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Science for Better Livelihoods in Dry Areas

Remote Sensing to Scale Analysis

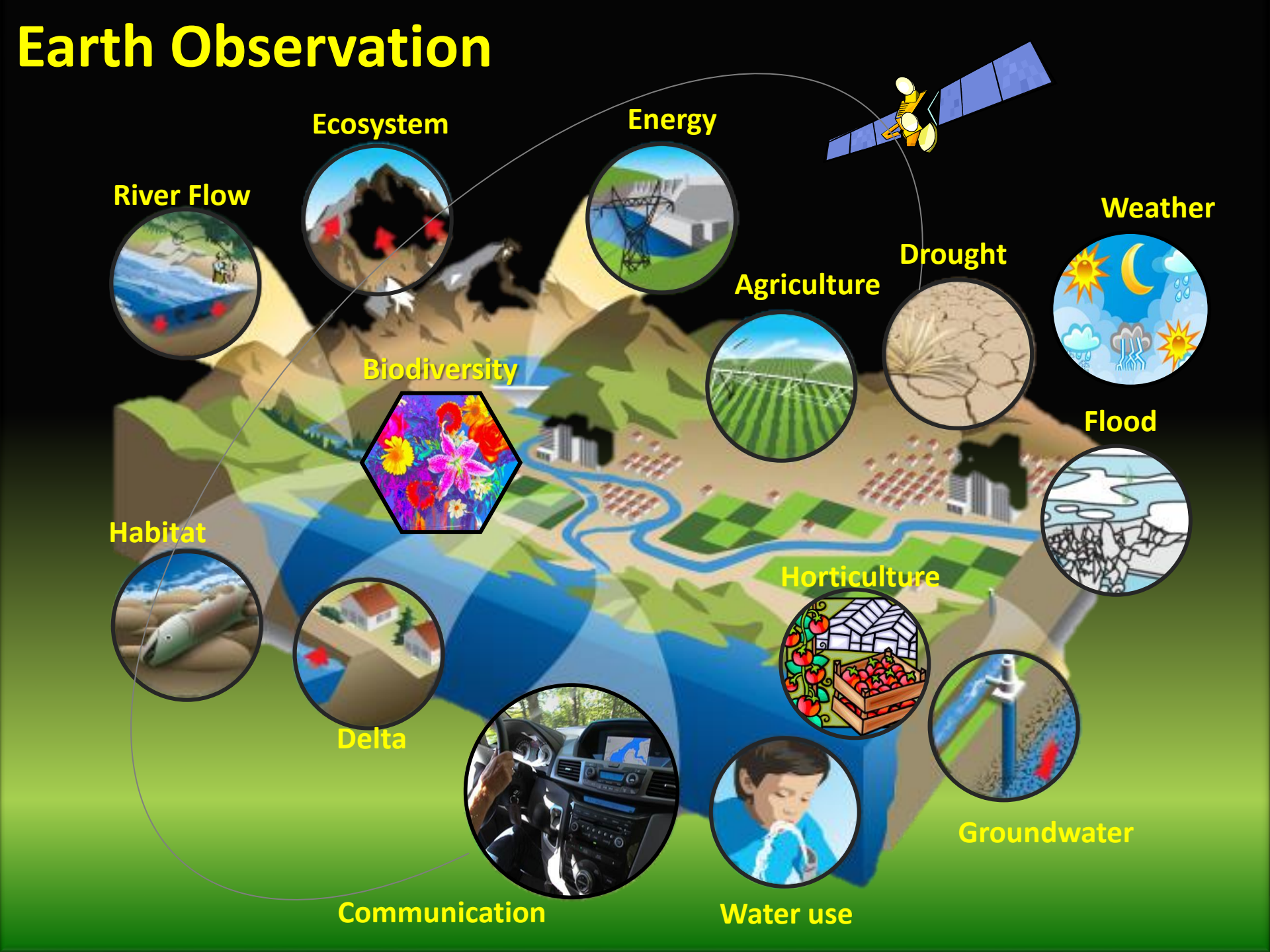
Farmscapes to Landscape Level

Pastoral | Agropastoral | Rainfed | Tree-based | Irrigated

Chandrashekhar Biradar, PhD
Principle Scientist (Agro-ecosystems)
Head, Geoinformatics Unit

Workshop on Integrating Biodiversity and Ecosystem Services into Foresight Models
May 7-8, 2015, Rome

Earth Observation



Role of Geospatial Science, Technology and Applications (GeSTA) in Agro-Ecosystems

Youth & Capacity Dev. Engaging and empowering young gen. by creating opportunities

156 Remote sensing missions in orbit°

12 Sensors potential in CRPs/IRPs, etc.

>6 are free

5 Regions

1) The West African Sahel and dry savannas , 2) East and Southern Africa , 3) North Africa and West Asia 4) Central Asia , and 5) South Asia.

Ensuring Food Security

Specific mutual-interaction & synergies between plant and animal species and management practices

Integrated agro-ecosystems: innovative approaches and methods for sustainable agriculture, while safeguarding the environment

Mapping present, emerging & future land use /land cover dynamics, cropping patterns, forage, intensities, water use, pest & diseases, climate change & impacts

Quantification of existing agricultural production systems

Characterization of vulnerable areas for increasing resilience and assist in identifying mitigation pathways with biophysical, socioeconomic and stakeholder feedback as well as specific needs & constraints

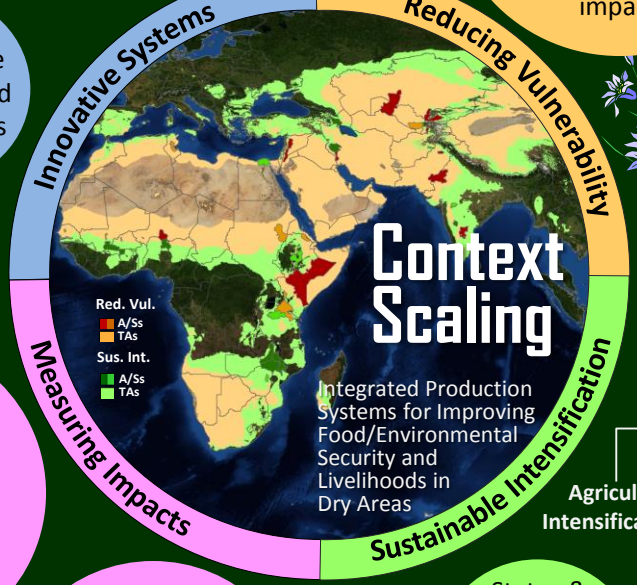
$ Startup 35.47m
Total 122.7m

Cooperative Research and Partnerships

Characteristics of agricultural and livestock production in small holder farming systems and rural livelihoods

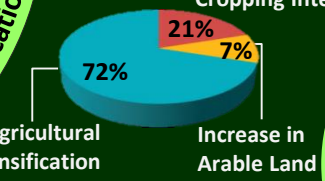
Gender Address social inequities, greater roles and priorities

Drylands 41% Earth's land area



increased Food production potential sources

Biodiversity Spatial enrichment and its role in food security, risk mitigation, & sustainability



Measuring the impact at spatial scales, rate, magnitude, synergy among the systems, CRPs, cross-regional synthesis

Mapping the extent of existing & traditional practices, indigenous knowledge, diversity, potential areas for modern & improved, productive, profitable, and diversified dryland agriculture, & linkages to markets

Geospatial commons , KM sharing, stakeholder feedback

Assessing the impact of outcomes in Action Sites, post-project implementation, & M&E

Status & trends of existing production systems

Delineation of potential, suitable areas for sustainable intensification, and diversification of ag. Innovation production systems

Farmers, stakeholders, policymakers, mobilization, & marketing

Health Changing diet patterns, nutrition and health

People 2.5b Live in Drylands

Livestock 1.5b Depend on Drylands

Improved Livelihoods

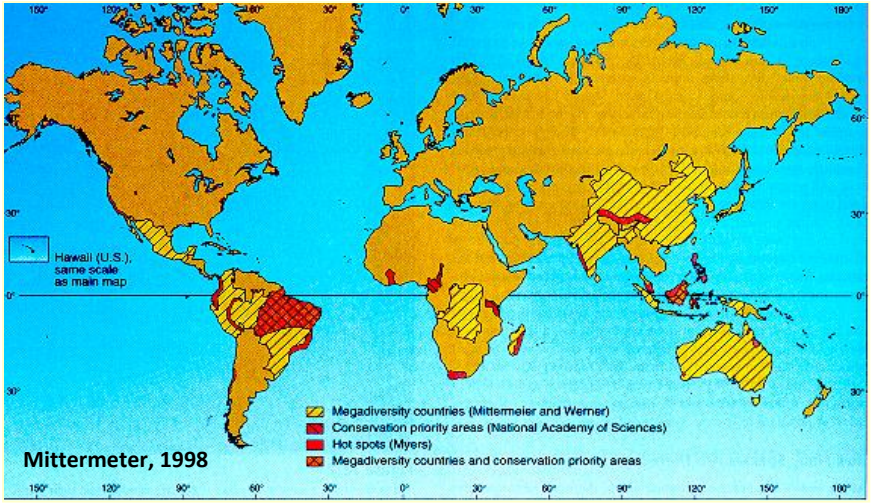
Assessment of present, emerging & future droughts, floods, pests & diseases, extreme events, infrastructure, migration

CGIAR RESEARCH PROGRAM ON Dryland Systems

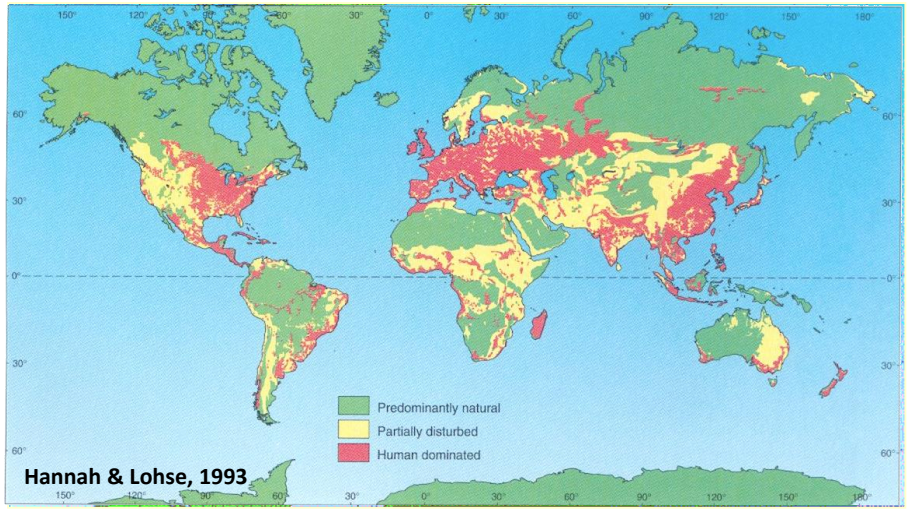
Biodiversity in Peril?

Under changing climate and demography?

