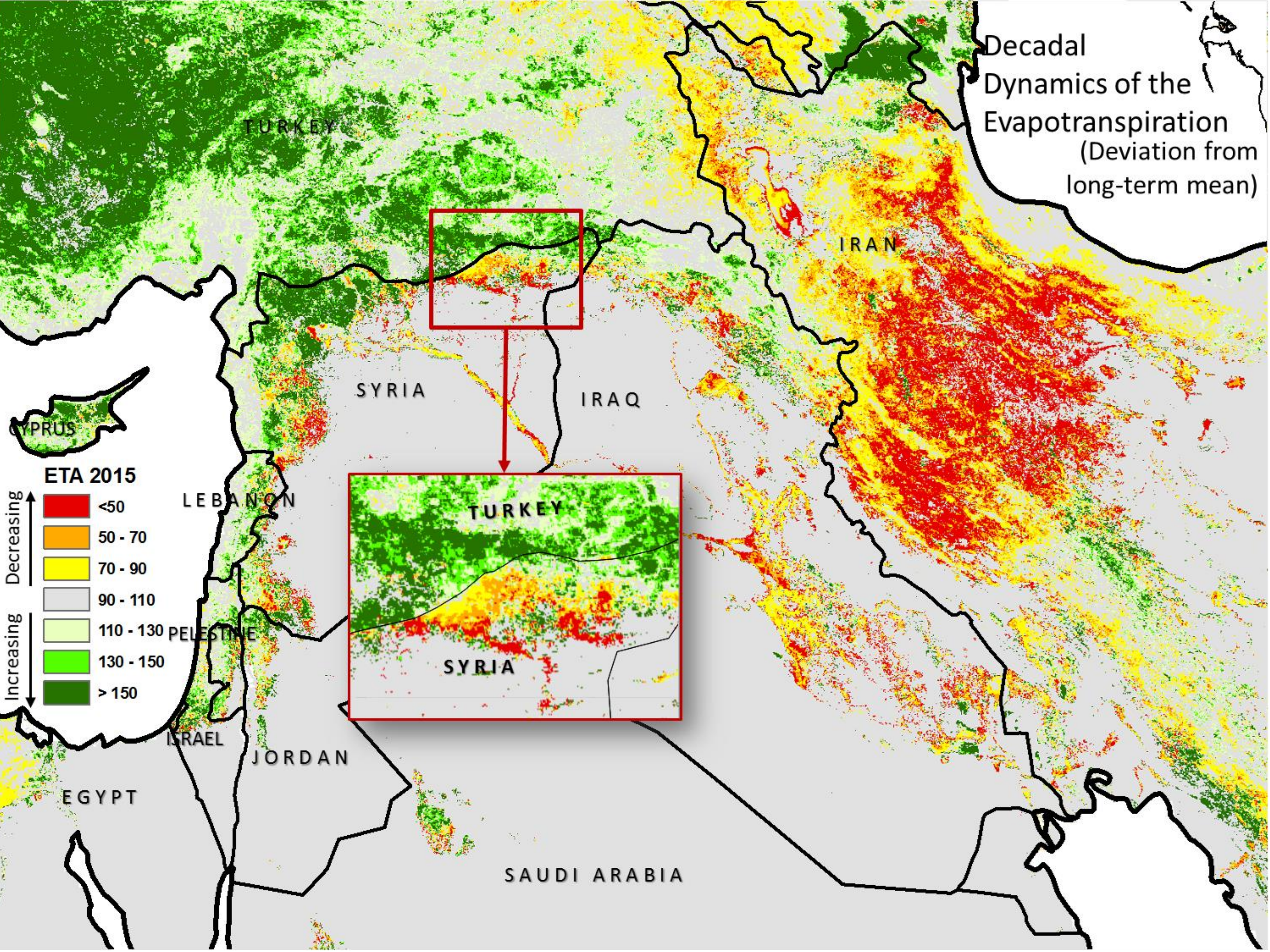









Decadal Dynamics of the Evapotranspiration
(Deviation from long-term mean)
TURKEY
IRAN
SYRIA
IRAQ
CYPRUS
LEBANON
PELESTINE
ISRAEL
JORDAN
EGYPT
SAUDI ARABIA
TURKEY
SYRIA
ETA 2003
Decreasing
Increasing
<50
50 - 70
70 - 90
90 - 110
110 - 130
130 - 150
> 150


Decadal Dynamics of the Evapotranspiration
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TURKEY
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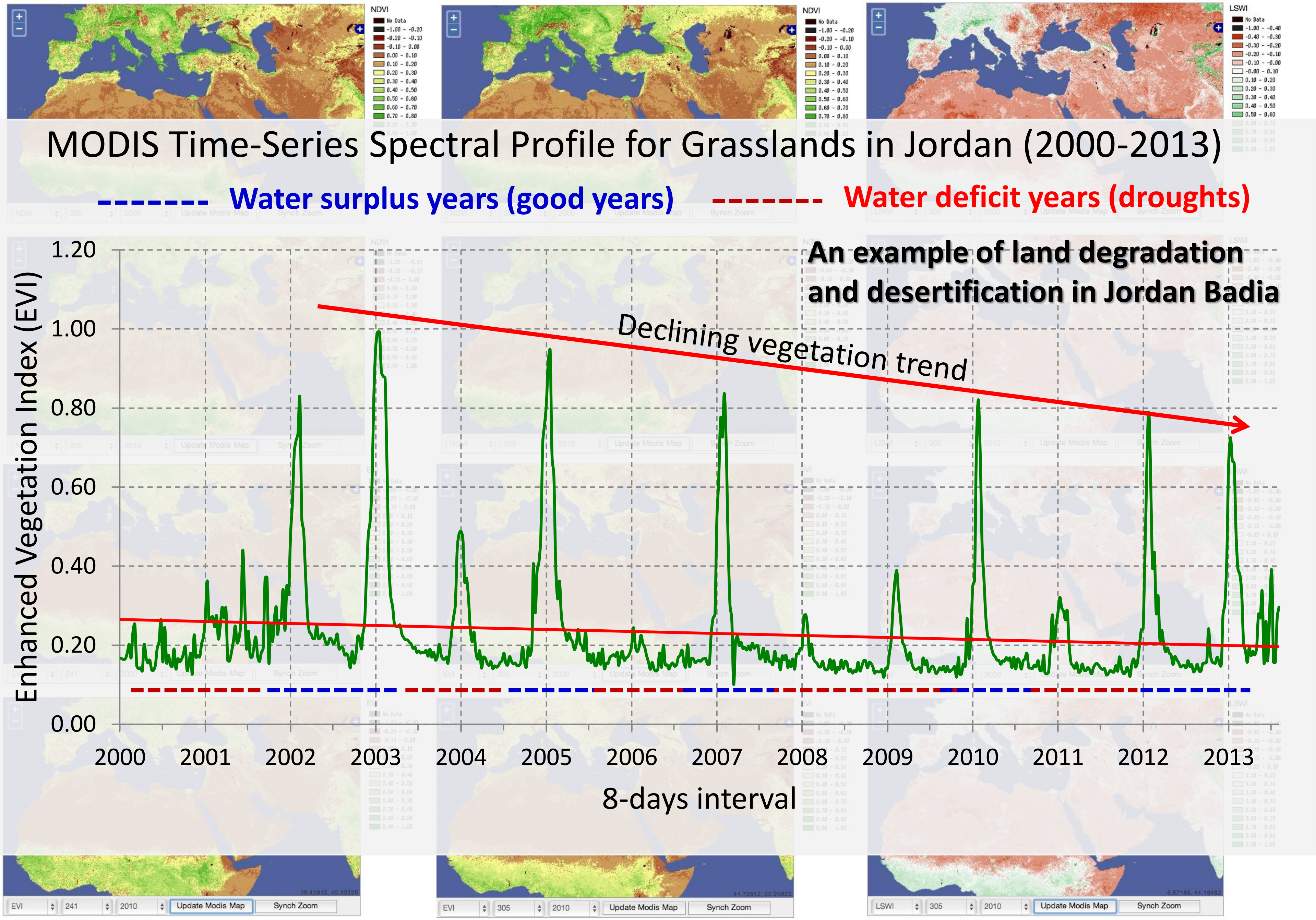
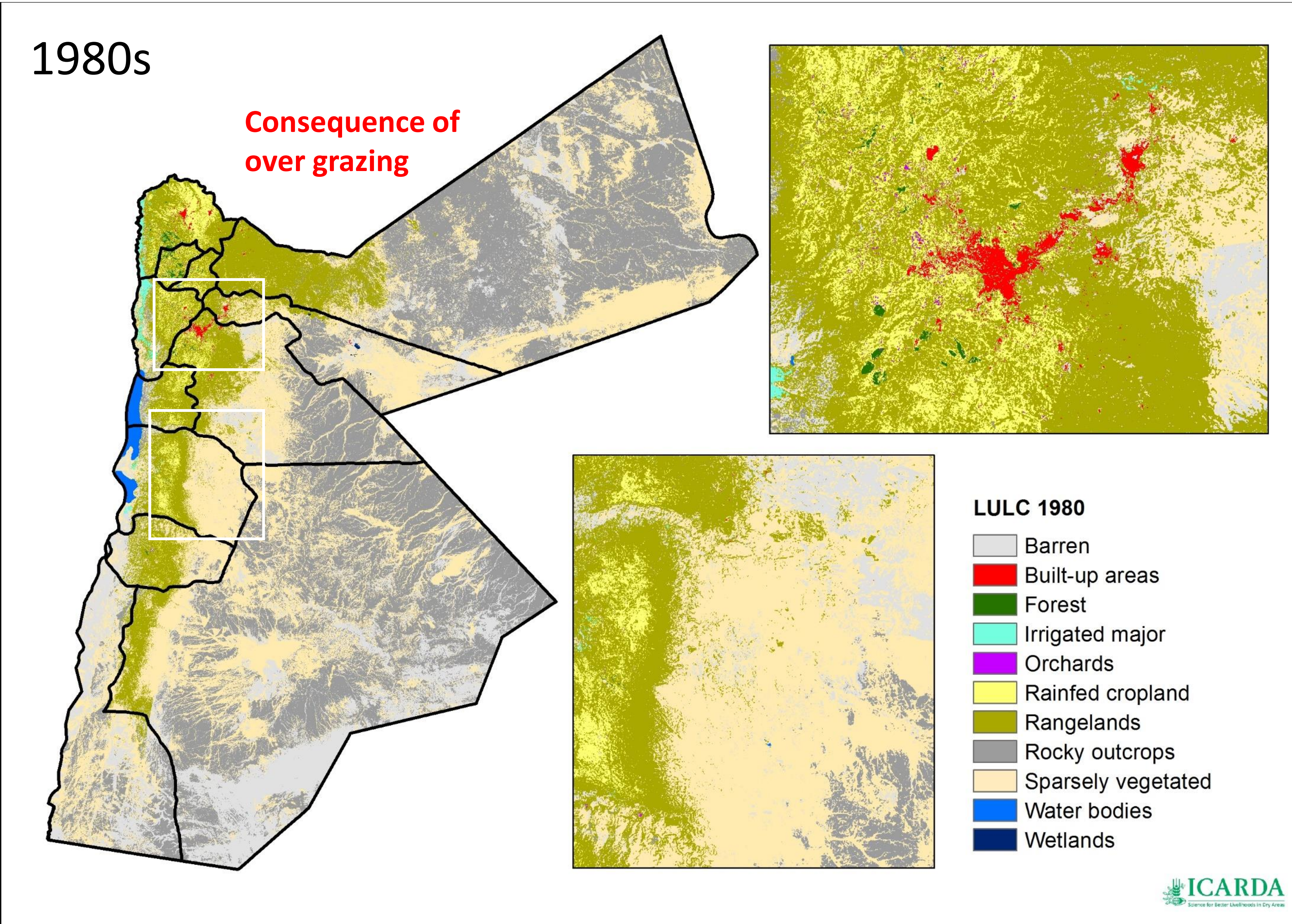
LEBANON
PELESTINE
ISRAEL
JORDAN
EGYPT
SAUDI ARABIA
ETA 2015
Decreasing
Increasing
<50
50 - 70
70 - 90
90 - 110
110 - 130
130 - 150
> 150
TURKEY
SYRIA