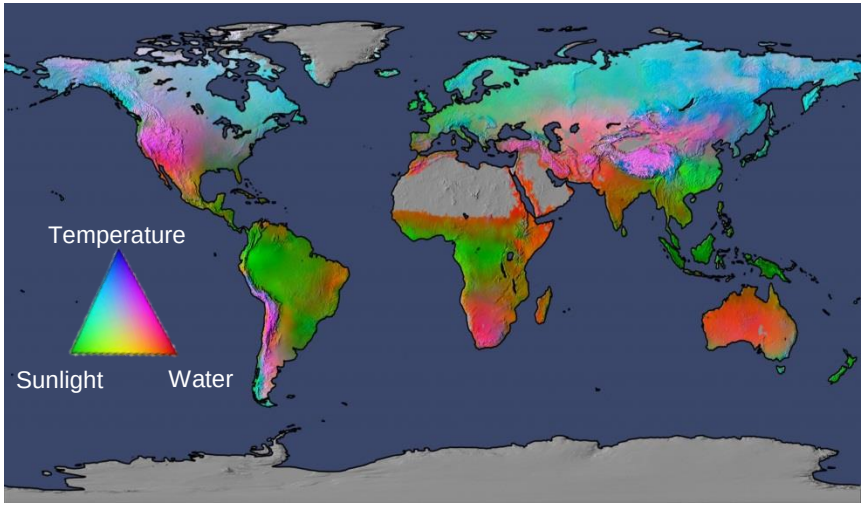
Biological Richness



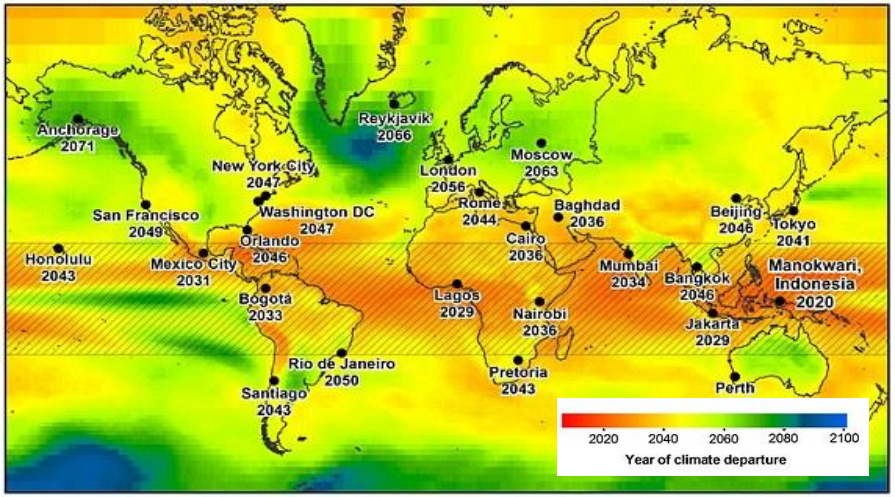
Human Induced Disturbance



Potential Climate Limits

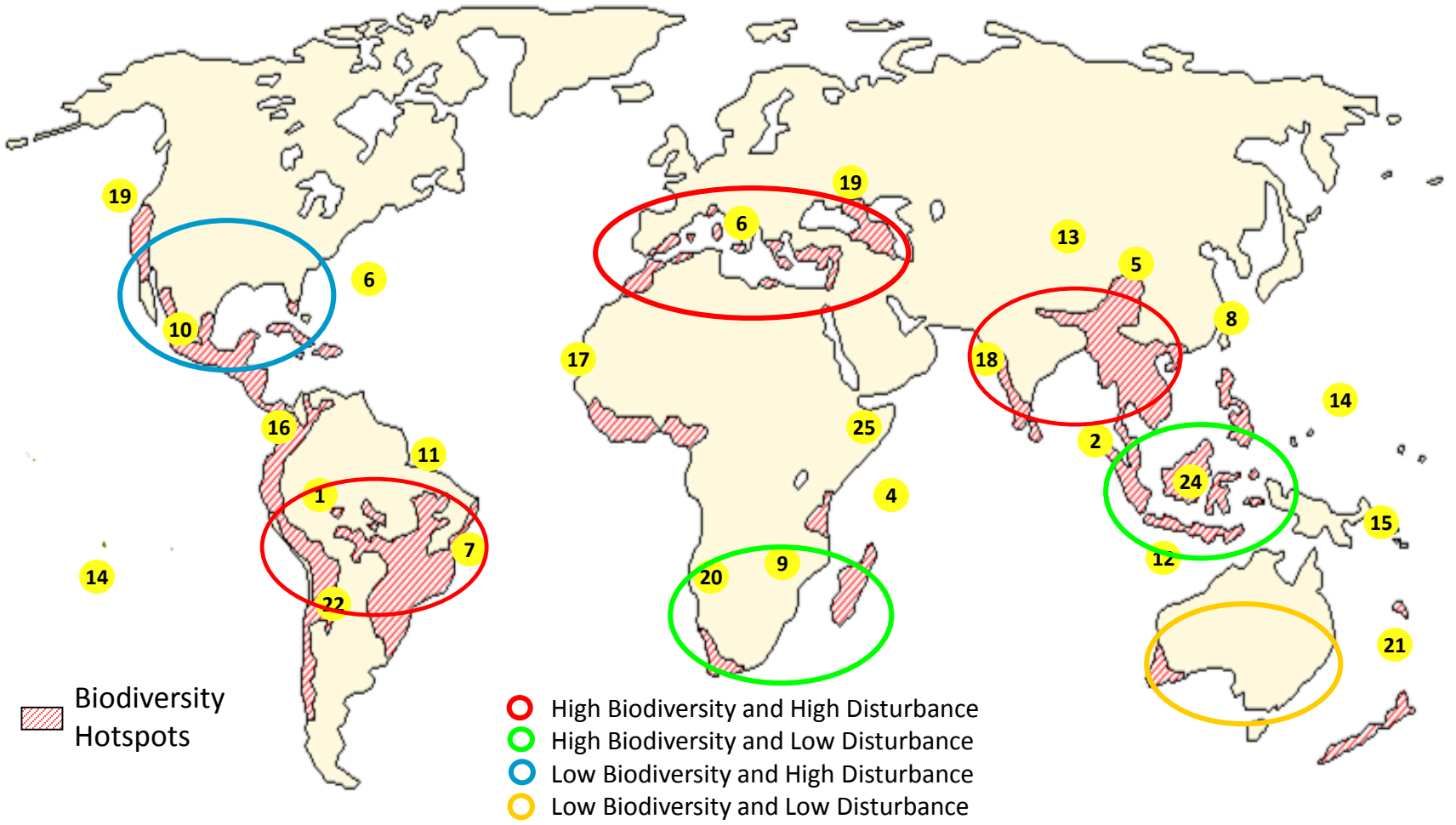


Ever Changing Climate



Biodiversity Hot Spots of the World

Context and Options



1. Tropical Andes, 2. Sundaland, 3. Mediterranean Basin, 4. Madagascar & Indian Ocean Islands, 5. Indo-Burma, 6. Caribbean, 7. Atlantic Forest Region, 8. Philippines, 9. Cape Floristic Province, 10. Mesoamerica 11. Brazilian Cerrado, 12. Southwest Australia, 13. Mountains of South-Central China14. Polynesia/Micronesia 15. New Caledonia, 16. Chocó-Darién-Western Ecuador, 17. Guinean Forests of West Africa, 18. Western Ghats & Sri Lanka, 19. California Floristic Province, 20. Succulent Karoo, 21. New Zealand, 22. Central Chile, 23. Caucasus, 24. Wallacea, 25. Eastern Arc Mountains & Costal Forests of Tanzania & Kenya

Agro-Biodiversity in Dry Areas

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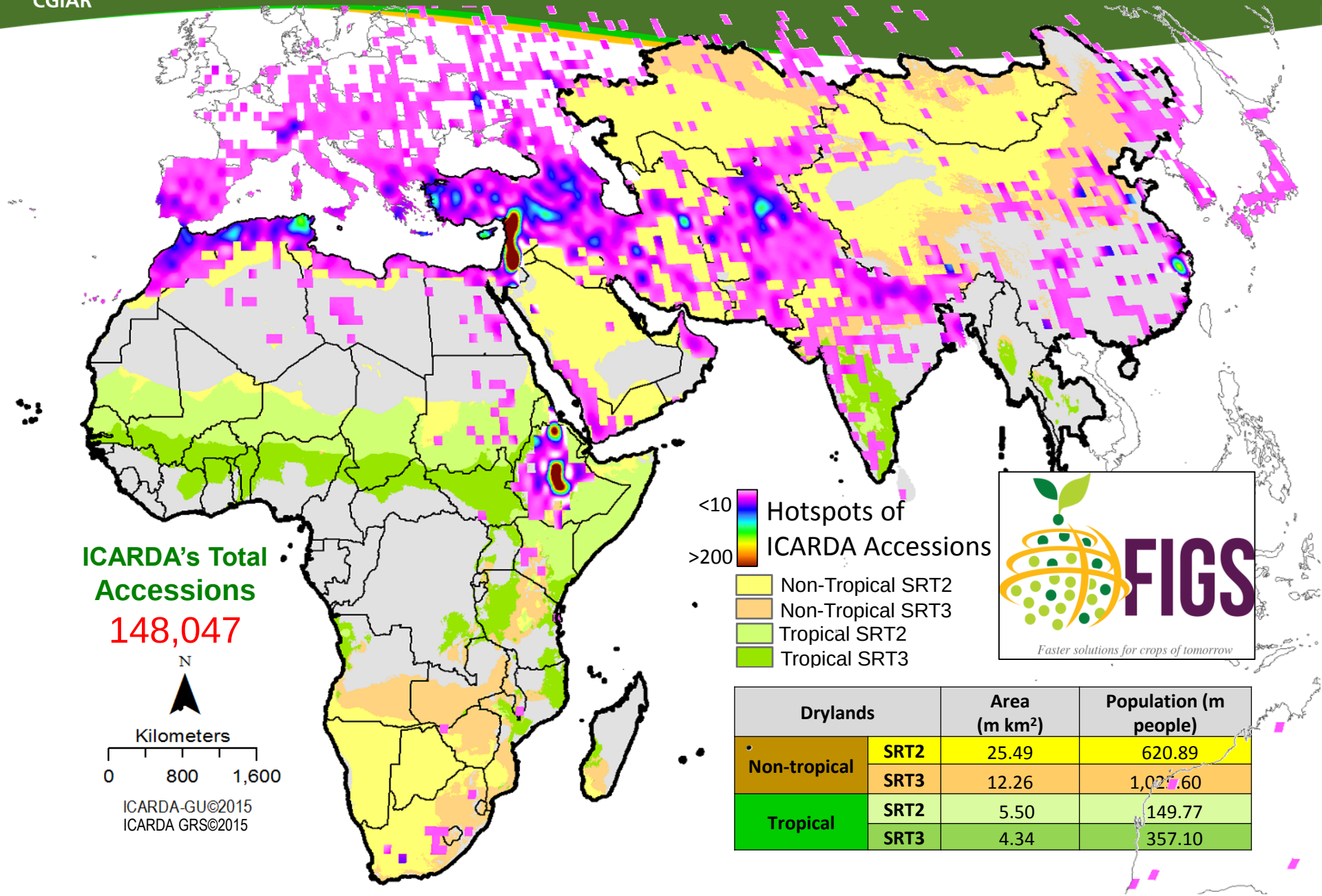
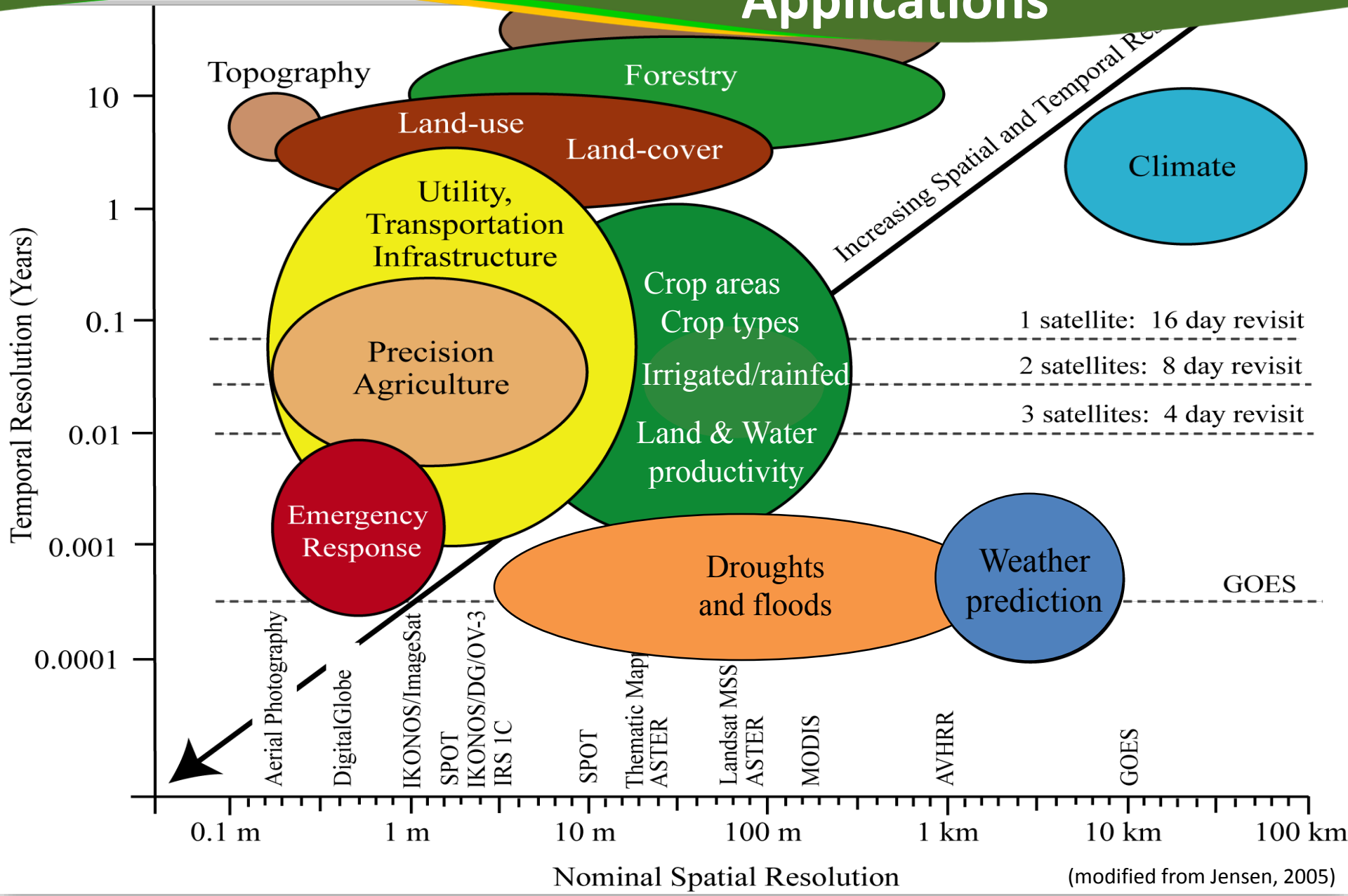


Drylands		Area (m km²)	Population (m people)
Non-tropical	SRT2	25.49	620.89
	SRT3	12.26	1,022.60
Tropical	SRT2	5.50	149.77
	SRT3	4.34	357.10

Spatio-Temporal Resolution vs. Applications



(modified from Jensen, 2005)

Remote Sensing Matrix at Farmscape to Landscape

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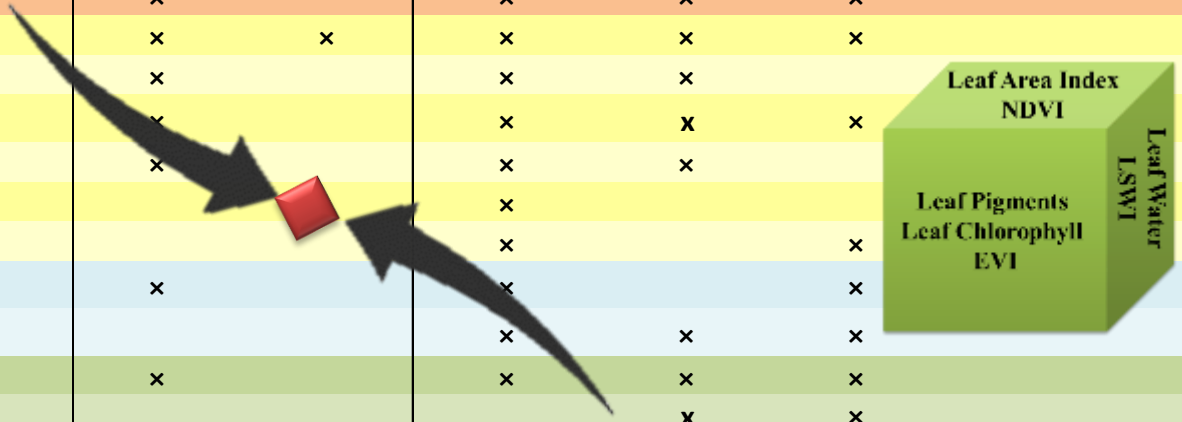
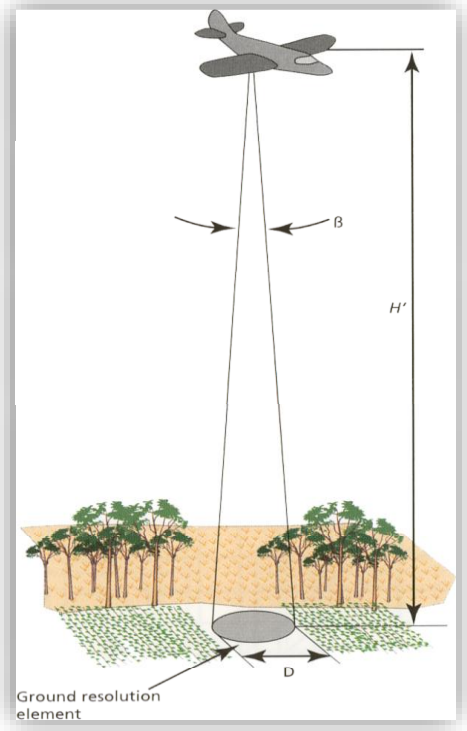
Biospectral – Biophysical

Example of One Sensor in each Platform/Scale

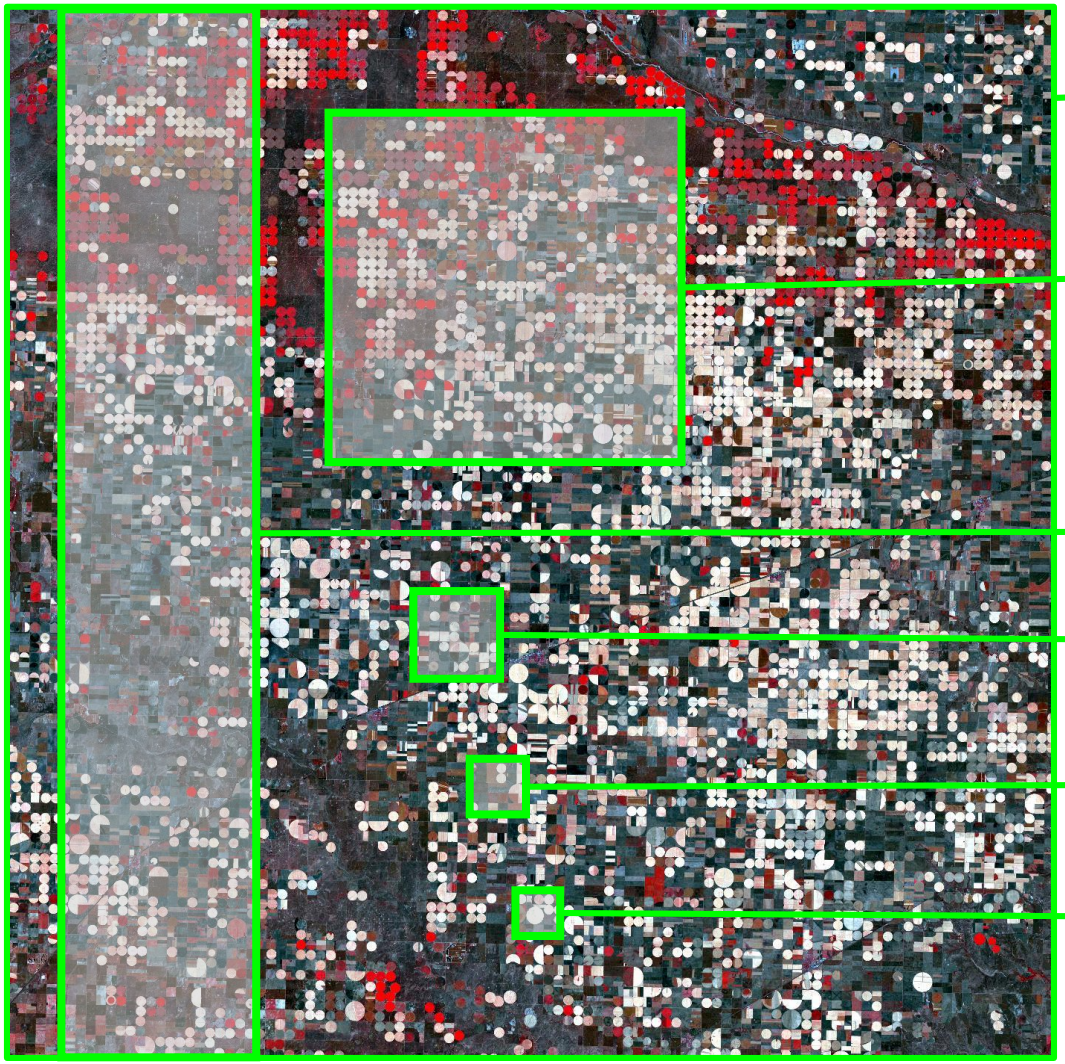
	Platforms	Ground/*in-situ*		Airborne		Spaceborne				
	Mode	Hyperspectral	Multispectral	Optical	LiDAR	Optical			LiDAR	SAR
RS data characteristics	Sensor	ASD FieldSpec	M× Camera	APs/UAVs	Lidar	WorldView-2	Landsat	MODIS	ICESat*	PALSAR
	Spectral	350-2500nm	4 bands	3-4 bands	1264nm	8 bands	7 bands	7/36 bands*	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			×				×		×



Scaling trade-off



Instantaneous field of view (IFOV) and altitude determines the ground area sensed by the sensor at a given instant

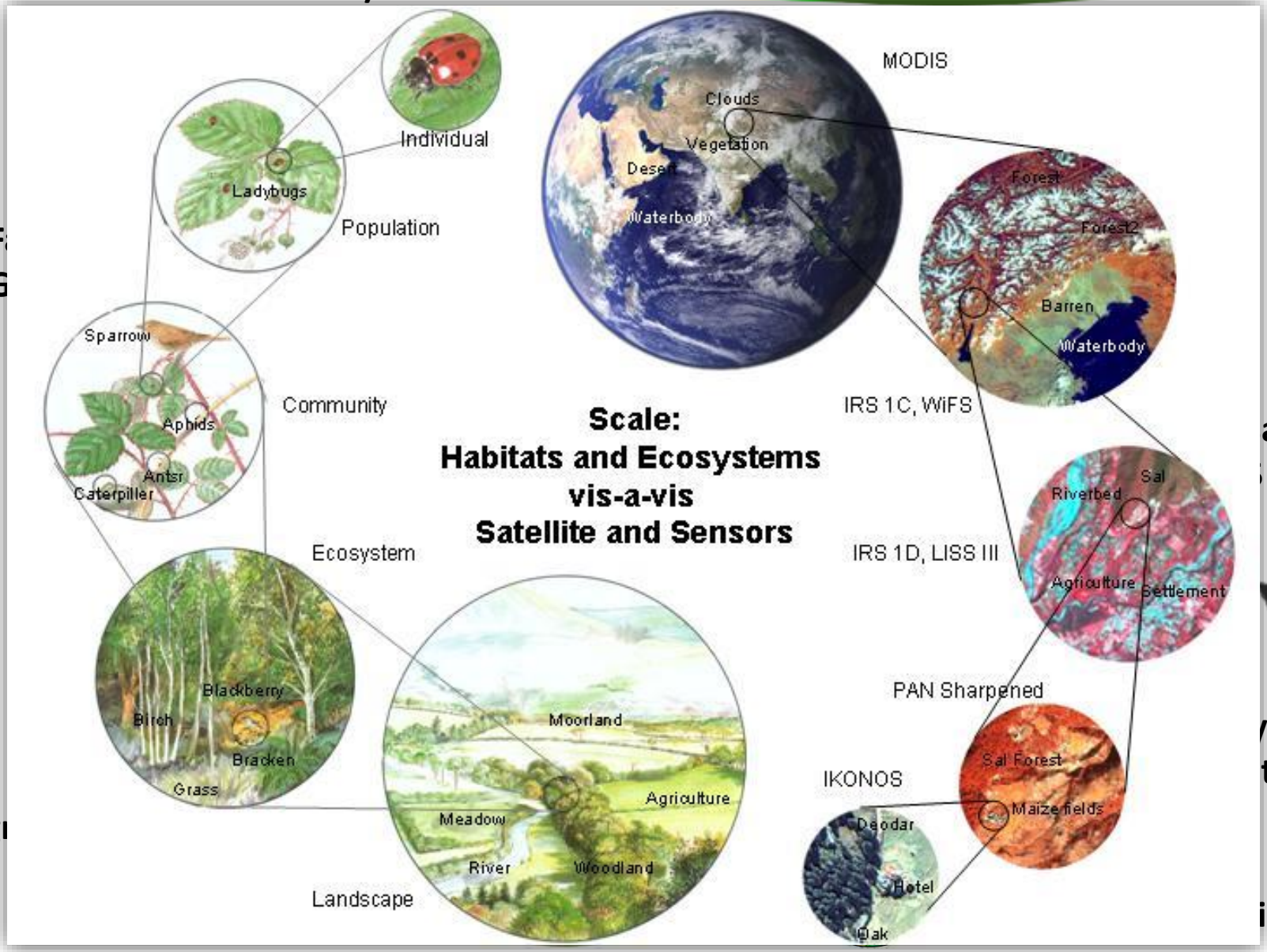


(USGS)