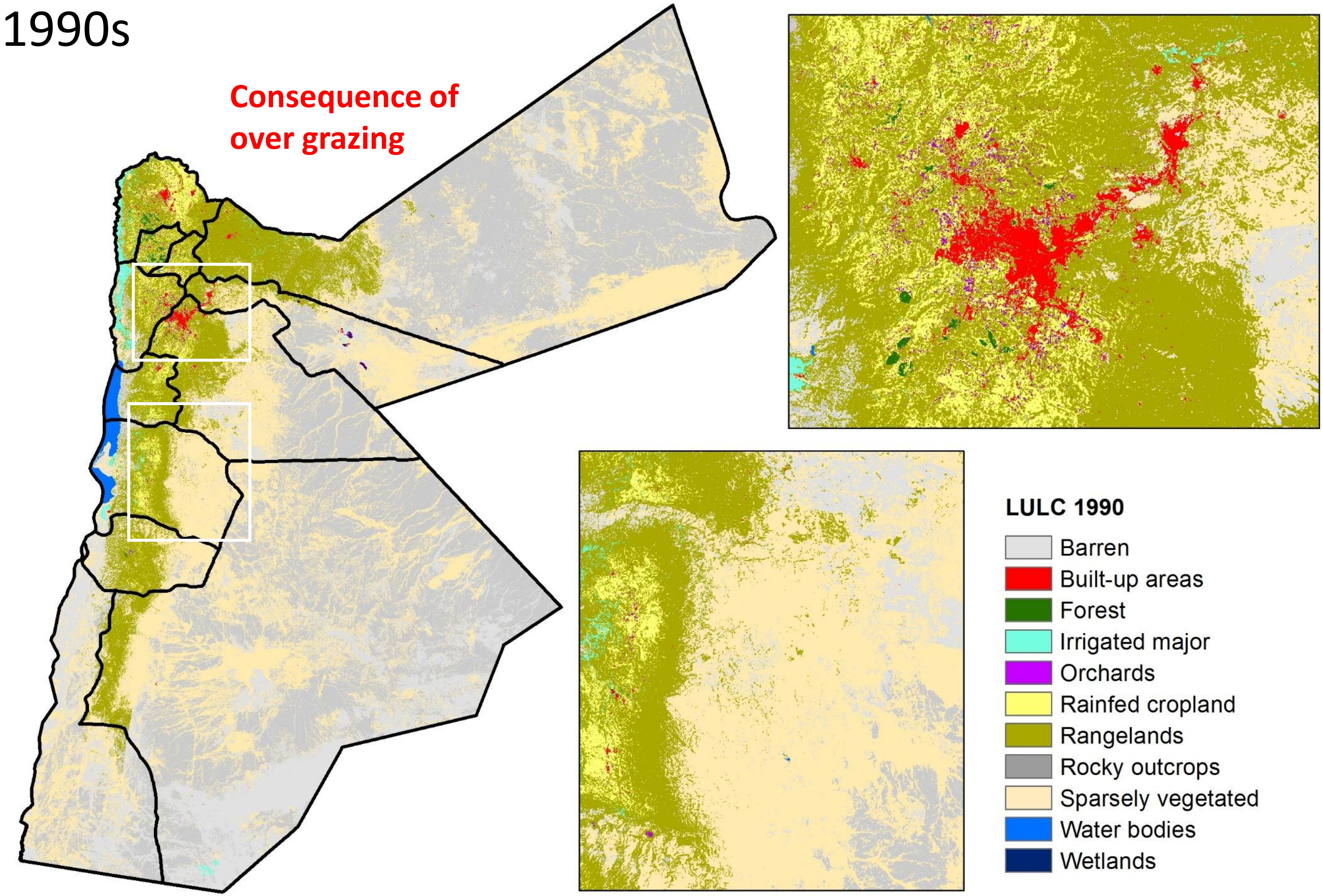
Changing land productivity



Changing Land Use and Land Degradation



Changing Land Use and Land Degradation



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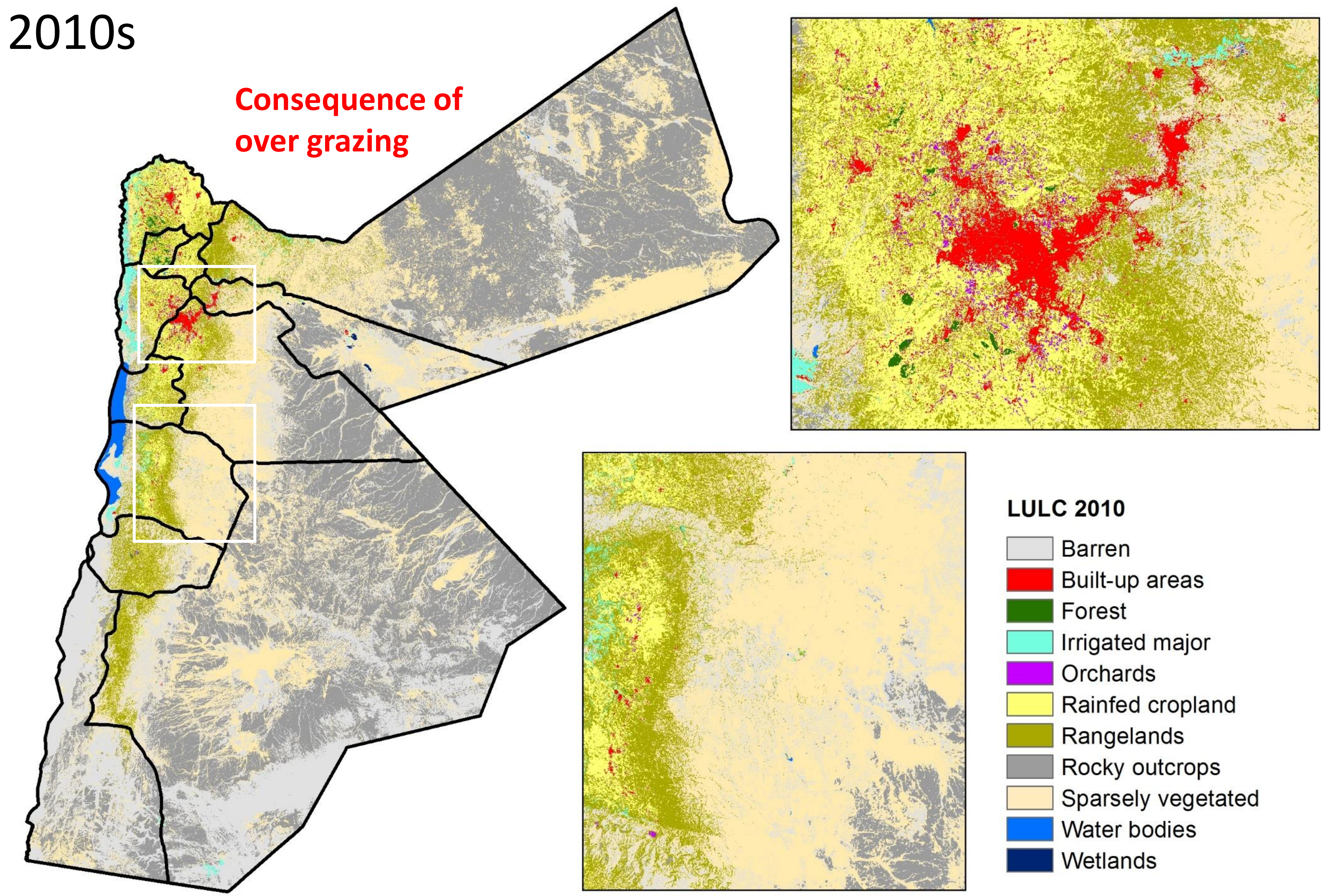
Changing Land Use and Land Degradation



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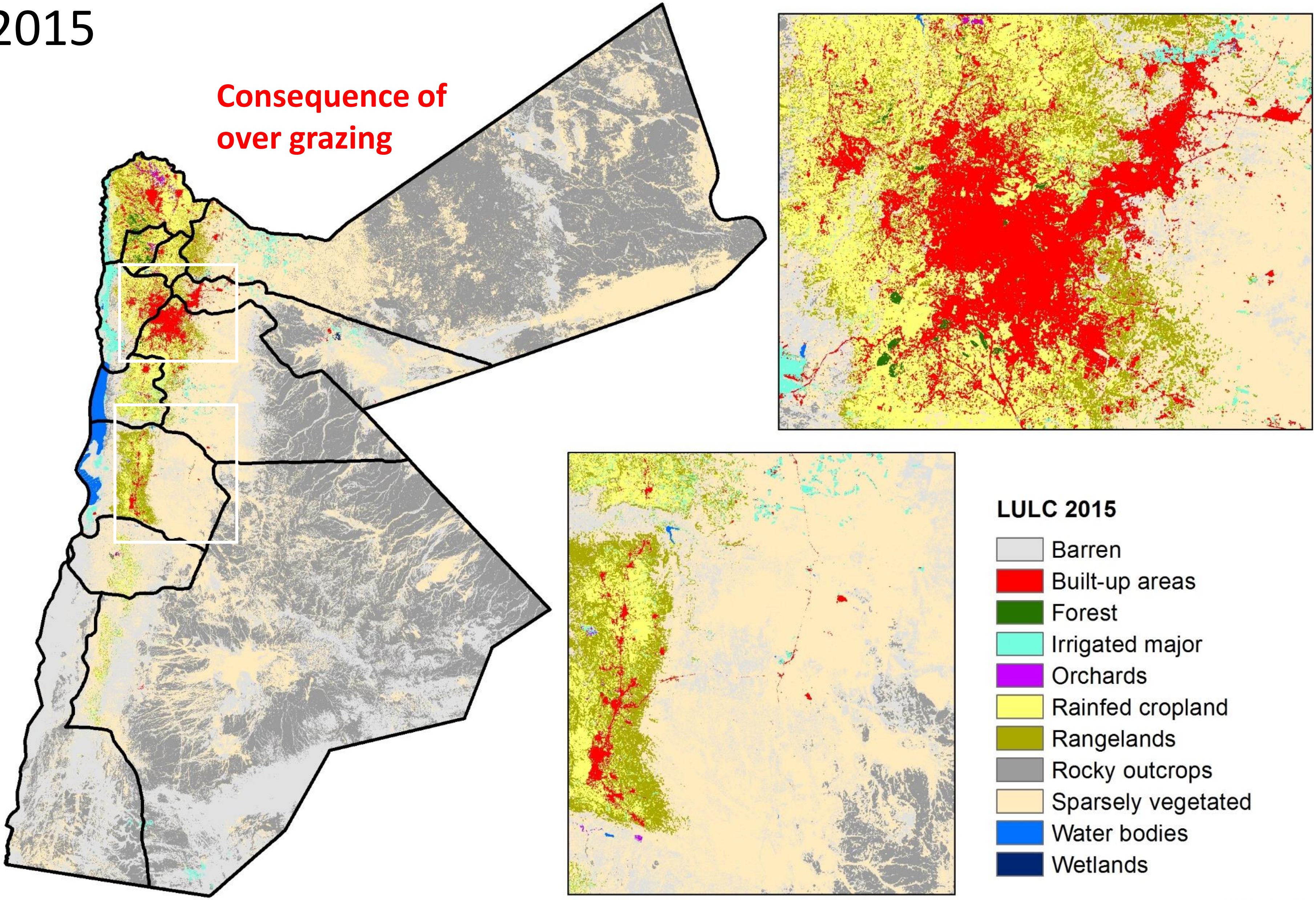
Changing Land Use and Land Degradation

2015

Consequence of over grazing



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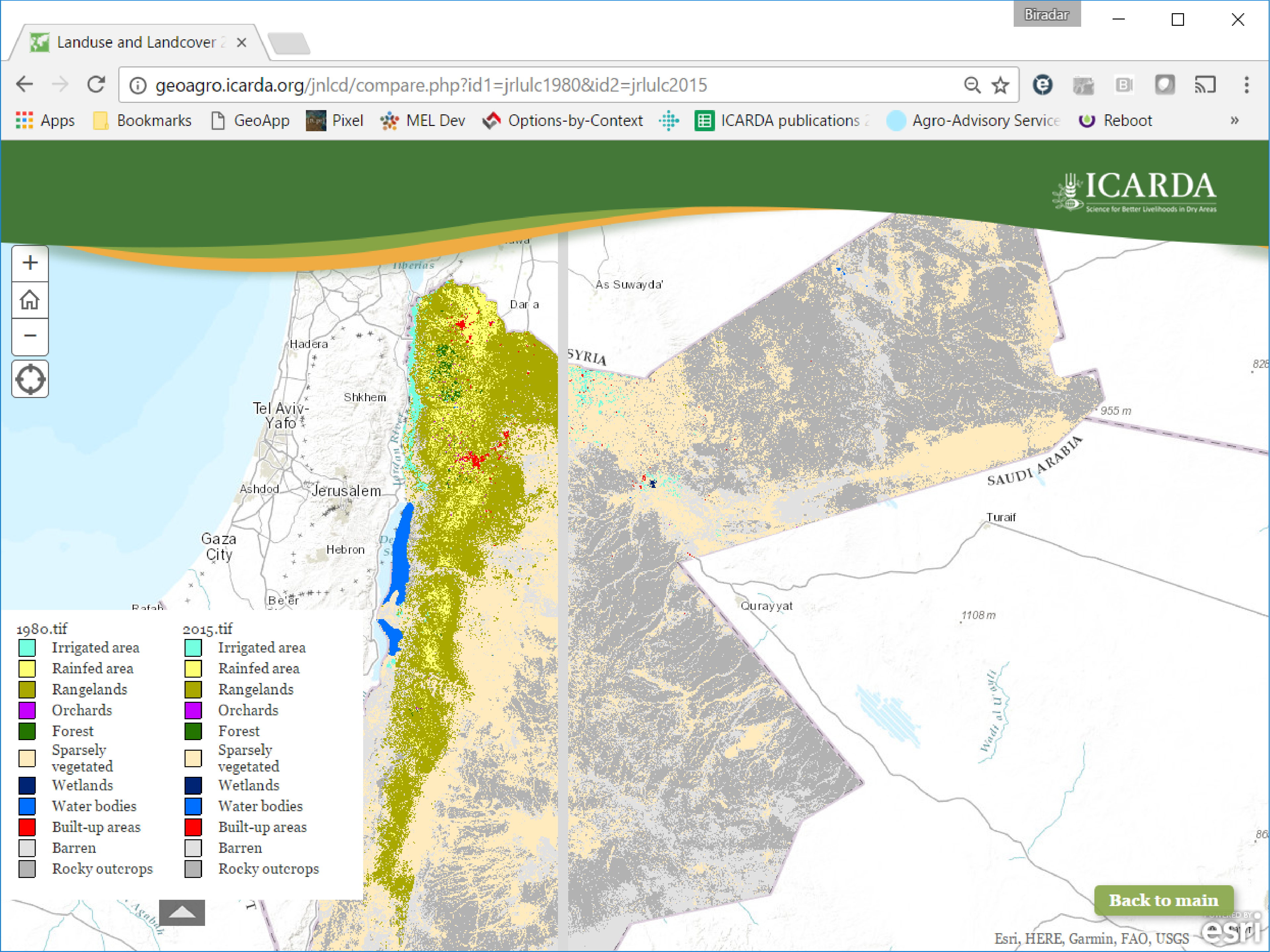
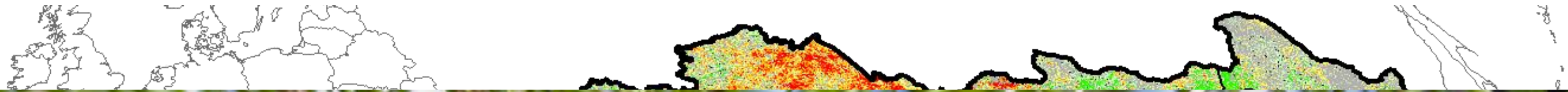
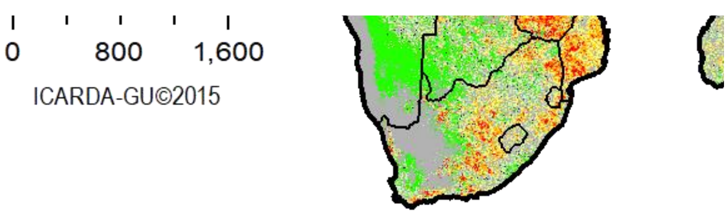