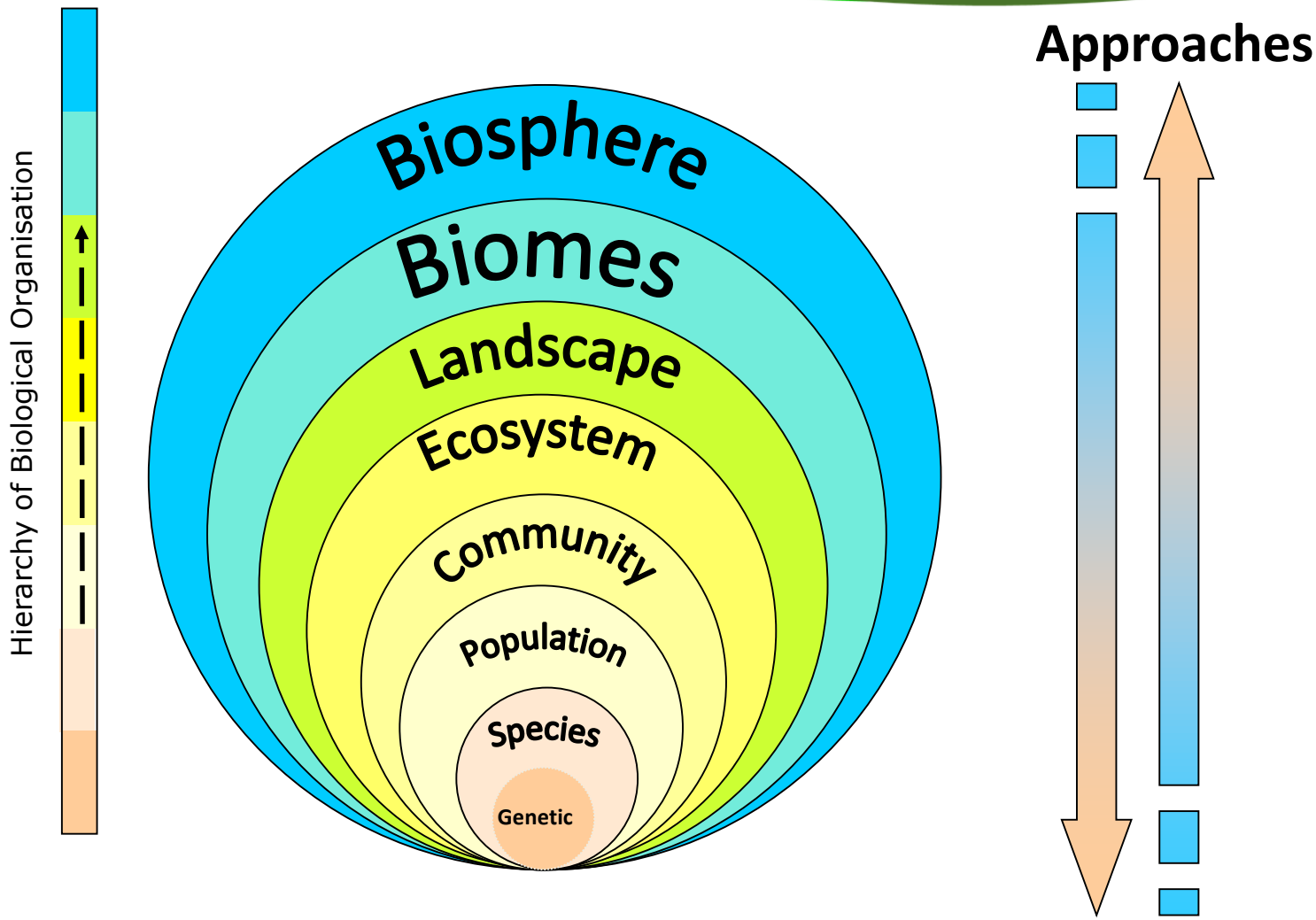
Agro-Ecosystems Services (AES)

Scaling Trade-offs
Pixel to national/regional

Varieties/



Approaches @ different Hierarchy



Time Consuming; Due to High extinction rate? It is overtaking inventory process

Stratified approach; Extrapolation on large landscapes possible, Systematic Monitoring and Spatial Environmental Database

Biodiversity Characterization

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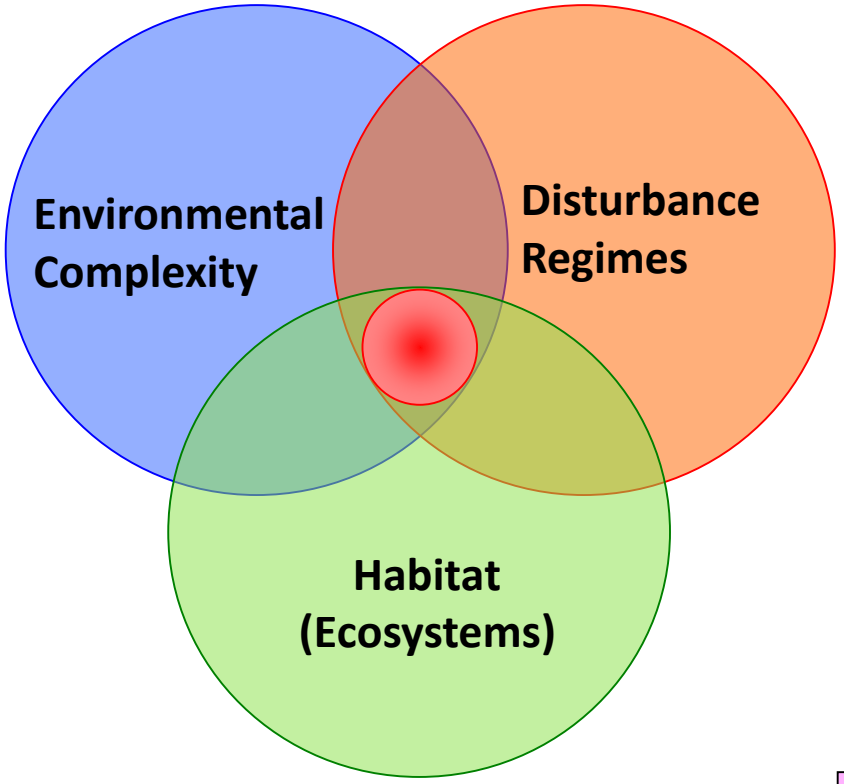
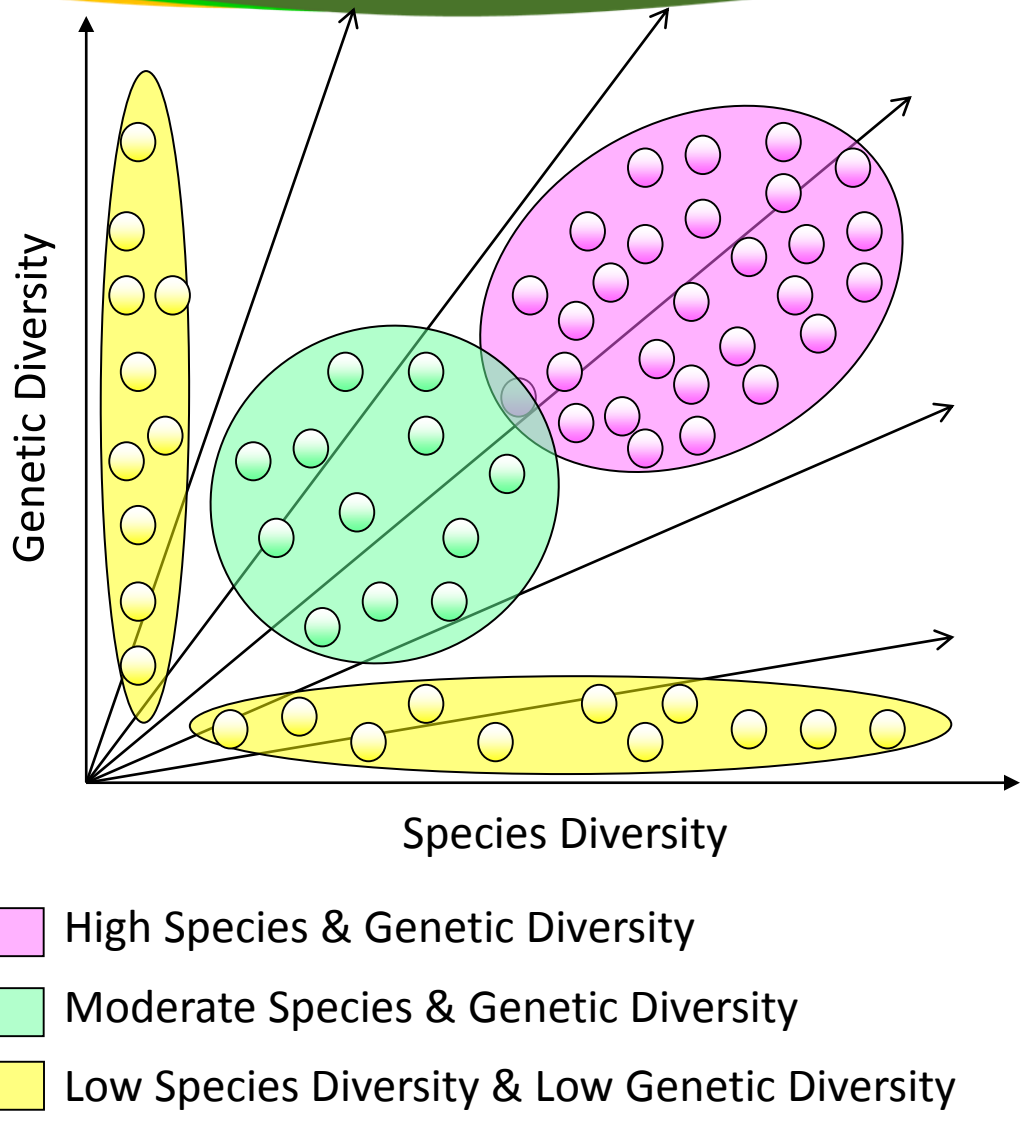
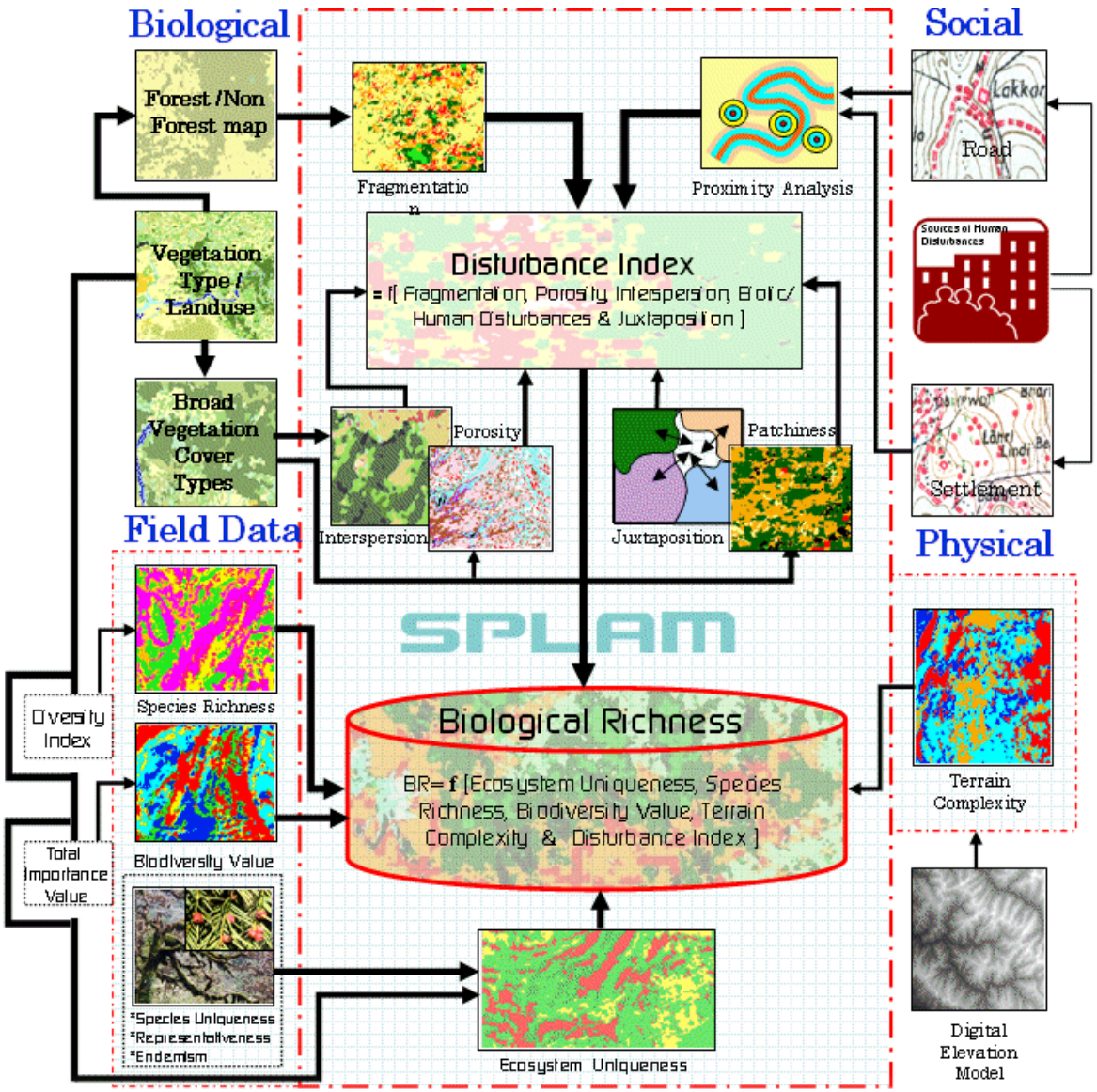
Biodiversity Prioritization

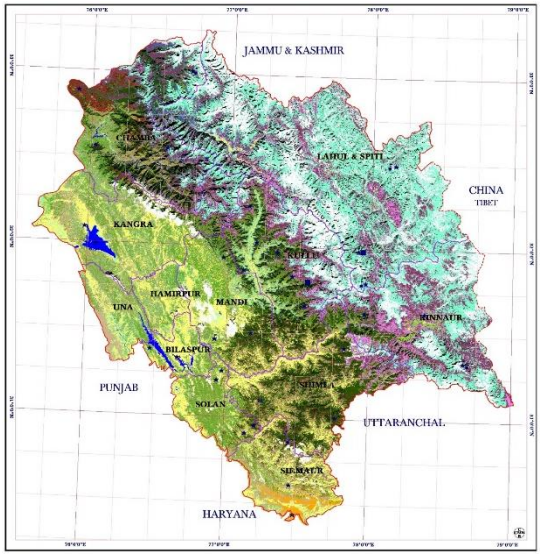


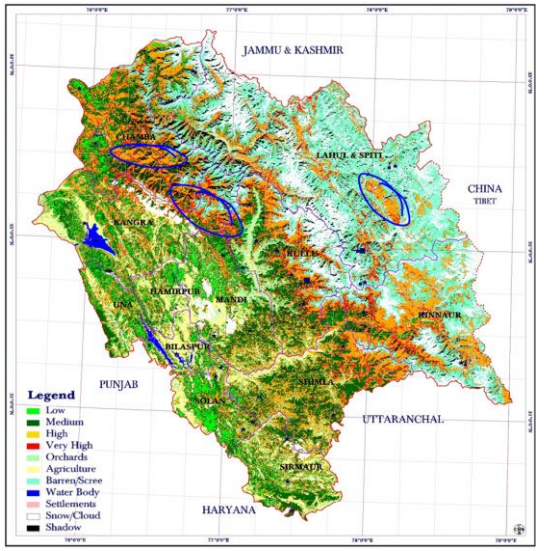


Biodiversity Characterization at landscape level

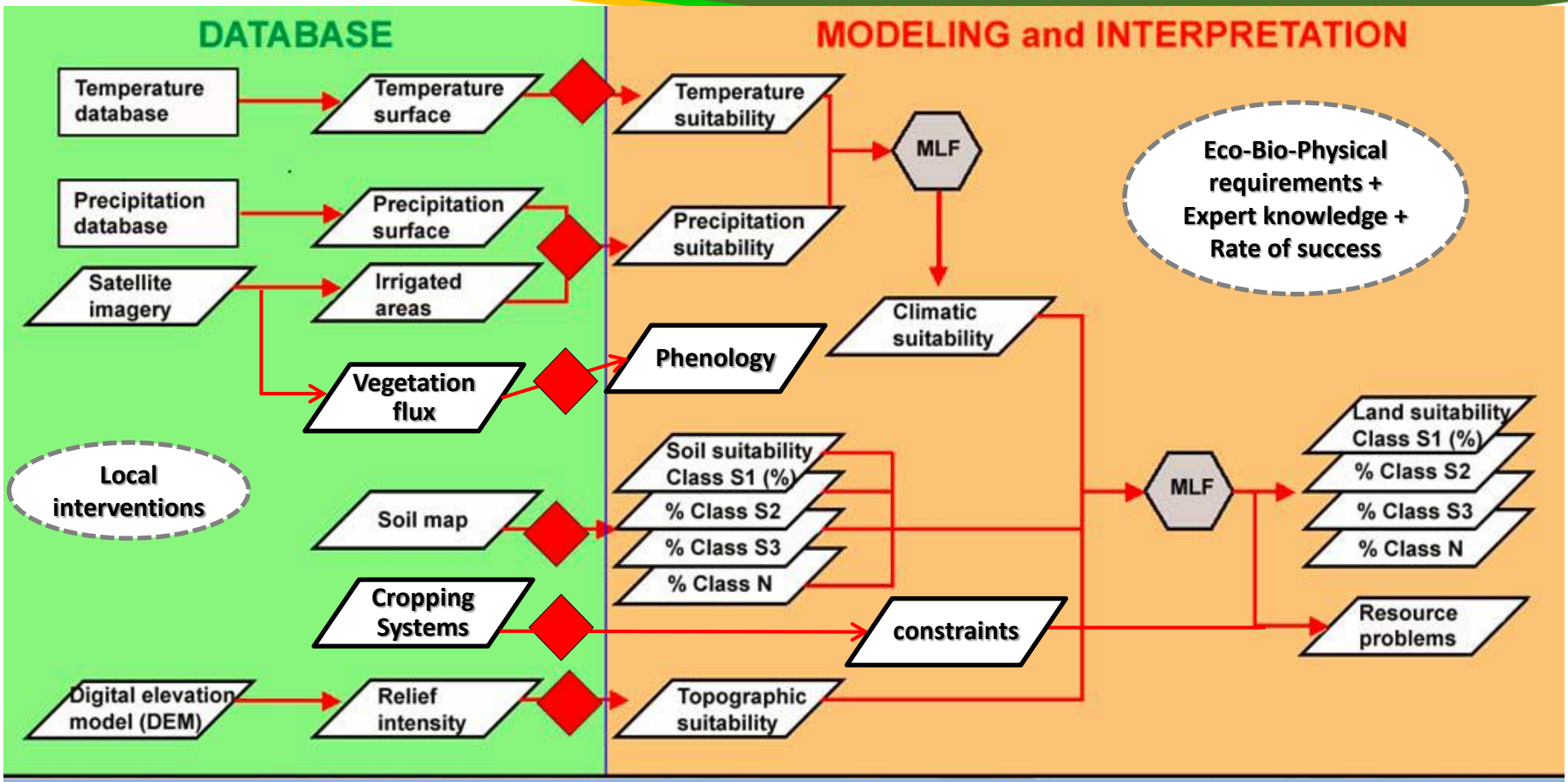
Spatial Landscape Analysis Model





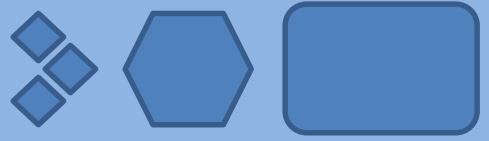


Mapping Similarity for Out-scaling



Similarity analysis within the defined farming system of probability or relatively suitability of given technology (e.g., CA Wheat)