Landuse and Landcover
Biradar
geoagro.icarda.org/jnlcd/compare.php?id1=jrlulc1980&id2=jrlulc2015
Apps
Bookmarks
GeoApp
Pixel
MEL Dev
Options-by-Context
ICARDA publications
Agro-Advisory Service
Reboot
ICARDA
Science for Better Livelihoods in Dry Areas
Tiberias
Dar a
As Suwayda'
Hadera
SYRIA
Shkhem
Tel Aviv-Yafo
Jordan River
955 m
SAUDI ARABIA
Ashdod
Jerusalem
Turaif
Gaza City
Hebron
Be'er
Qurayyat
1108 m
Wadi al U'ayli
1980.tif
Irrigated area
Rainfed area
Rangelands
Orchards
Forest
Sparsely vegetated
Wetlands
Water bodies
Built-up areas
Barren
Rocky outcrops
2015.tif
Irrigated area
Rainfed area
Rangelands
Orchards
Forest
Sparsely vegetated
Wetlands
Water bodies
Built-up areas
Barren
Rocky outcrops
Back to main
Esri, HERE, Garmin, FAO, USGS
esri

Changing Water Balance

Frequent deviation from long-term averages





- Large fluctuation in water balance
- Climate variability and extreme events
- Dominance of mono-cropping / few commodity focus
- Depleted soil organic carbon

Changing diet pattern >> cropping systems

Sustainable alternatives for future food

Pulses for the people and planet

Daal/Falafal	Chicken	Mutton	Beef
1,250lt	4,325	5,520	13,000

[mixed crops, livestock, fish and trees]

Resilient Agroecosystems
for sustainable future

Building inclusive production systems for economically viable and ecologically sustainable agroecosystems

- more crop per drop ; more yield per acre
- in a inch of land and a bunch of crop

-multi dimensions
-integrated systems
-compound productivity

Big Data driven decisions (space & time) for better strategy for investment, intervention, implementation and impact

Ecological intensification
Target specific interventions
Bridging the gaps
Inputs use efficiency
Agricultural policy
Halt degradation
Technology scaling

- food and nutritional security
- resilience and risk reduction
- agro-ecosystem sustainability
- adaption and mitigation
- citizen science and collective actions
- Equitable trade and social security

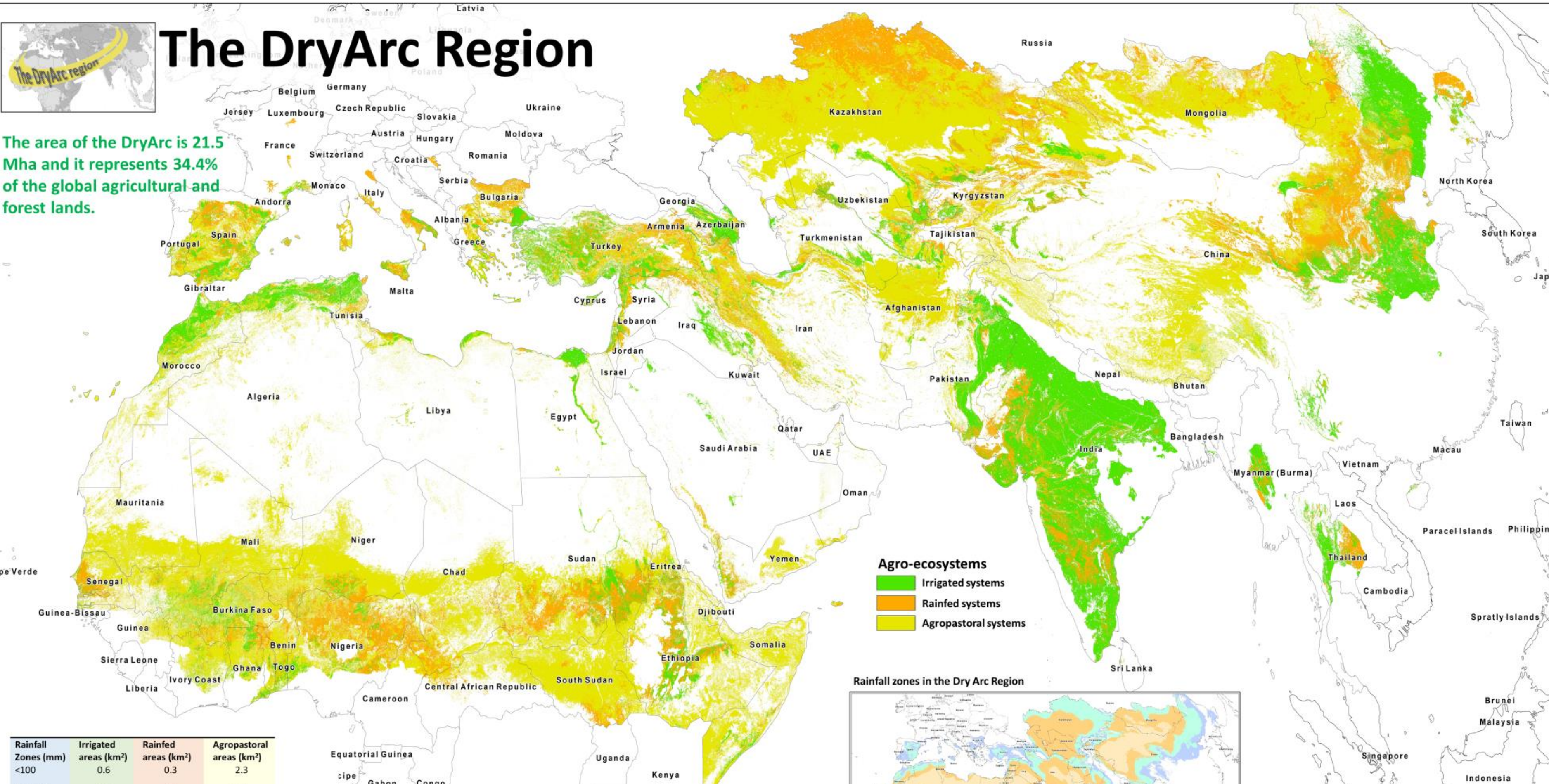
Food and Nutrition

<<<more health per acre>>>

people, animals and soil

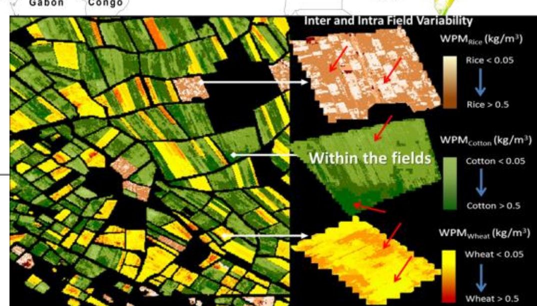
The DryArc Region

The area of the DryArc is 21.5 Mha and it represents 34.4% of the global agricultural and forest lands.



Rainfall Zones (mm)	Irrigated areas (km²)	Rainfed areas (km²)	Agropastoral areas (km²)
<100	0.6	0.3	2.3
100-250	1.5	1.8	13.9
251 to 450	3.3	6.8	14.0
451 to 650	4.3	4.7	6.0
> 651	16.9	10.0	13.7
Total	26.5	23.6	49.9

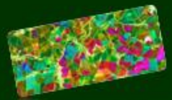
ICARDA ICRISAT IFPRI IWMI WorldFish



Earth Observation and BIG DATA…

Earth Observation Systems for Agro-Ecosystem Research

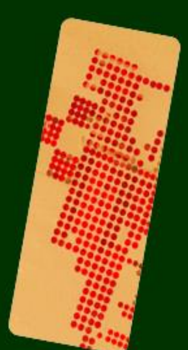
ACTIVE SATELLITE SENSORS AND CHARACTERSTICS



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

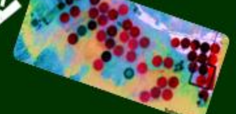
Medium resolution (5 - 30 m)

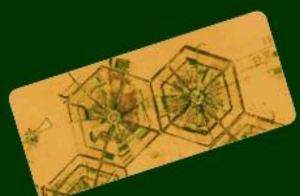
Satellite	Multispectral resolution (m)	B, s	Swath width (km)
ASTER (15m)			
VNIR (Visible Near Infrared)	15	VIR (4)	60
SWIR (Shortwave Infrared)	30	SW (6)	60
TIR (Thermal Infrared)	60	TIR (5)	60
CBERS - 2			
WFI	260	R, IR	890
CCD	20	B, G, R, IR	113
IRMSS	(2.7)	P-	27
LANDSAT 5TM -7ETM	30 (14.8)	B, G, 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			
COSMO-SKYMED 4	1, 5, 15, 30, 100	X-B (HH, VV, HV, VH)	10, 40, 30, 100, 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

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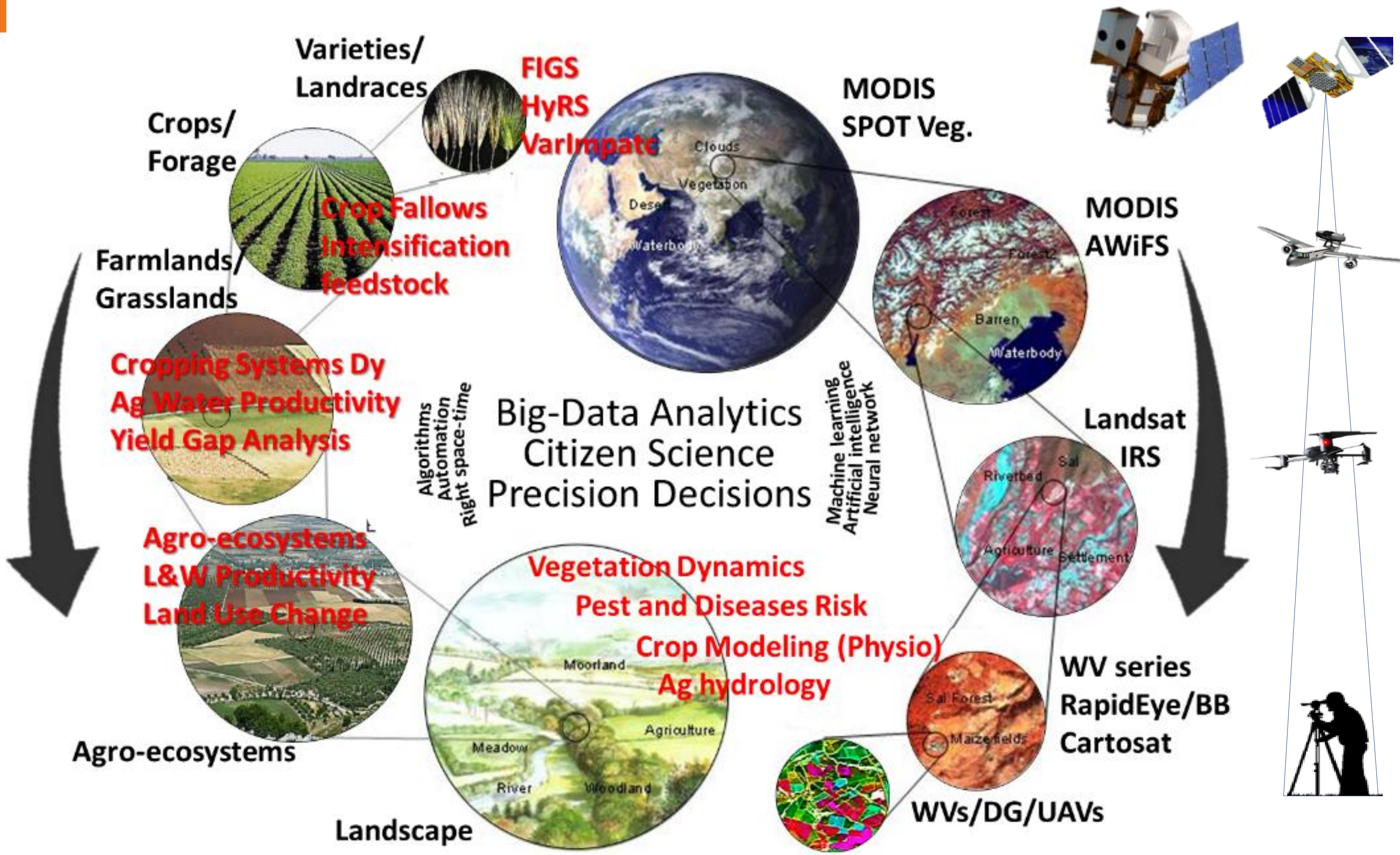
Science for Better Livelihoods in Dry Areas

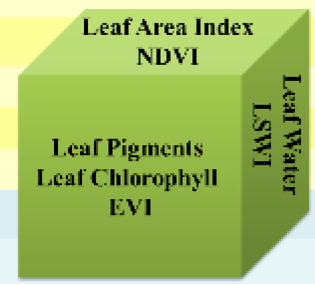
Cross-cutting disciplines and trade offs



Cross-cutting disciplines and trade offs

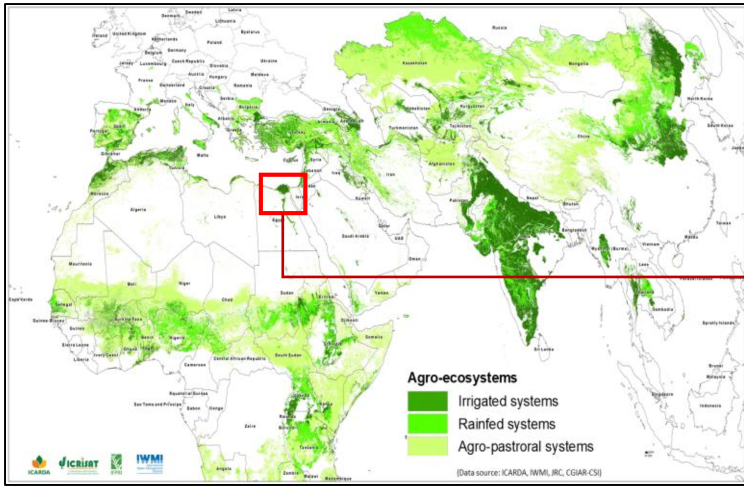
Example of One Sensor in each Platform/Scale