Tier level of scaling up

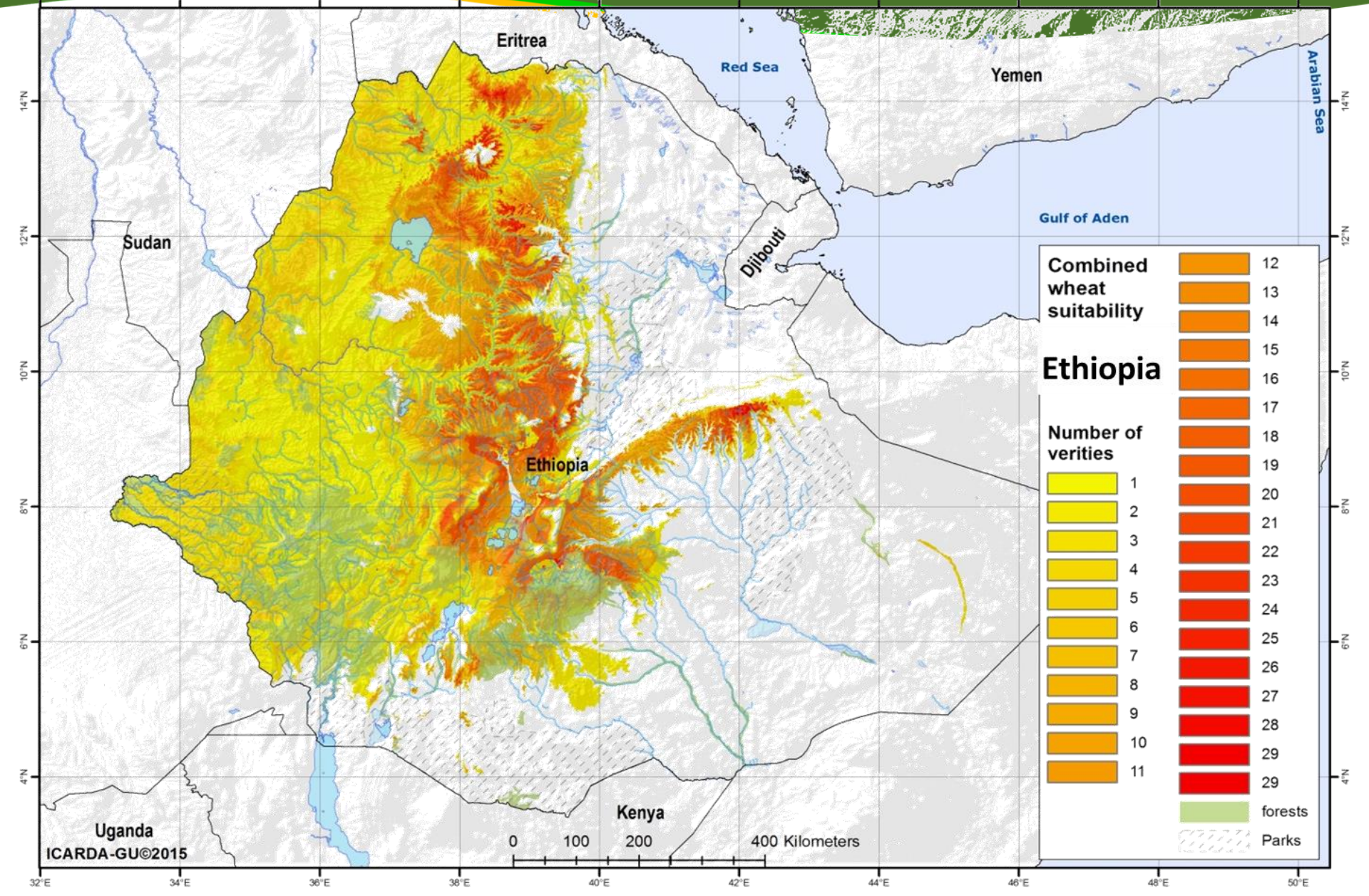


Matching with requirements

MLF Most limiting factors methods

Potential Area for Wheat Expansion

Combined Wheat Product Lines



Wheat varietal suitability maps

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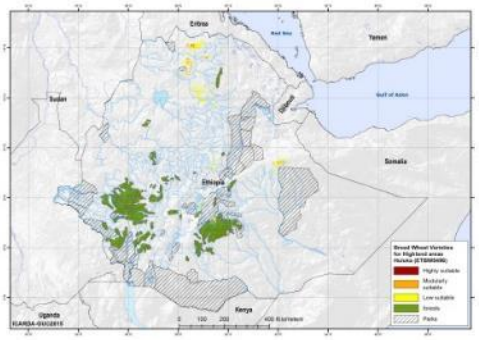
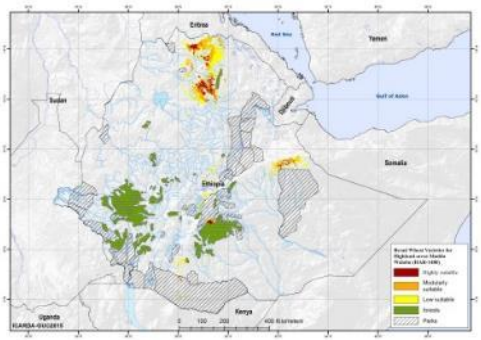
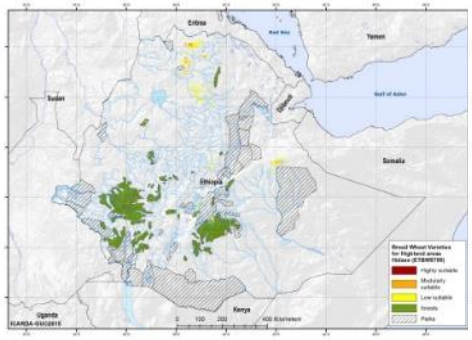
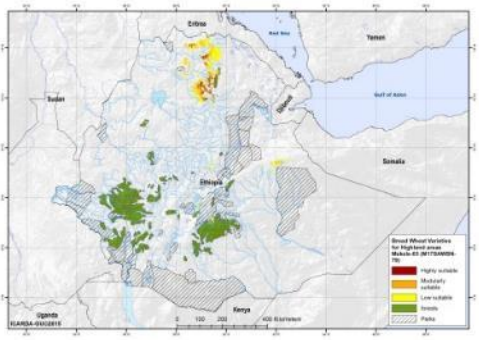
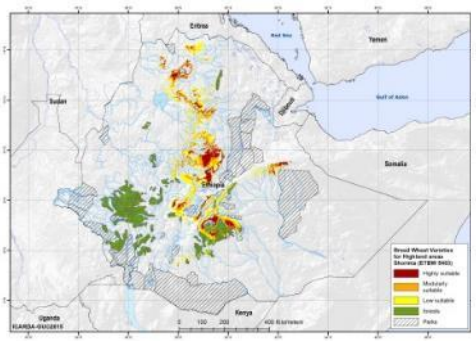
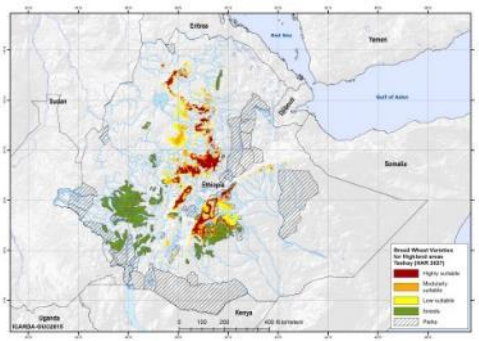
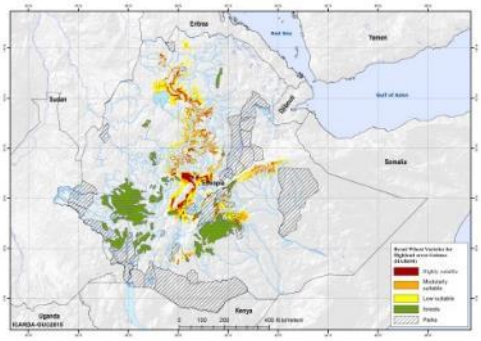
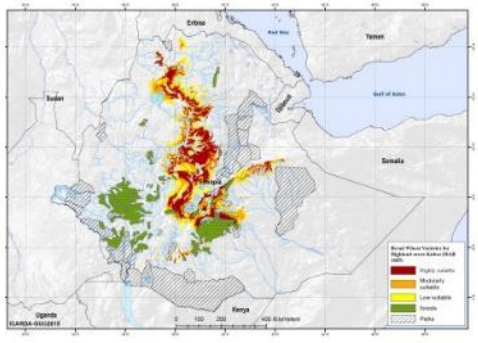
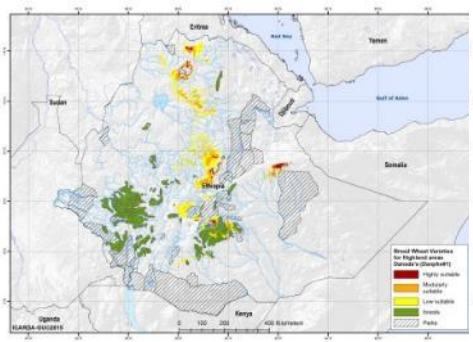
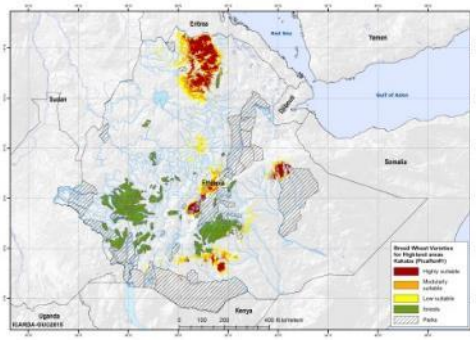
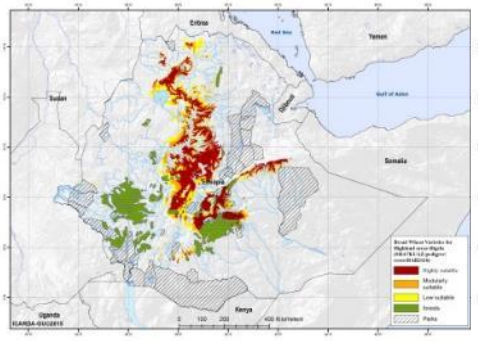
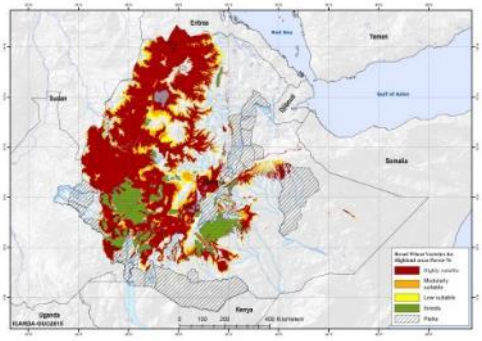
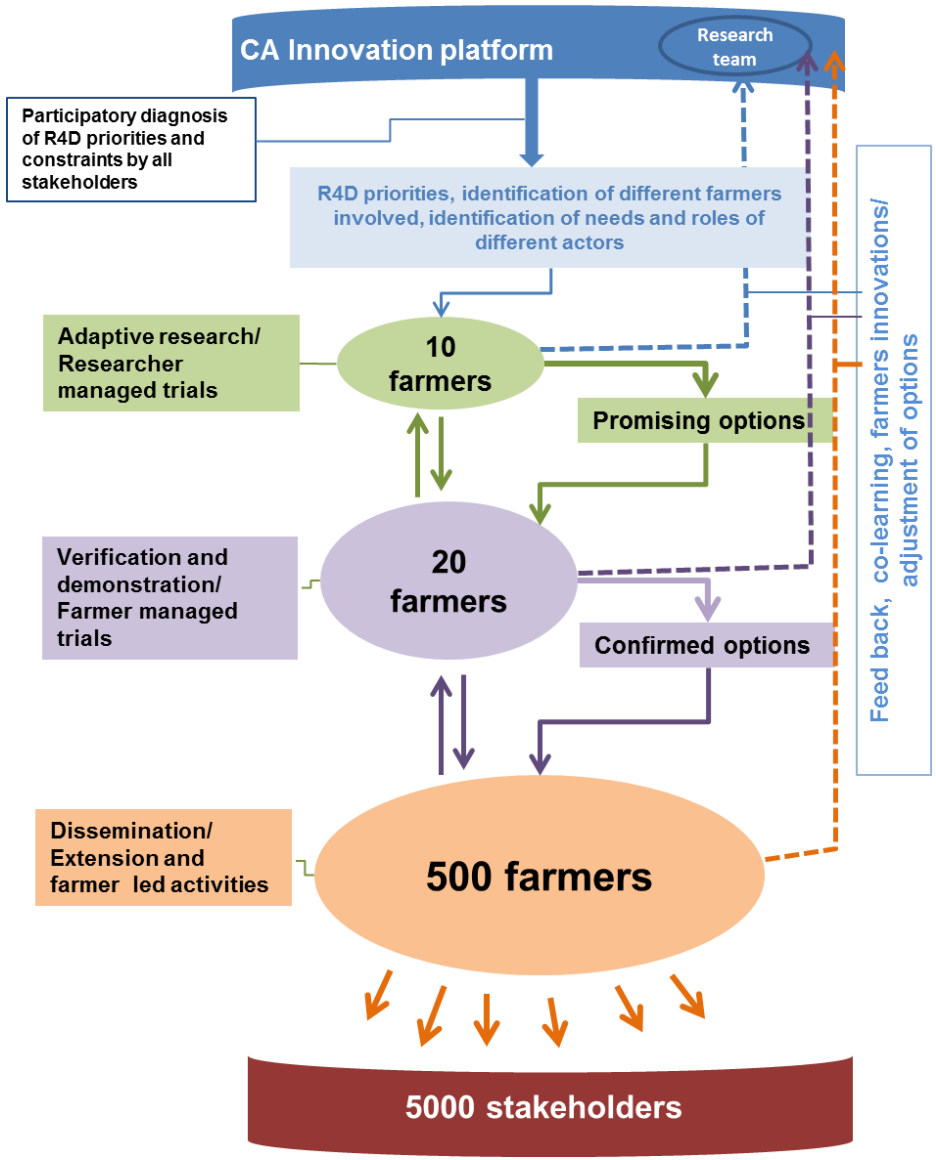
Bread Wheat Varieties for Highlands

Adoption of Conservation Agriculture

North Africa



Mapping and Monitoring

(distribution, condition, residue, productivity)

10 Research Trails

20 Farmers Trails

500 Extension Trials

5000+ Adaptation

Impact Assessment

Similarity Mapping for Adoption of CA

Regional Similarity for Morocco Platform

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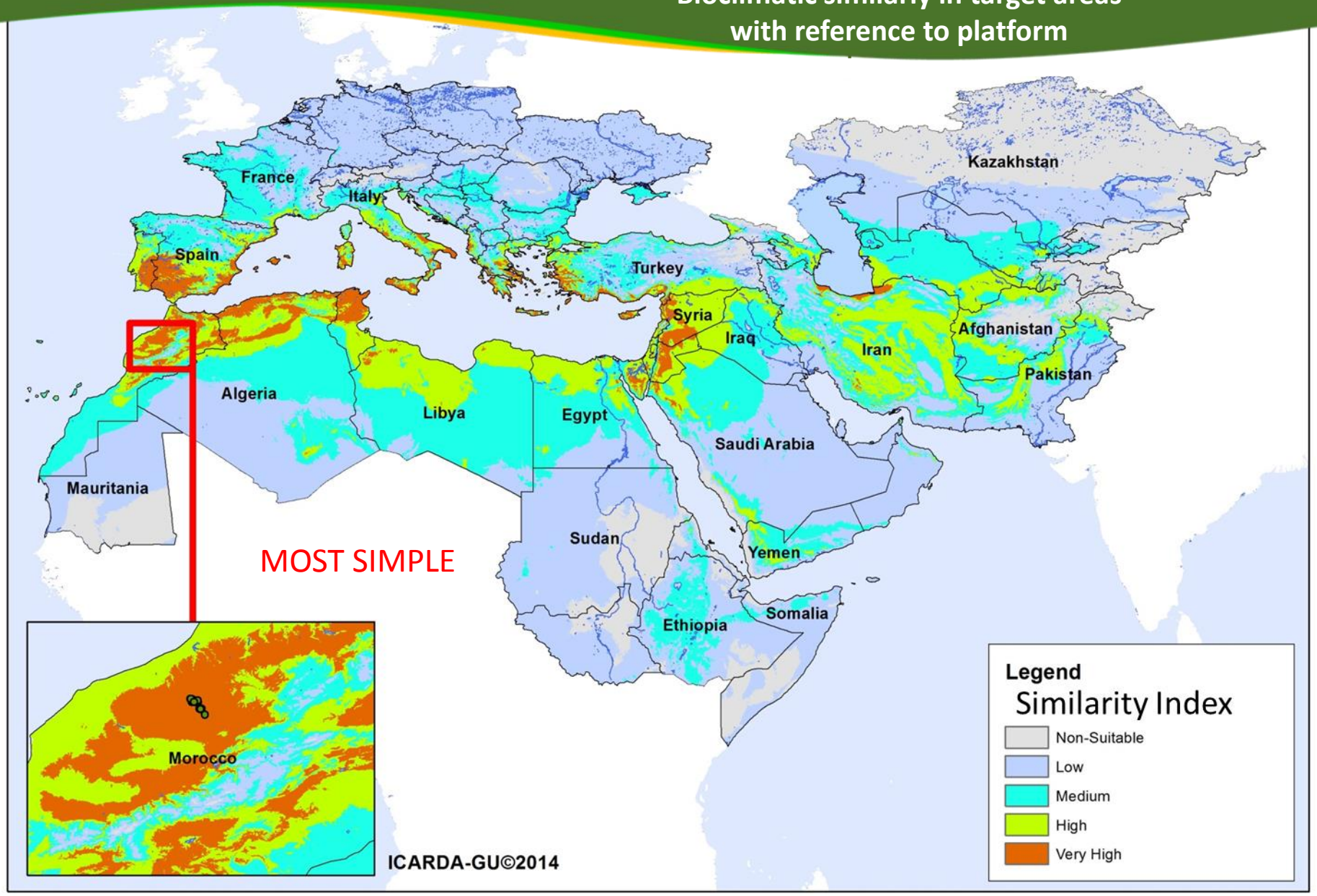
Bioclimatic similarly in target areas with reference to platform