	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			×				×		×

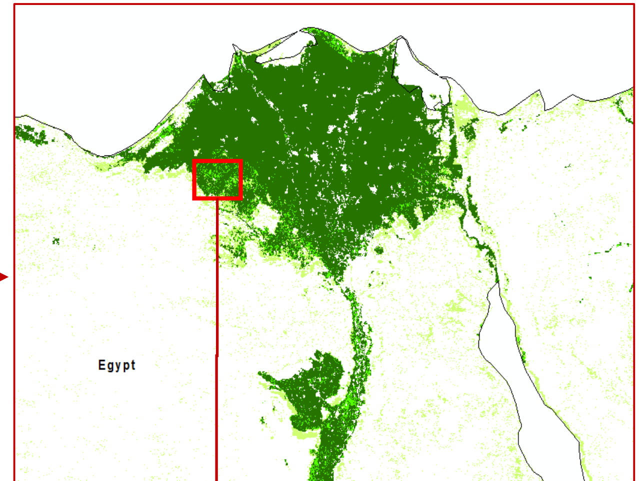


Farm Typology and Agrotagging

International agencies



Governments

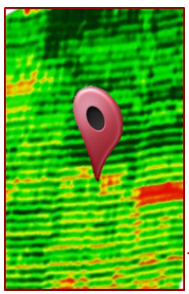


Irrigated systems

Rainfed systems

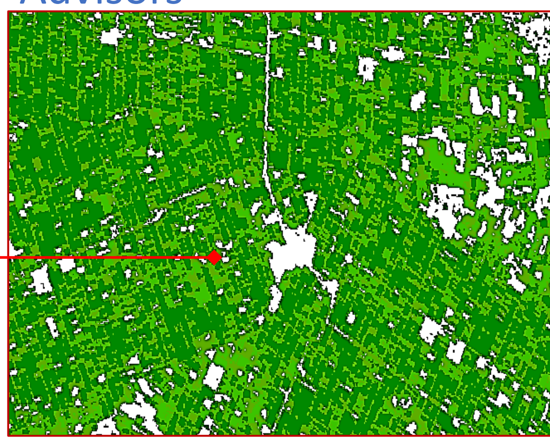
Agro-pastroral systems

Farmers

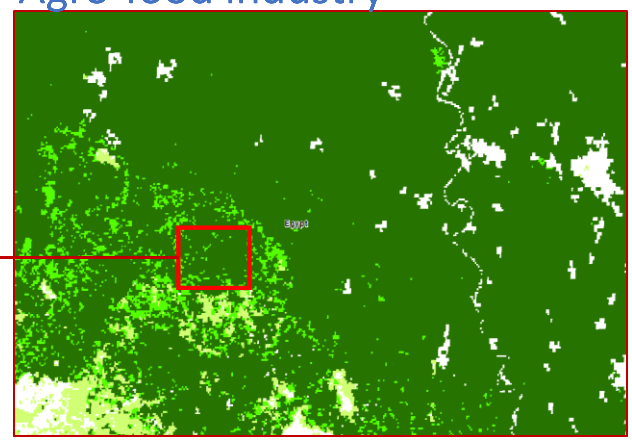


- Inputs/reuse
- Yield/Production
- Markets/income
- Functional flows

Advisors



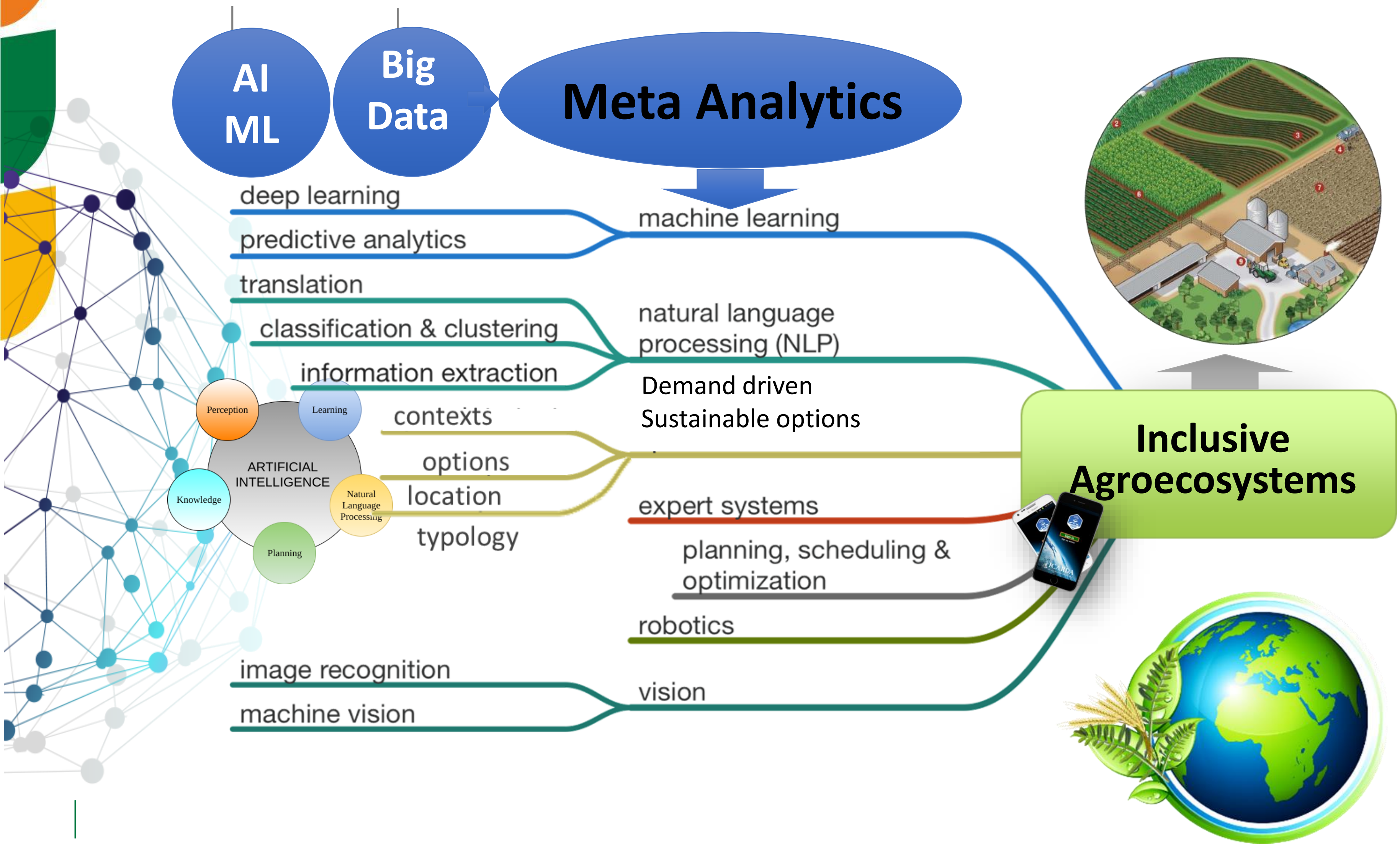
Agro-food industry



There is a big **black hole** in farming systems **typology**; if we don't make a strong and coordinated effort to add this layer the practical applications to farming systems design and policy advise will remain largely **"in the sky".** This is one of the challenge we want to address in the DryArc interface

Integration and Interoperability

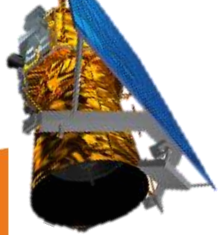
@ genetics, chemistry, weather, agronomy, trade…



Technologies are mature but need quality data for precision decisions

- Thousands of research and outreach data points in each season across the agro-ecosystems
- Open source near real-time earth observation data at field, farm and landscape scales
- Enormous power of cloud computing, open access, algorithms and analytics to process data on time
- Smart phone enabled apps and cloud web-GIS for decision making at point, farm and administrative units

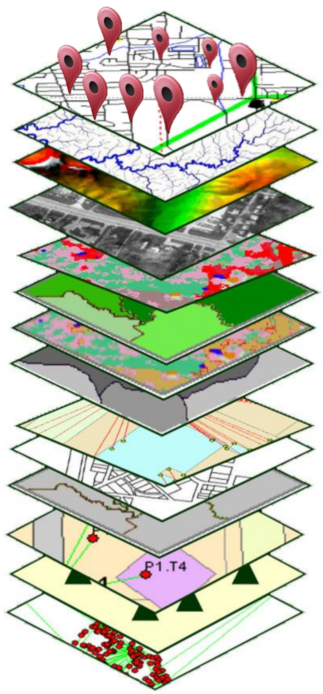
Digitization of farming systems



Big Data and Citizen Science driven…

Data Layers

Geo-Tagging
research & outreach data
Satellite data
Crop data
Climate data
Soil data
Water data
Topography
Demography
Ecological data
…



Computation

Algorithms

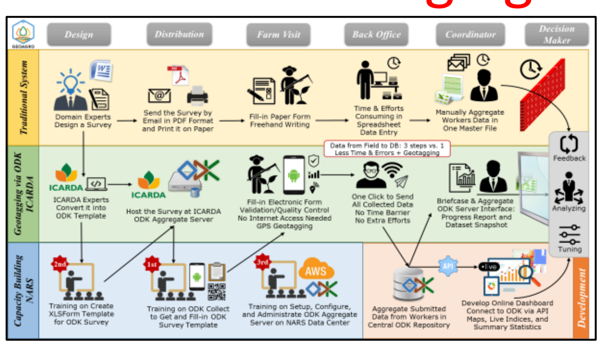
Biggest drivers

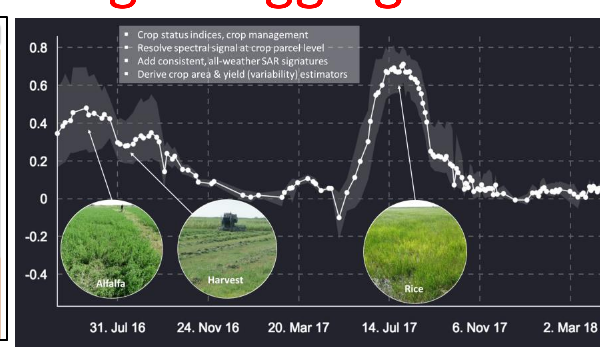
Applications

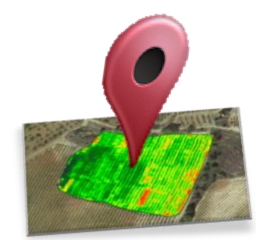
Scalability

Mapping
Monitoring
Targeting
Estimating
Forecasting
Warning
Lending
Insurance
Value chains
Carbon-Credits

Geo-taging and Agro-tagging



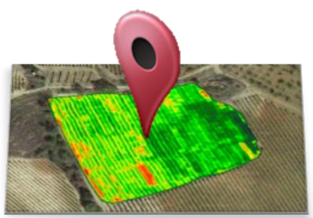




Paradigm shift towards economically viable ecologically sustainable options

1. Functional productivity
2. Yield & Rotation
3. Crop growth
4. Incentives

Farm Focus



Pixel/Farm/Parcel

A single entity for each & every developmental entry point

Build resilient agroecosystems

Financial inclusion

Better livelihoods

Ecological intensification

Right crop at right place and time

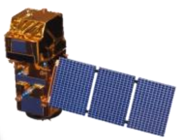
Resilient cropping systems

better integration of crops, livestock, fish, trees & people

Optimizing resource use by integrated approach

compound intensification in cereal based systems

Evolving areas in Big Data Science for building inclusive Agroecosystems



3 days revisit

30m

10m

Open source

1.0m

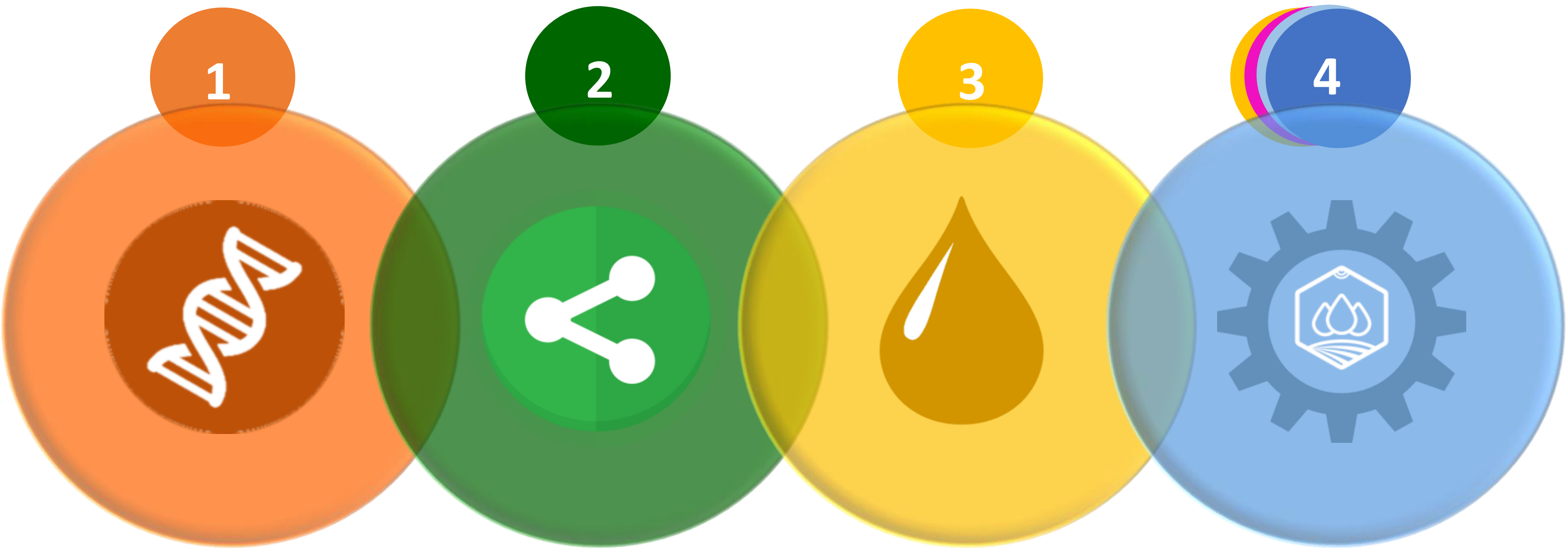
0.3m

Agreements

<Biggest drivers

Integration and coordinated efforts

(Geolocalize the research, scaling and impacts)



Biodiversity & Crop Improvement Program

>> research plots, > farm trials / demonstrations, > international nurseries > germplasms, > NARS partners feedbacks, > etc.

Resilient Agricultural Livelihood Systems Program

>> research plots, > agronomy, >CA/Zero tillage> livestock, > rangelands, > household surveys, > value chains, > etc.

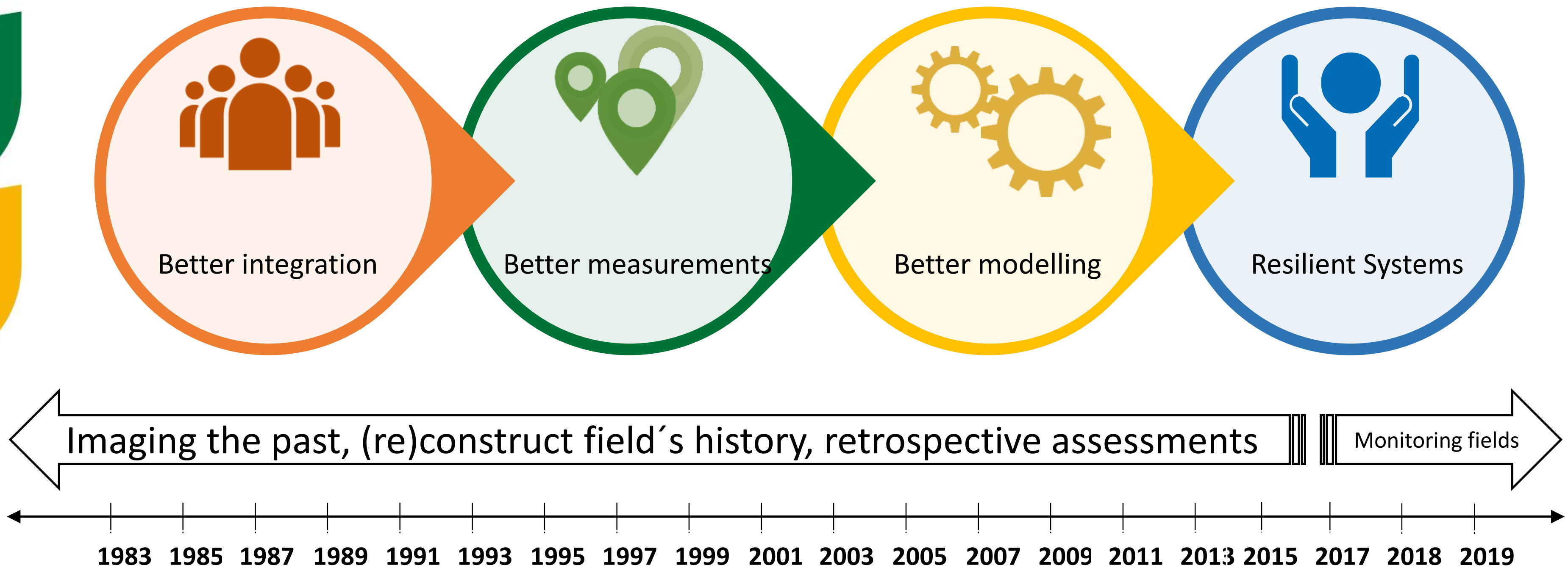
Water, Land Management & Ecosystems Program

>> field data, > raised beds> Field ETs, > AWPs, > soils, > hydrology, > land degradation,> erosion>, hydrology, > etc.

Cross Cutting Themes Big Data and ICTs

>> big-data, > open access resources, > cloud computing, > gender data, > > scaling > capacity dev., > modelling, > etc.

Moving from narrow sense (yield) to a new economically and ecologically sound functional model for well being of the people and the planet…



Rebuilding integrated systems is the key to exponential efficiency and growth in the world largest and oldest industry - "agroecosystems"

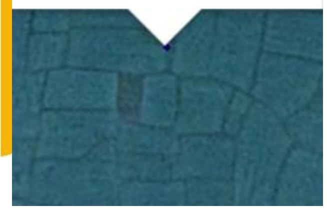

Geotagging
Agrotagging
Farm typology
Cropping systems
Scaling options

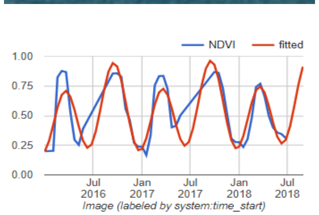

Dynamics of cropping systems

Jamdigri-moved

Jamdigri	
FID	11
BATCH	1
SchemeName	Jamdigri
District	BANKURA
Block	JOYPUR
Scheme_Typ	MDTW
Village_Mo	Jamdigri
Lat	23.07006
Long	87.47454
PhysicalPr	100
HODate	November 6, 2015

Directions: To here - From here

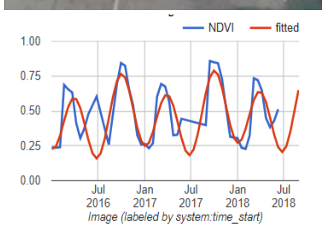




Pakurseni LDTW

Pakurseni LDTW	
FID	115
BATCH	2
SchemeName	Pakurseni LDTW
District	PASCHIM MIDNAPORE
Block	NARAYANGARH
Scheme_Typ	TW
Village_Mo	Pakurseni
Lat	22.19834
Long	87.44147
PhysicalPr	100
HODate	July 18, 2016

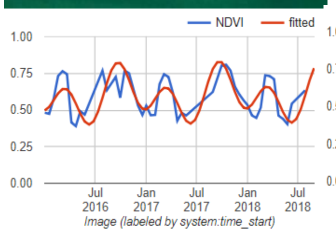
Directions: To here - From here



Hariharpur

Hariharpur	
FID	40
BATCH	1
SchemeName	Hariharpur
District	PASCHIM MIDNAPORE
Block	SABANG
Scheme_Typ	Mini(E) RLI
Village_Mo	Hariharpur
Lat	22.138147
Long	87.630084
PhysicalPr	100
HODate	March 23, 2015

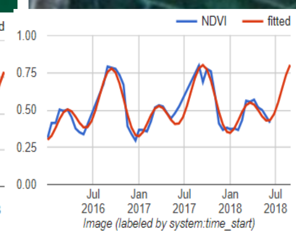
Directions: To here - From here



Kalisara LDTW

Kalisara LDTW	
FID	24
BATCH	1
SchemeName	Kalisara LDTW
District	BIRBHUM
Block	MAYURESWAR I
Scheme_Typ	LDTW
Village_Mo	Kalisara
Lat	24.05688
Long	87.84444
PhysicalPr	100
HODate	June 29, 2016

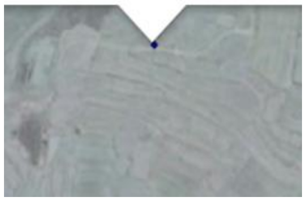
Directions: To here - From here

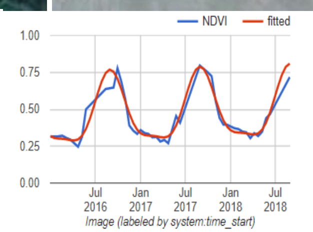


Kundra - IV PDW

Kundra - IV PDW	
FID	294
BATCH	3
SchemeName	Kundra - IV PDW
District	BIRBHUM
Block	RAJNAGAR
Scheme_Typ	PDW
Village_Mo	Kundra
Lat	23.965694
Long	87.356806
PhysicalPr	100
HODate	November 14, 2017

Directions: To here - From here

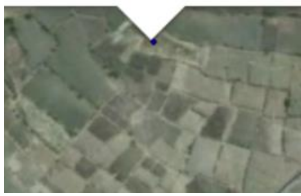


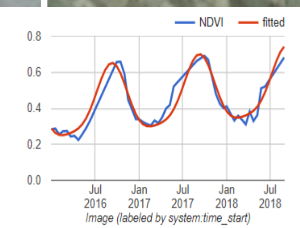


Gosain Bundh SFMIS-moved

Gosain Bundh SFMIS	
FID	71
BATCH	2
SchemeName	Gosain Bundh SFMIS
District	PURULIA
Block	KASHIPUR
Scheme_Typ	SFMIS(40ha)
Village_Mo	Uluberia
Lat	23.477367
Long	86.790317
PhysicalPr	100
HODate	September 10, 2015