Resilience and Vulnerability

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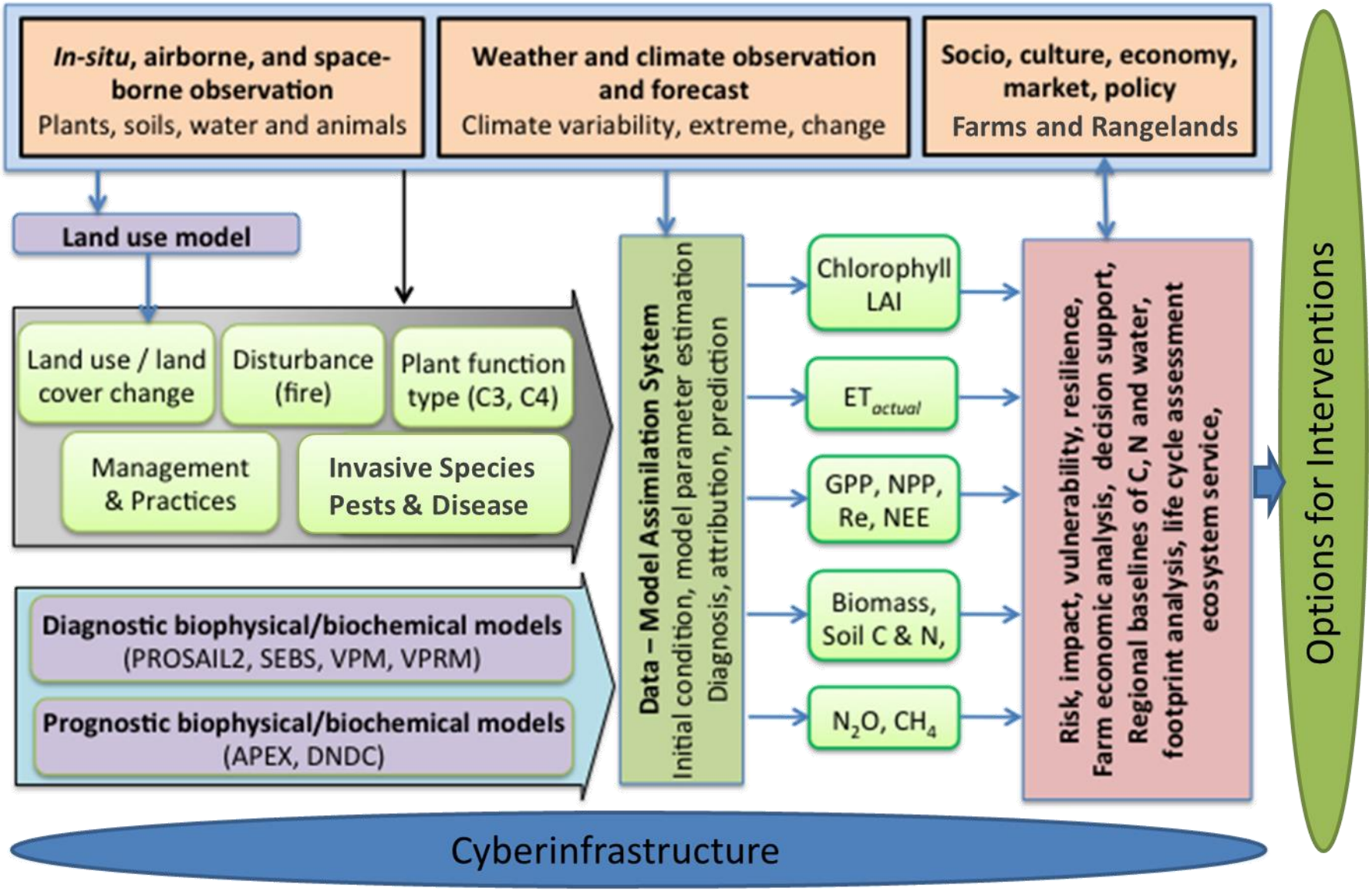
Agro-Ecosystem Services

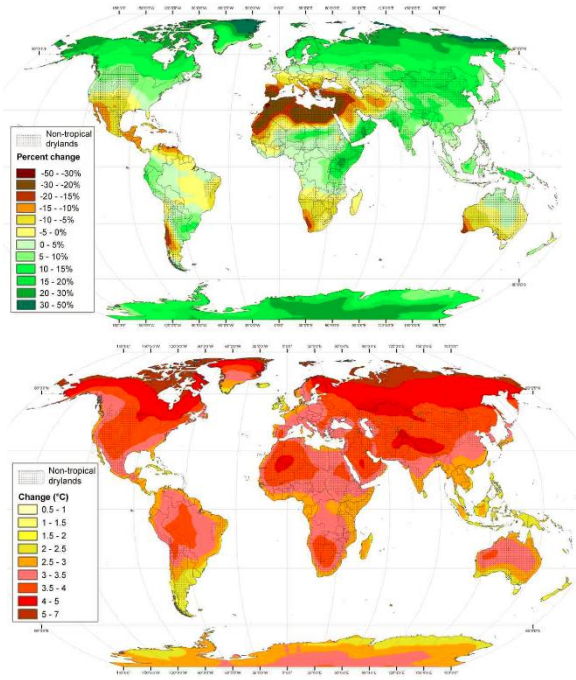
EVEN MORE COMPLEX

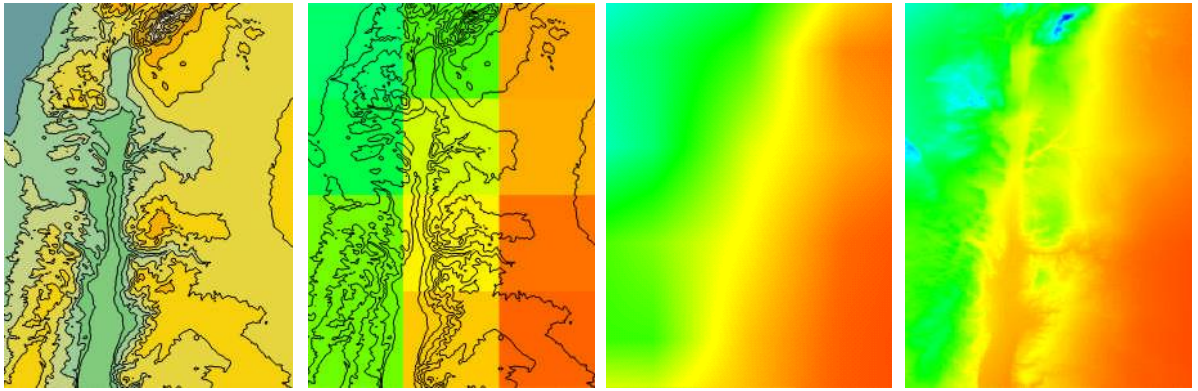


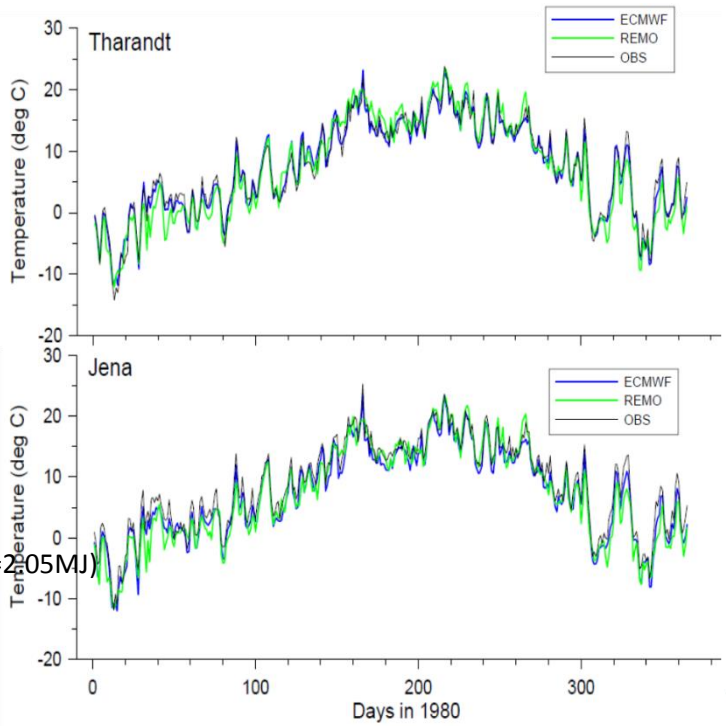
Climate Variables

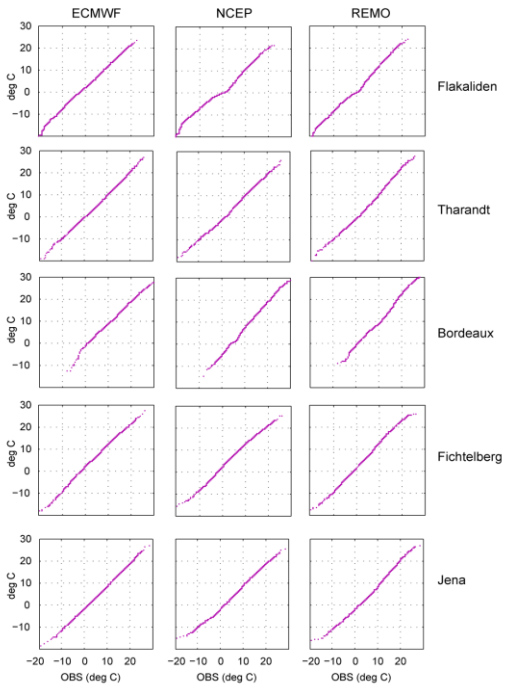
1979/2013 to 2080/2099

1km, Daily, 21 bioclims









a. tmax---maximum temperature at 2 meter (degC)
b. tmin---minimum temperature at 2 meter (degC)
c. precip---precipitation (mm)
d. ABSH---absoluate humidity(kg/m3 scaled by 106)
e. RHY---ralative humidity(%)
f. PAR---photosynthesis active radiation (mol PPFD=2.05MJ)
g. uwind---wind at east-west direction(m/s)
h. vwind---wind at north-south direction(m/s)
i. VPD---vapor pressure deficit(Pa)