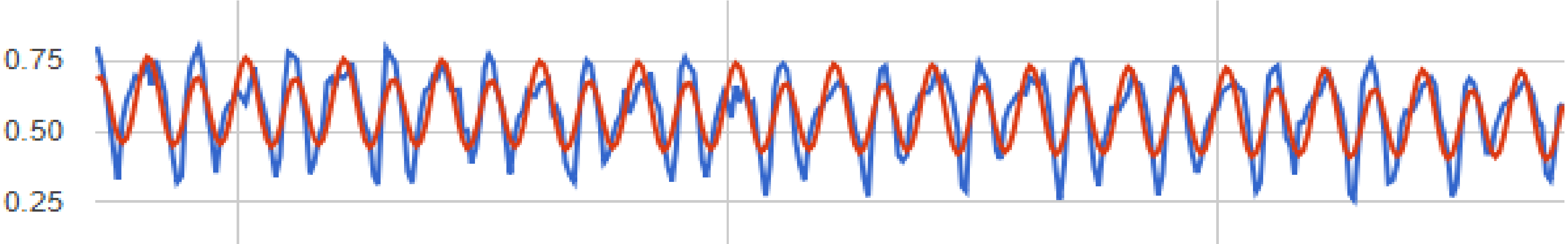
Directions: To here - From here



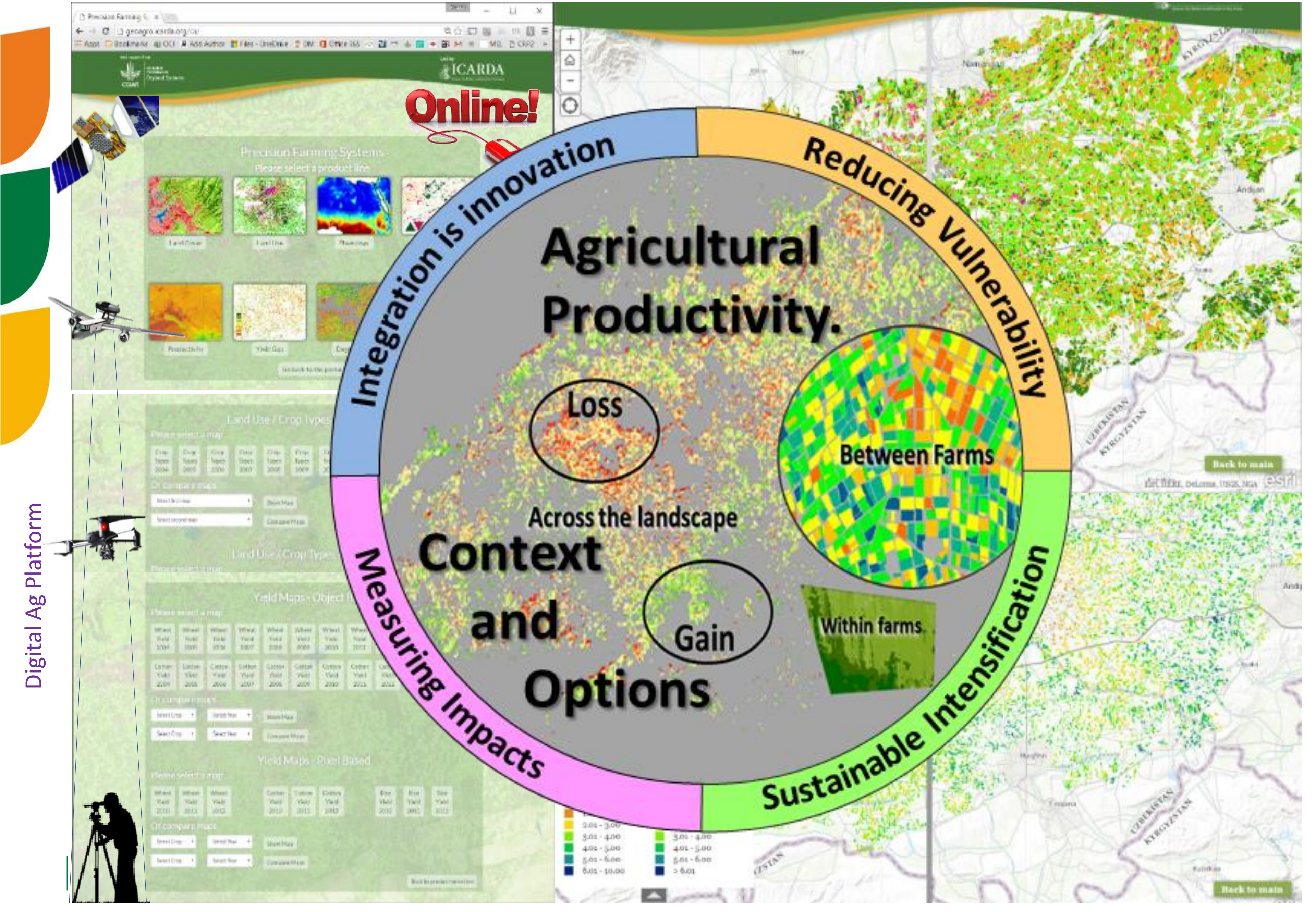


Fallows in Double cropped area

Fallows in Single cropped area

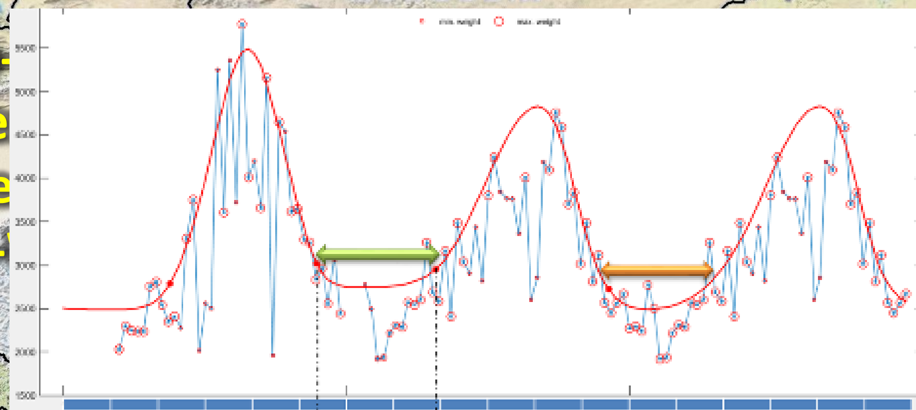


Quantification of Farming Systems @ multiple-scales

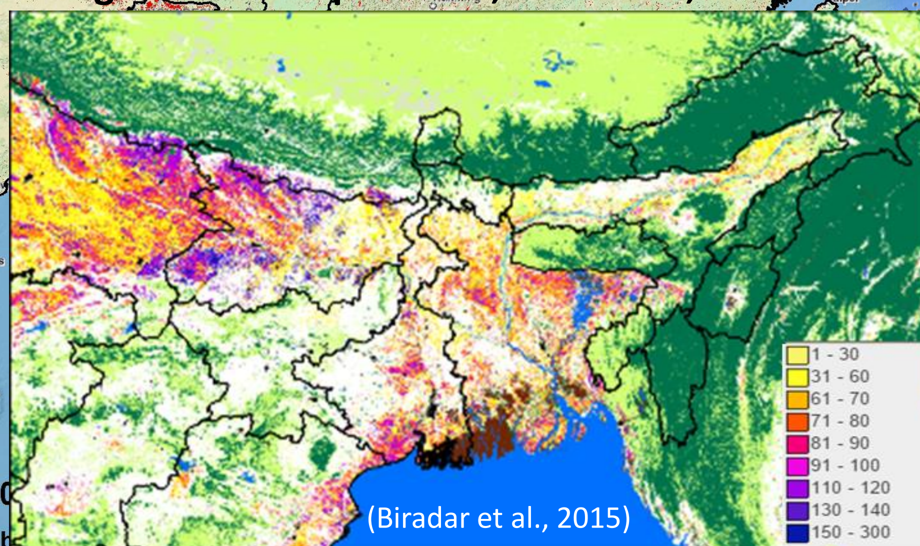


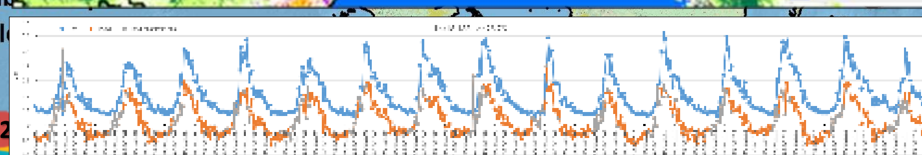
Dynamics of Cropping Systems

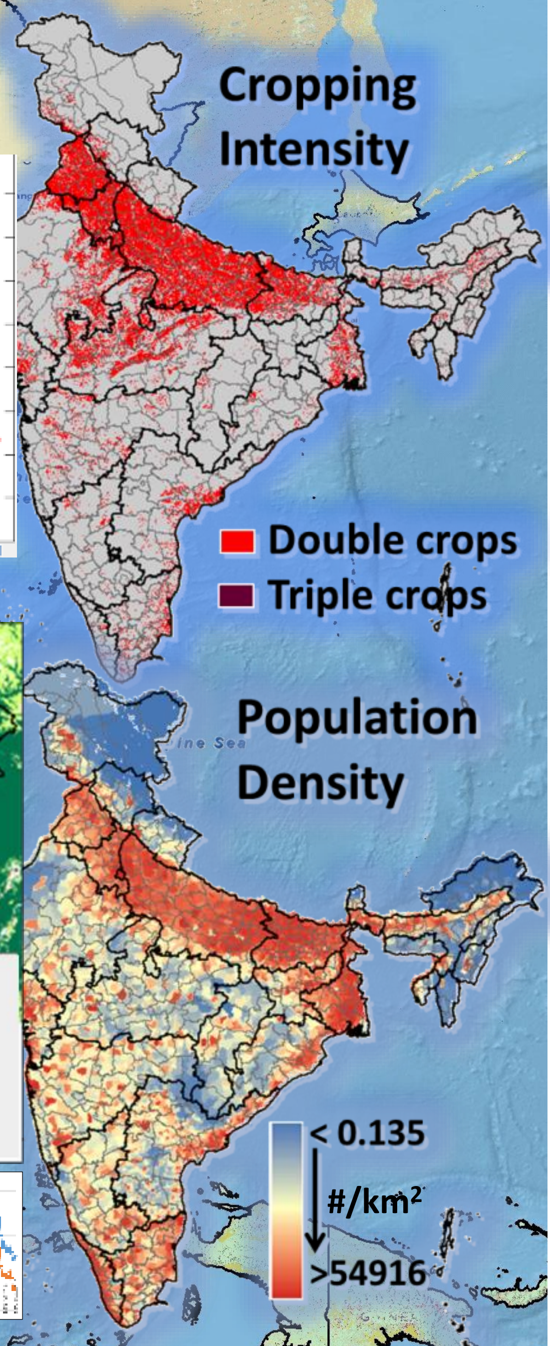
- Integrated Agro-
- Sustainable Inte
- Input Use Efficie
- Thematic Land-



Length of the crop fallows, start-date, end-date





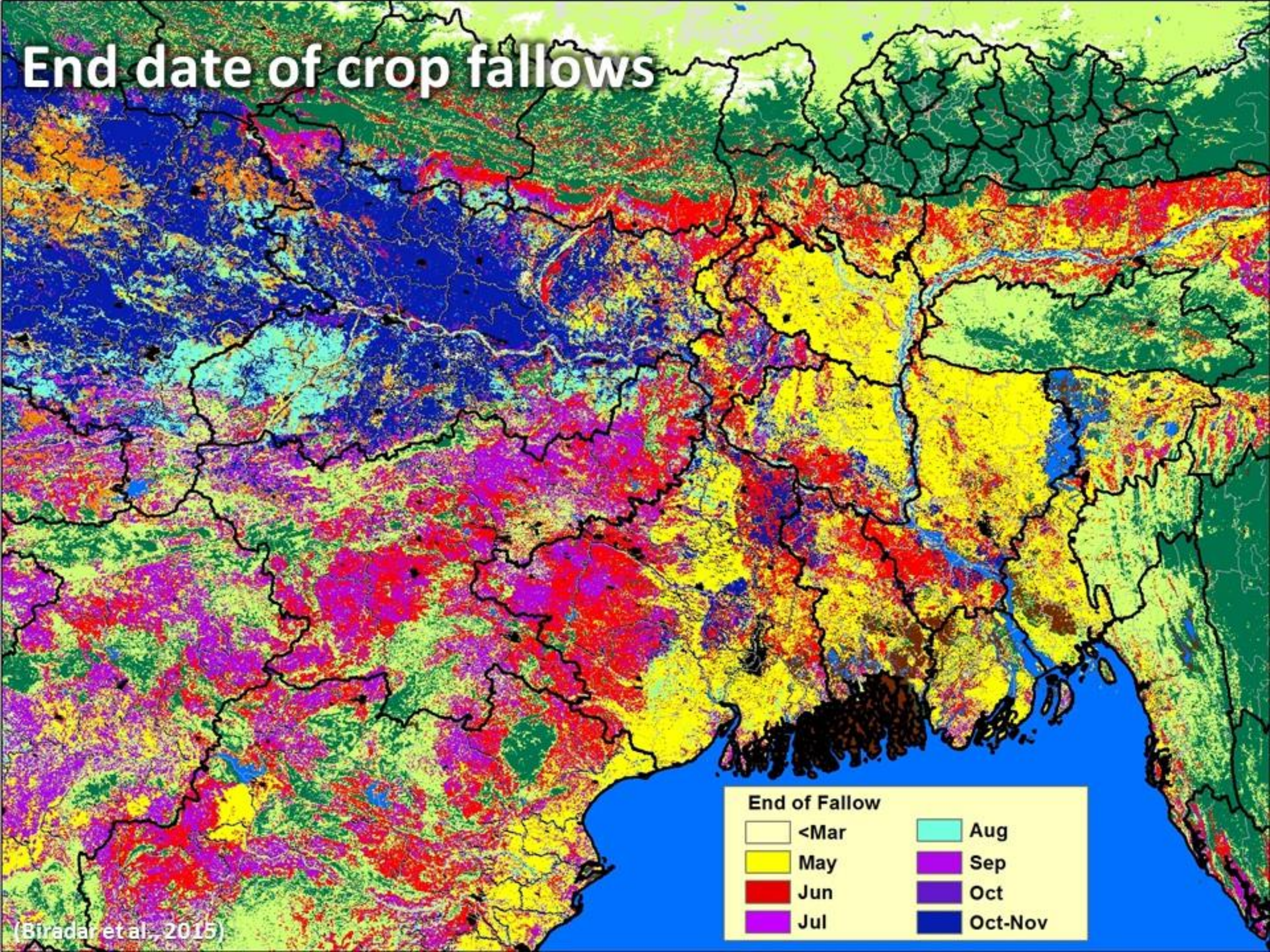


Biradar and Xiao, 2009

Agricultural Intensification

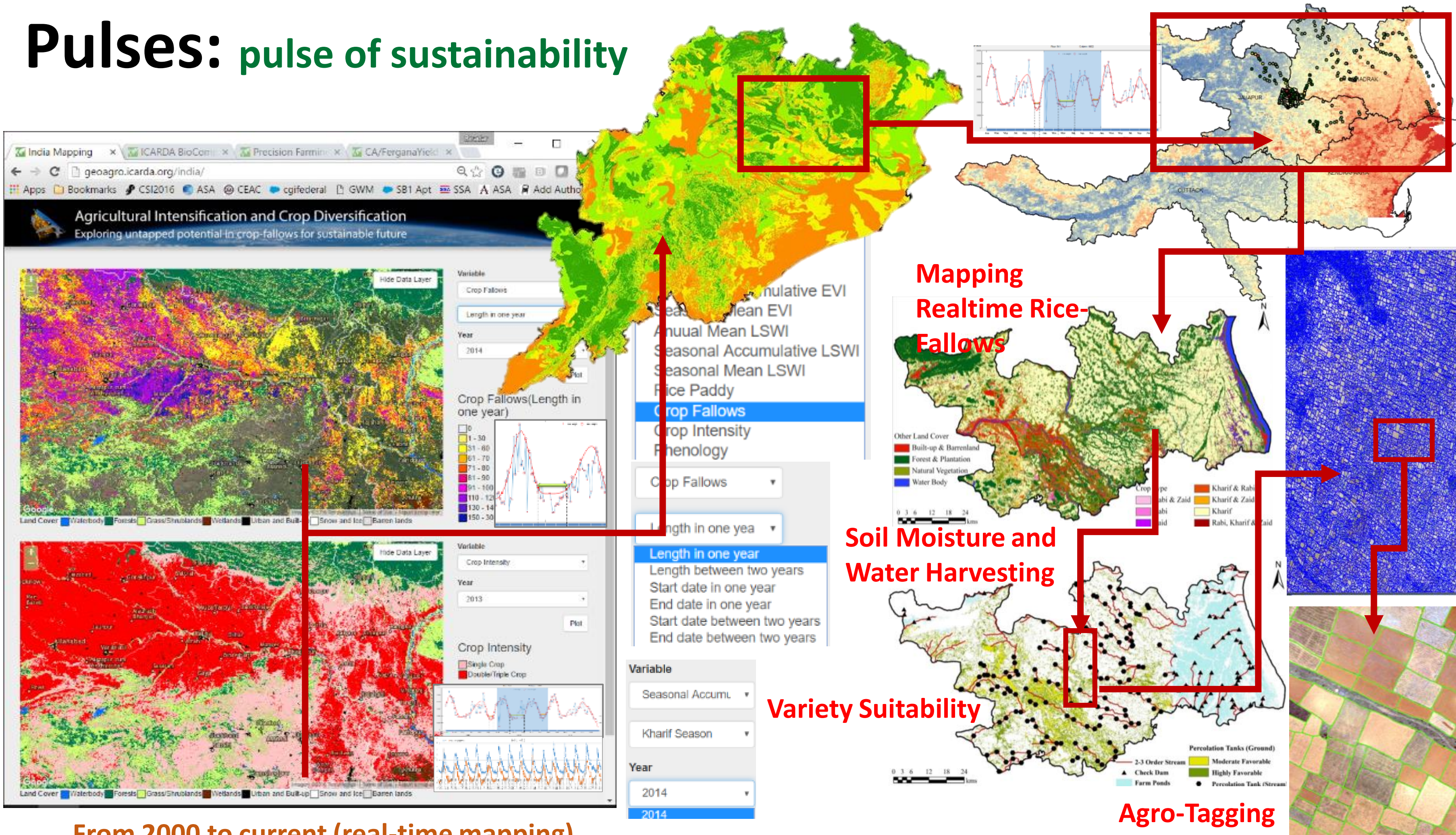
Increase in Arable Land

End date of crop fallows



Realtime mapping for sustainable intensification

Pulses: pulse of sustainability



From 2000 to current (real-time mapping)

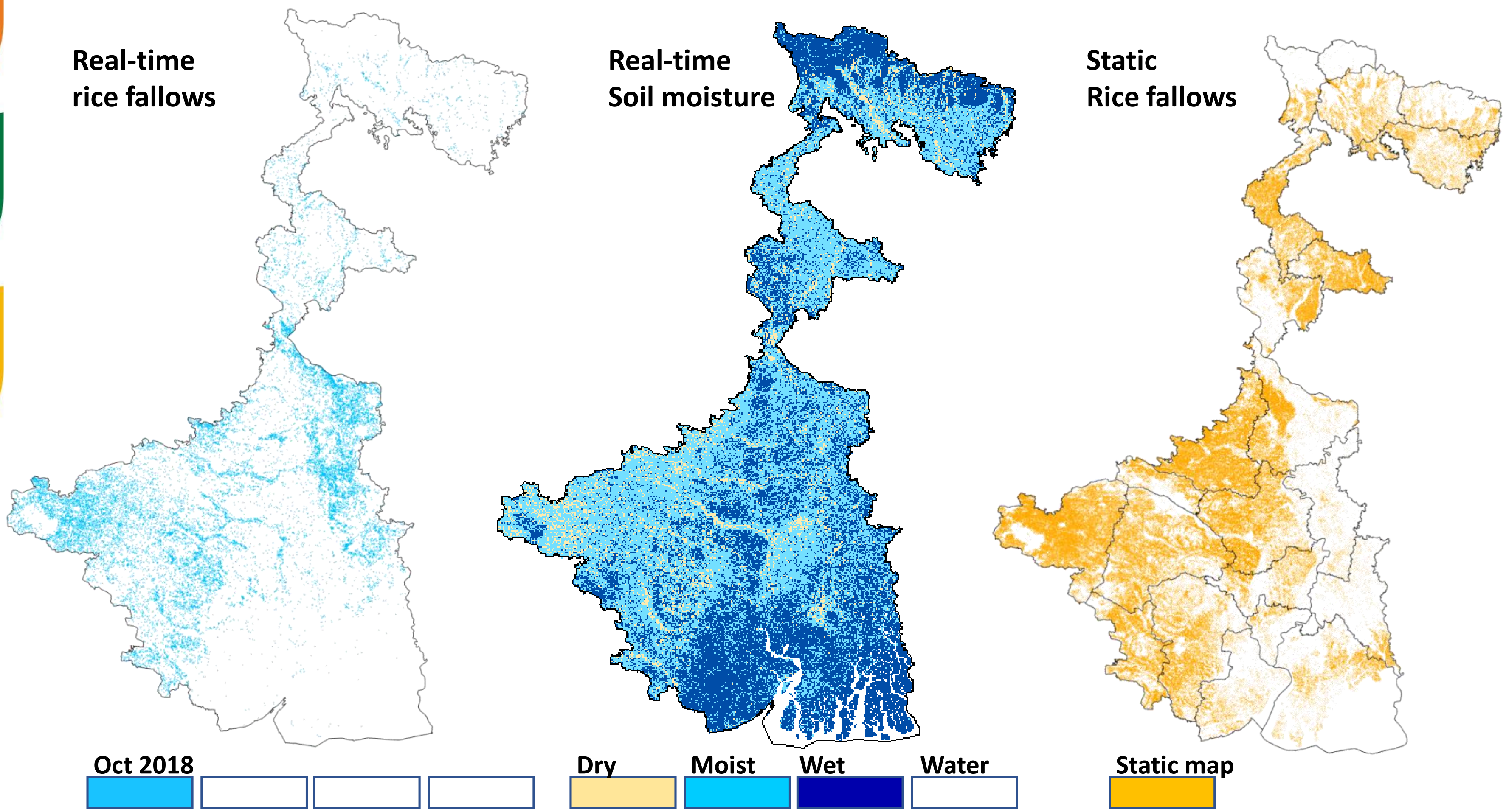
e.g., Lentil as gap filler, relay crop, inter crop

Lentil in Rice-based Cropping Systems

- **Irrigated**
  - Rice – EE Lentil – Boro rice
  - Rice – Relay E Lentil – Boro rice
- **Rainfed**
  - Rice – EE Lentil
  - Rice – Relay E Lentil

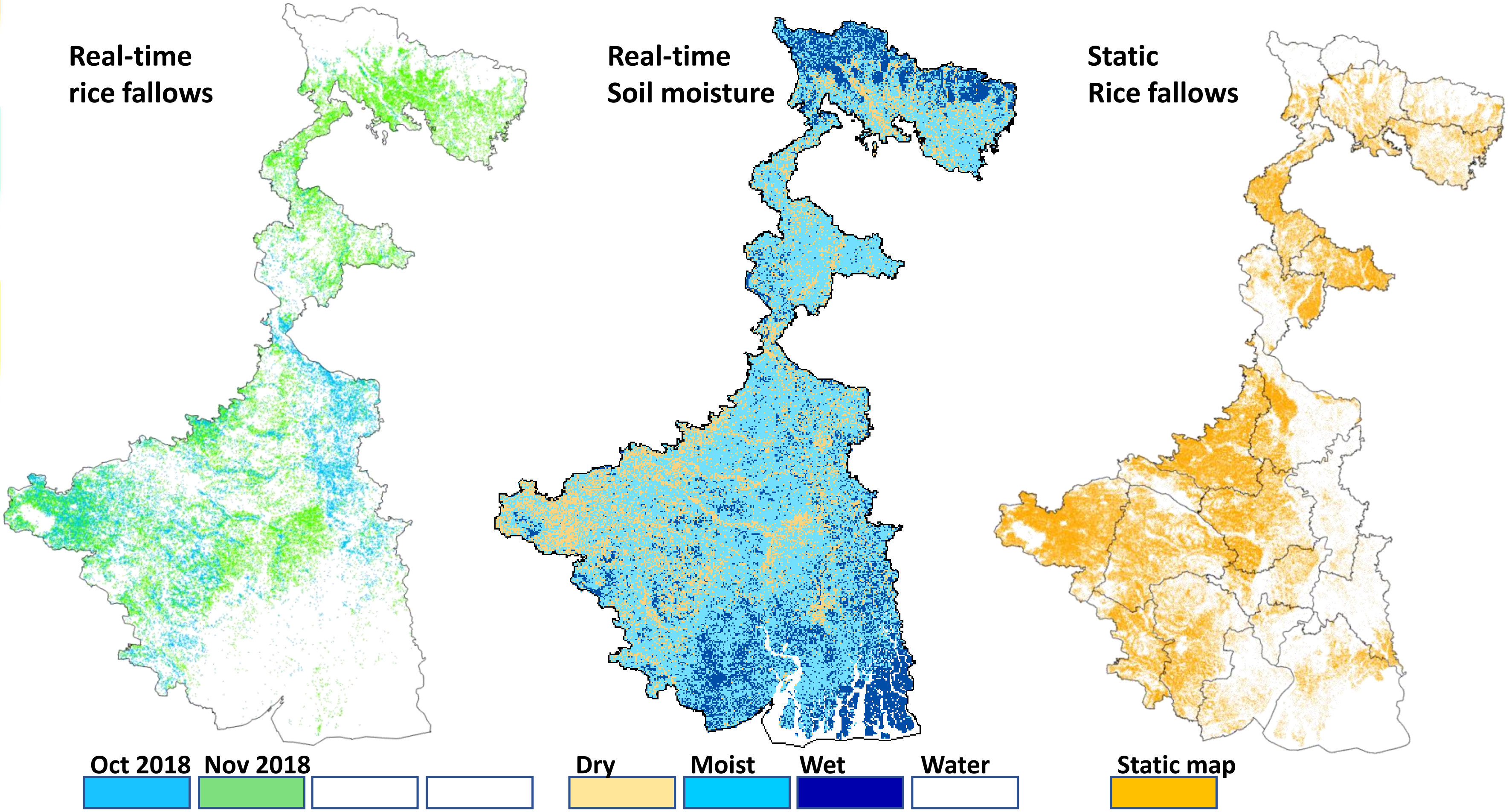
Sustainable intensification of the rice-fallows

Real-time monitoring to target site specific interventions (package of practices)



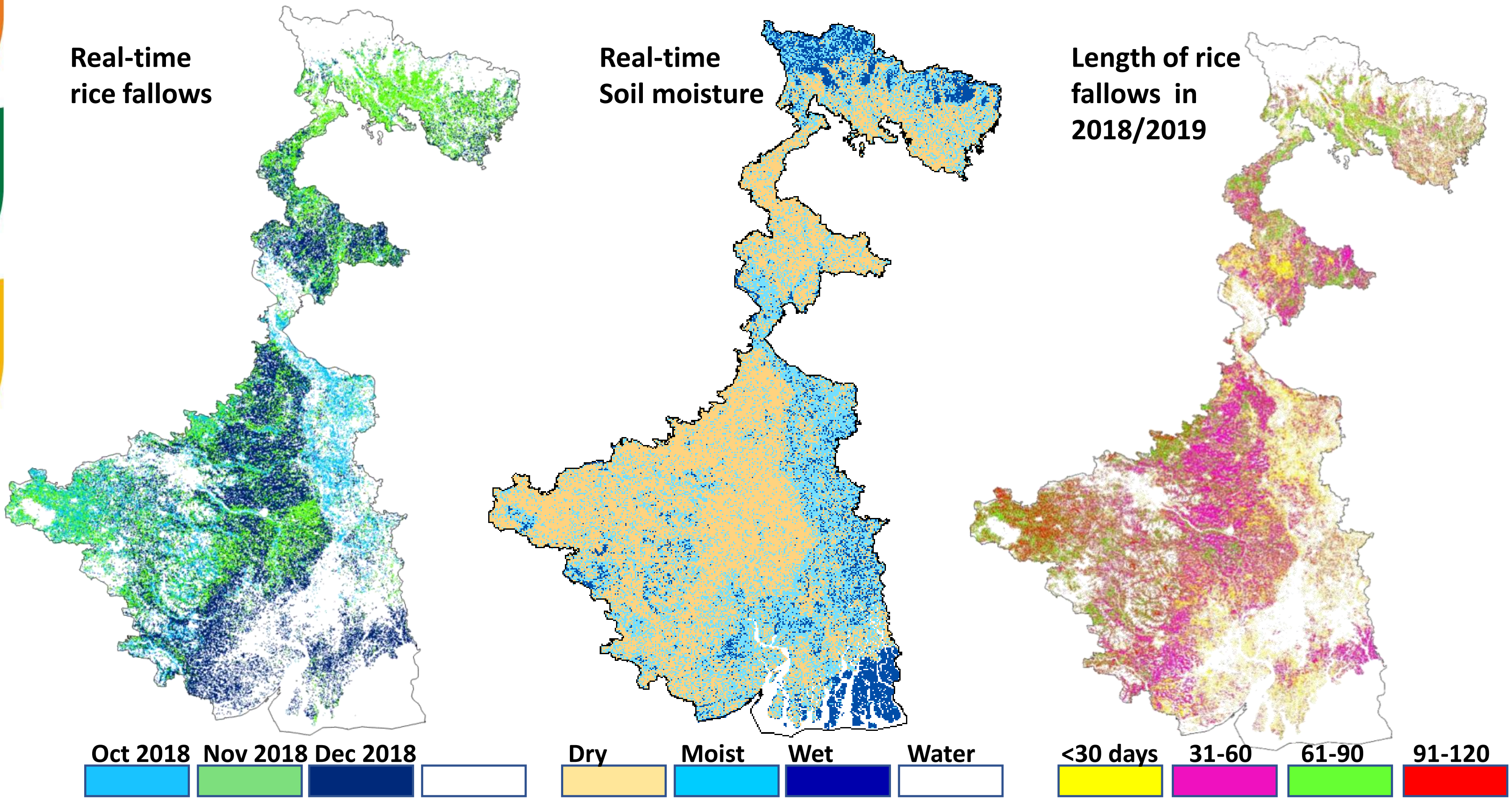
Sustainable intensification of the rice-fallows

Real-time monitoring to target site specific interventions (package of practices)



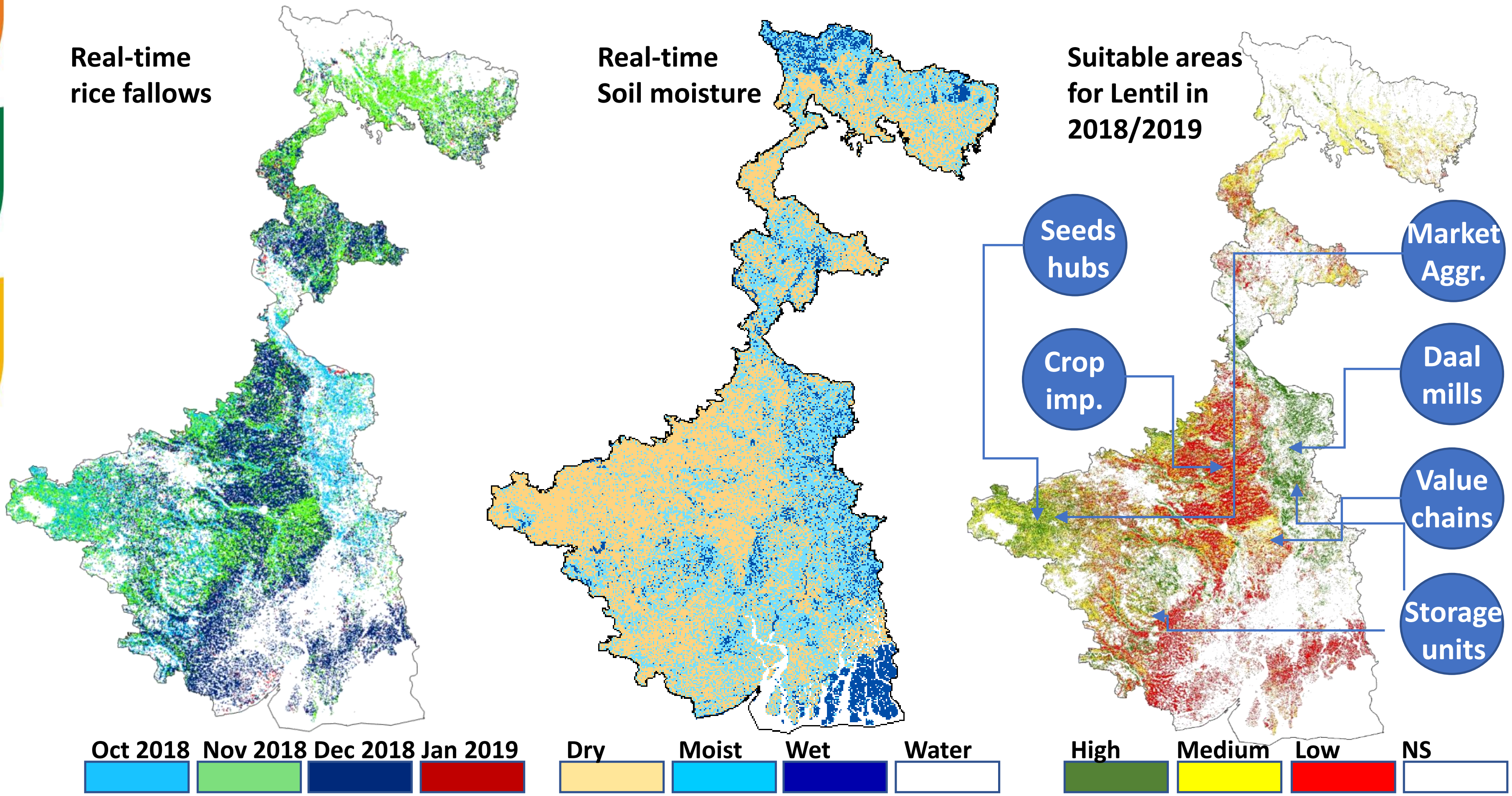
Sustainable intensification of the rice-fallows

Real-time monitoring to target site specific interventions (package of practices)



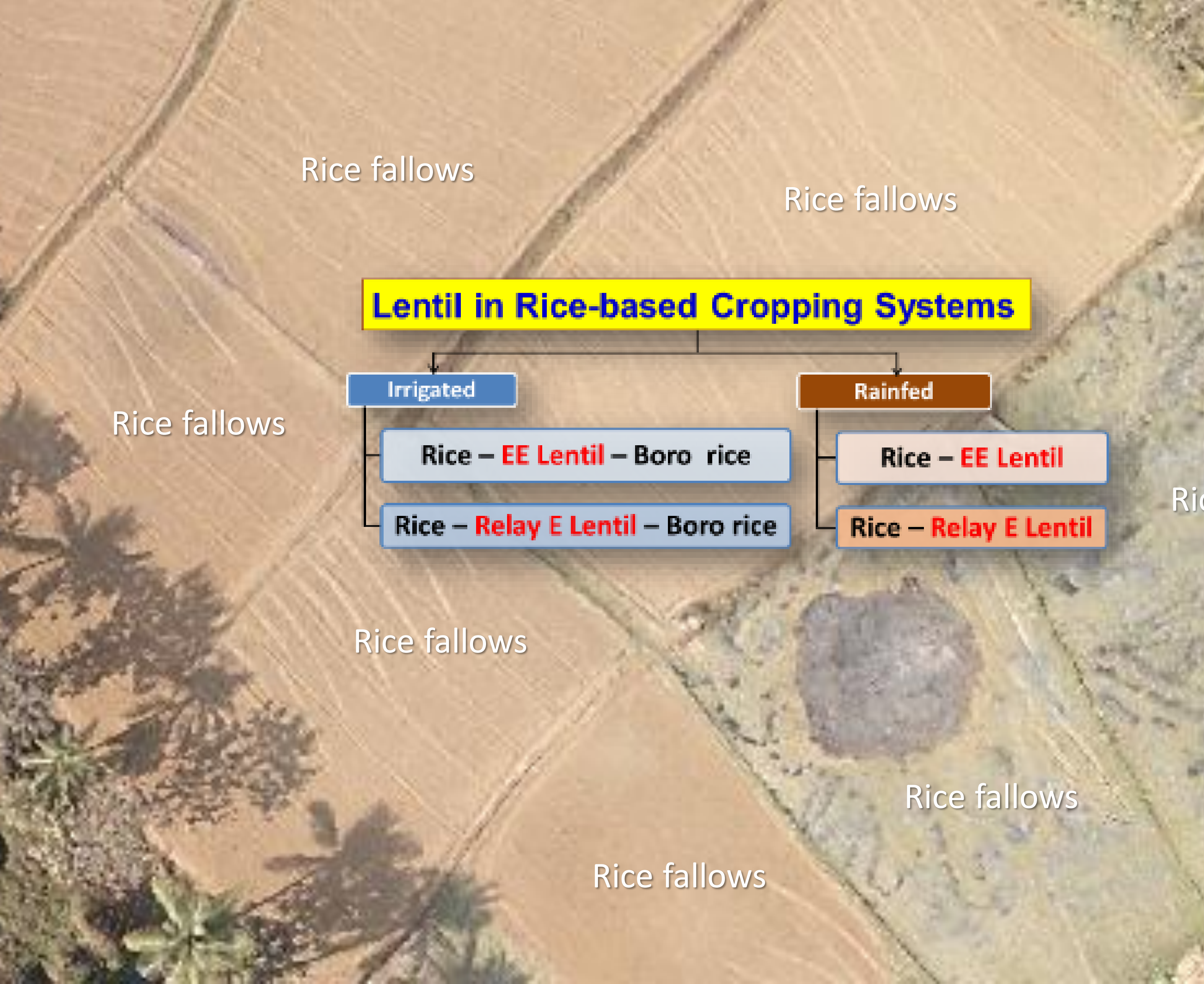
Sustainable intensification of the rice-fallows

Real-time monitoring to target site specific interventions (package of practices)



Small farms field the world: food grown in small farms are more healthy, tasty, nutritious and it helps rebuilding living soils and resilient agroecosystems

DryArc from Dry to Green

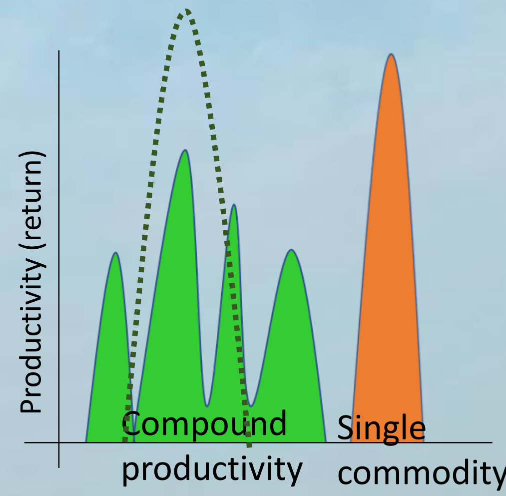


Lentil in Rice-based Cropping Systems

- **Irrigated**
  - Rice – EE Lentil – Boro rice
  - Rice – Relay E Lentil – Boro rice
- **Rainfed**
  - Rice – EE Lentil
  - Rice – Relay E Lentil

DryArc from Dry to Green

- Rice fallow under pulses
- Increased income (2-3 times)
- Increased resource use efficiency
- Rebuilding healthy soil and biota
- Better nutrition and health
- Addressing 8 of the 17 SDGs

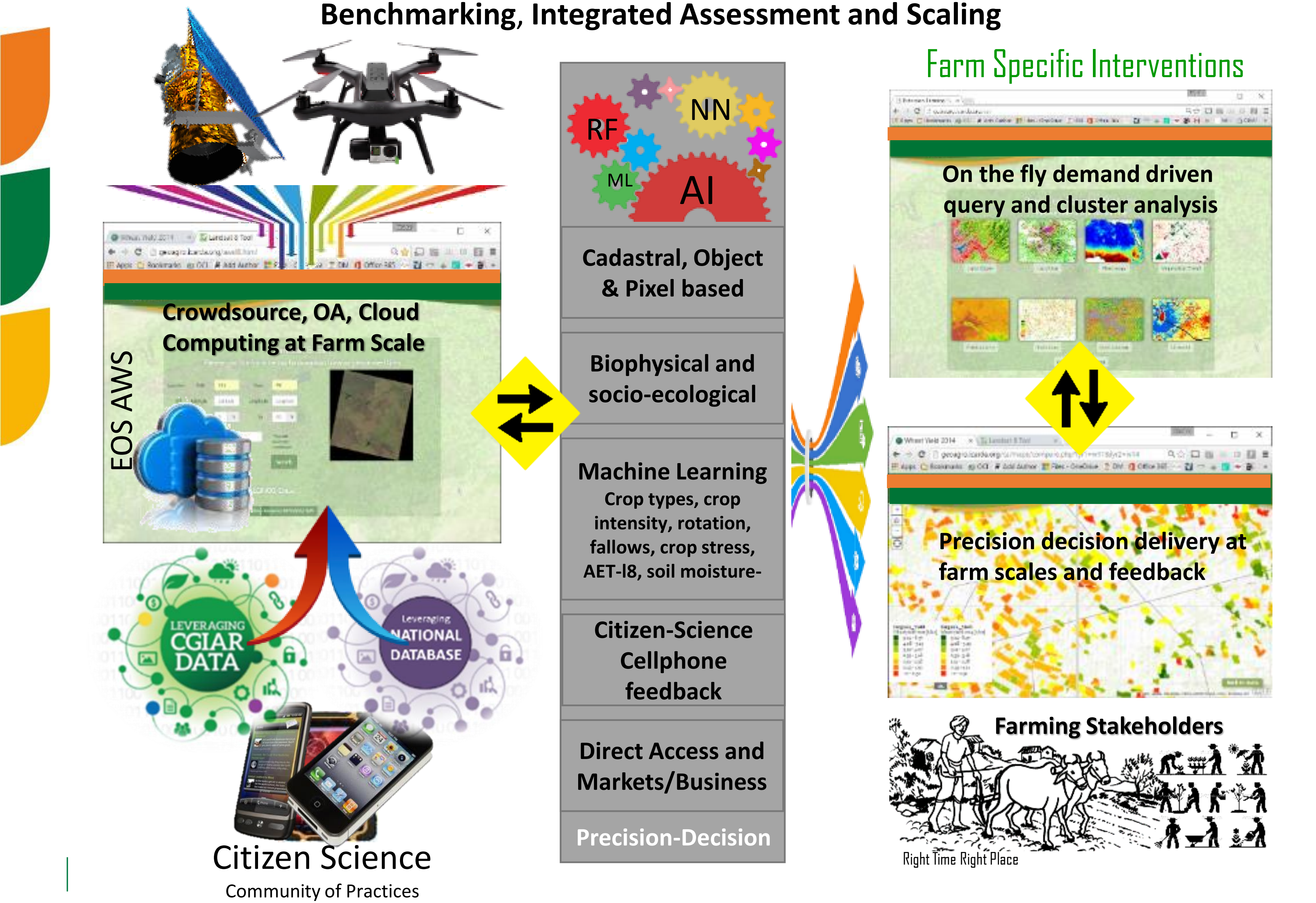


Way forward

- There is **no systematic maps and database** are available at farm level and near real-time dynamics
- There is a big **black hole** in farming systems **typology,** it **need strong and coordinated efforts** to build this layer for number of modeling and policy applications;
- Recent advances in **Earth Observation System**, Open-Access, Machine Learning, Cloud Computing, Smartphone, and Citizen Science making Big-Data analytics much **smarter, interoperable and useful** ever before.
- GeoAgro based **Eco-Smart Farming Systems** Designs have a high potential in the DryArc Region

DryArc Interface Platform

Benchmarking, Integrated Assessment and Scaling



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eAtlas-DCL Priority Regions
eAtals-Watershed
NLCD Jordan
Dateplam Management
Programs
BCIP
RALS
IWLE
Projects
Digital Agriculture
Eco-Intensification
Ag-Water Productivity
Crop Modelling
Land Degradation
Watershed
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Productivity (return)
Compound productivity
Single commodity

Spatial Informed decisions for targeting research and development investments for sustainable and resilient agri-food systems in the dry areas

Thank You

c.biradar@cgiar.org

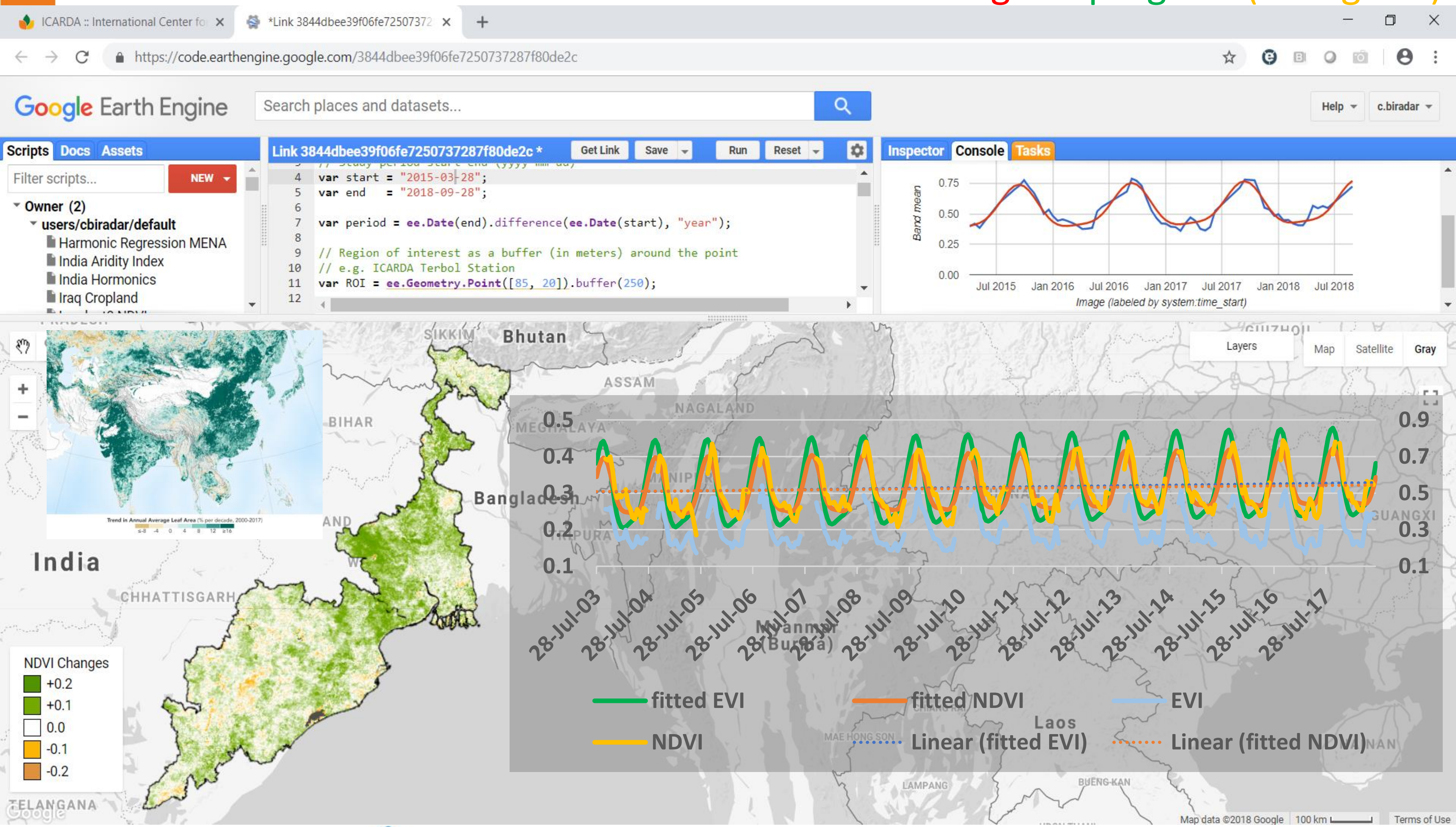
Chandrashekhar Biradar
Head-Geoinformatics Unit
Principal Scientist (Agro-Ecosystems)

List of countries in the DryArc Region (draft)

1	Afghanistan	26	Ghana	51	Niger
2	Albania	27	Greece	52	Nigeria
3	Algeria	28	Guinea	53	Oman
4	Andorra	29	Guinea-Bissau	54	Pakistan
5	Armenia	30	India	55	Portugal
6	Azerbaijan	31	Iran	56	Qatar
7	Bahrain	32	Iraq	57	Saudi Arabia
8	Benin	33	Israel	58	Senegal
9	Bosnia and Herzegovina	34	Italy	59	Serbia
10	Bulgaria	35	Ivory Coast	60	Sierra Leone
11	Burkina Faso	36	Jordan	61	Somalia
12	Cameroon	37	Kazakhstan	62	South Sudan
13	Central African Republic	38	Kuwait	63	Spain
14	Chad	39	Kyrgyzstan	64	Sudan
15	China	40	Lebanon	65	Syria
16	Croatia	41	Libya	66	Tajikistan
17	Cyprus	42	Macedonia	67	Thailand
18	Djibouti	43	Mali	68	Togo
19	Egypt	44	Malta	69	Tunisia
20	Eritrea	45	Mauritania	70	Turkey
21	Ethiopia	46	Mongolia	71	Turkmenistan
22	France	47	Montenegro	72	UAE
23	Gambia, The	48	Morocco	73	Uzbekistan
24	Gaza Strip	49	Myanmar (Burma)	74	West Bank
25	Georgia	50	Nepal	75	Yemen

Tracking Farming Systems Dynamics

Monitoring the progress (or regress)



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Tracing changes to target interventions