Climate Extremes

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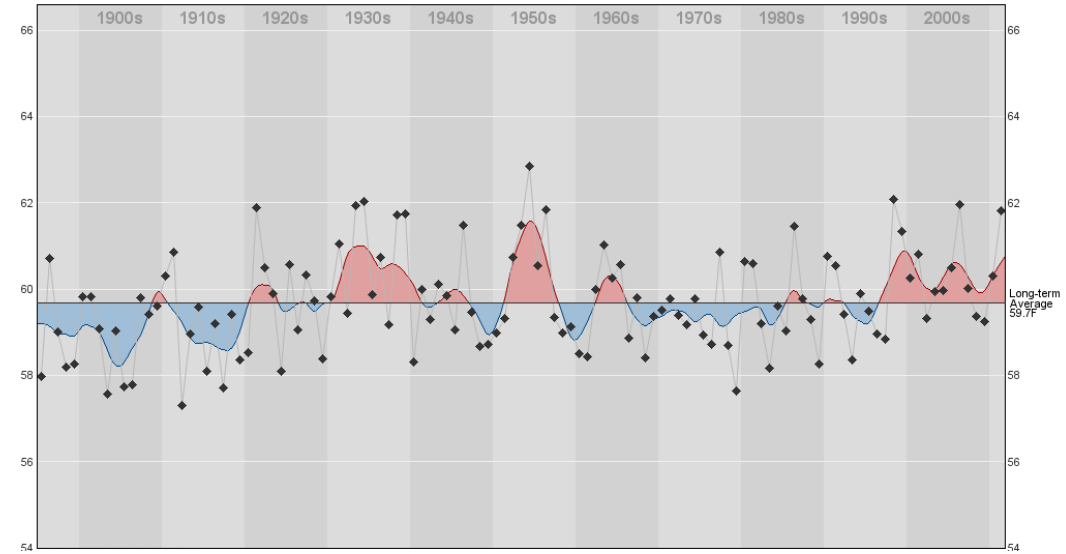
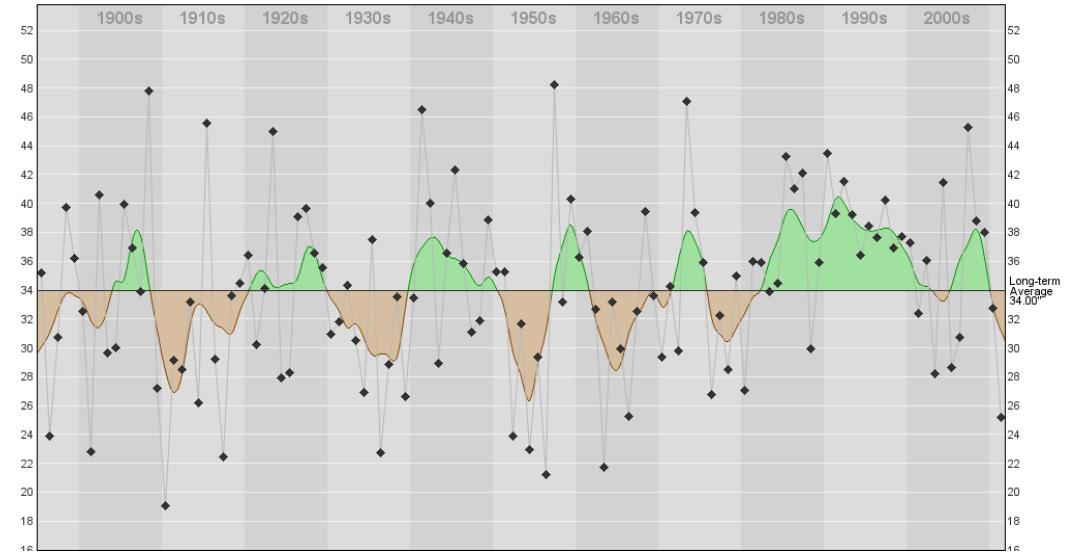
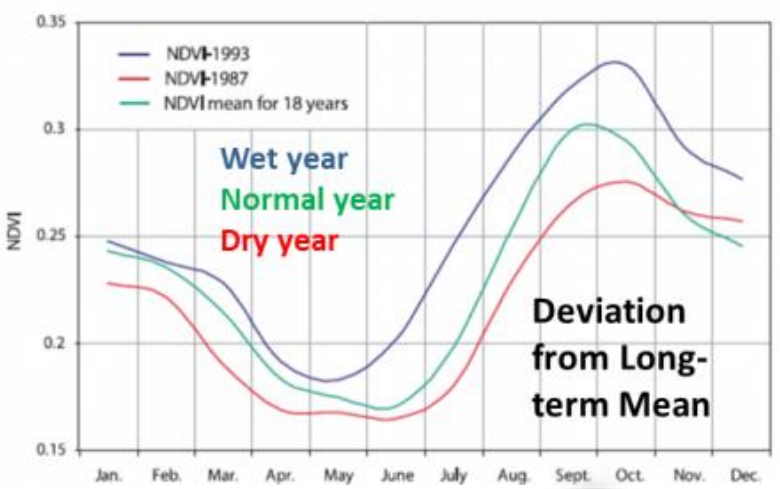
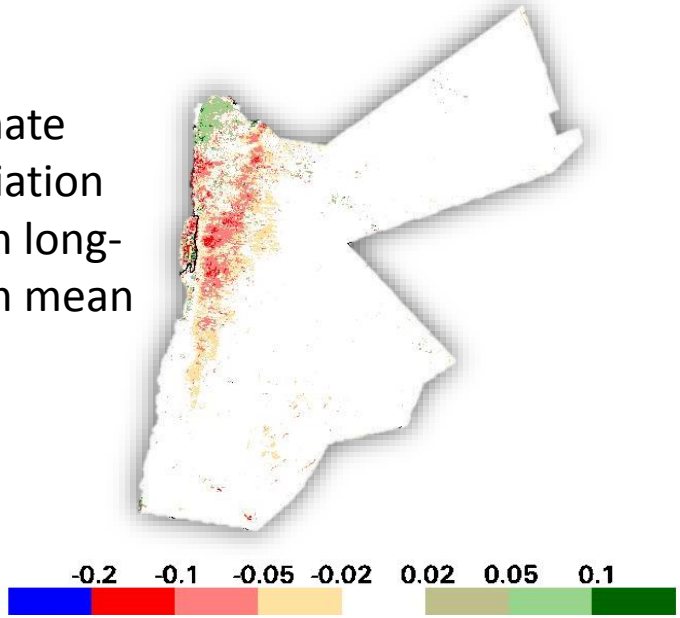
National to Local Scale







Climate Deviation from long-term mean



Mapping Pest & Disease Risk

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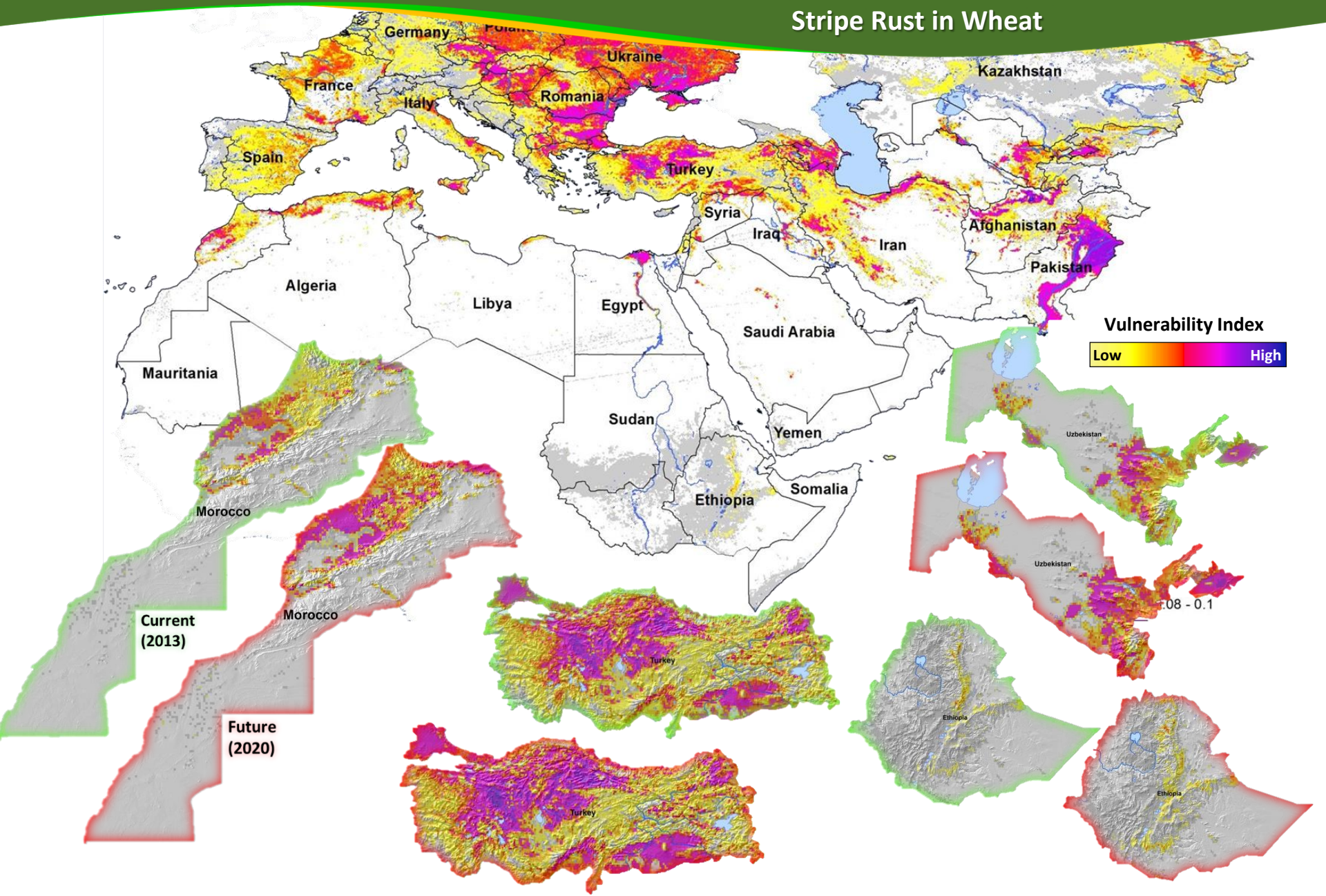

Geoinformatics

Science, Technology & Applications

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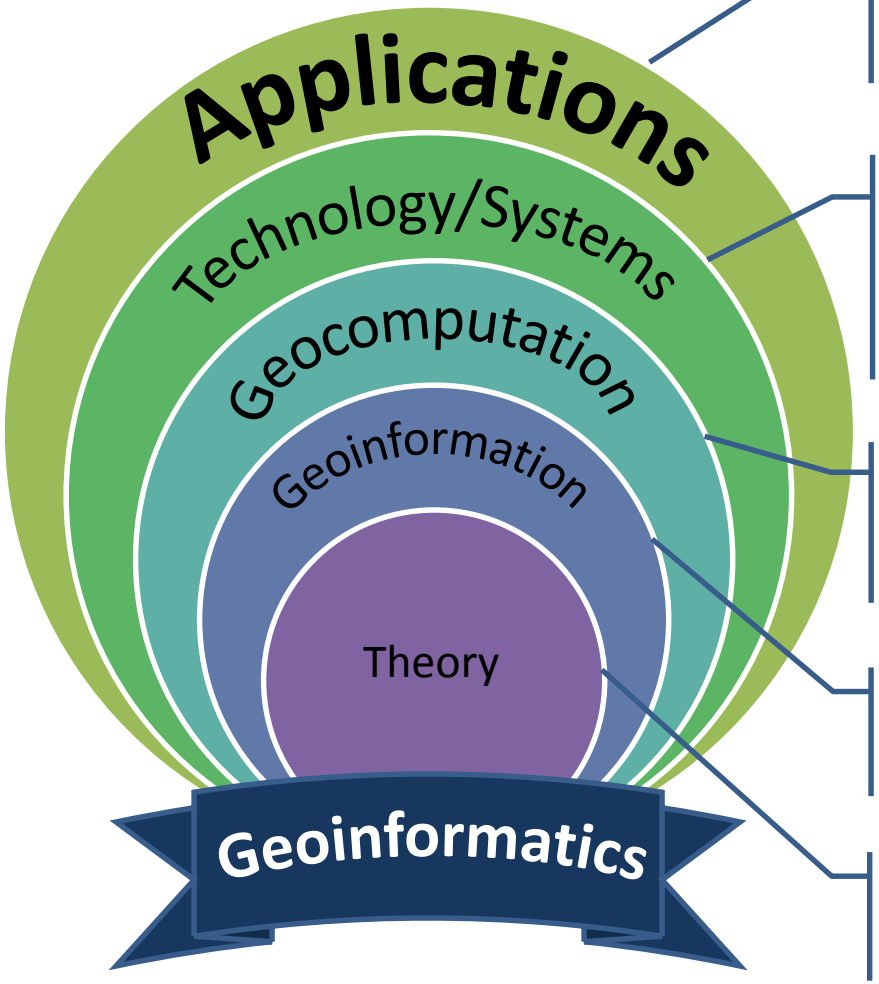
Science for Better Livelihoods in Dry Areas



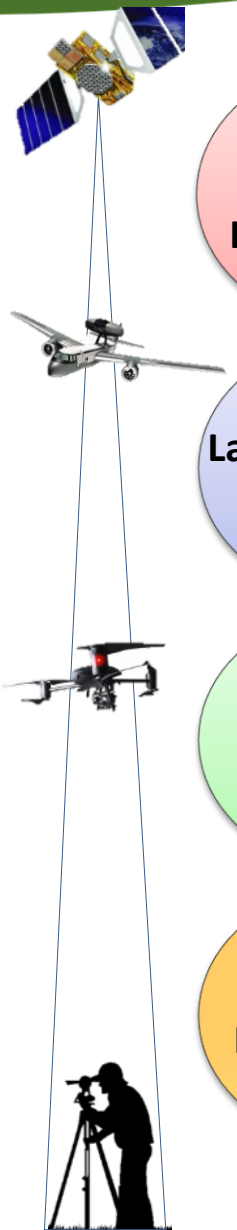
Agro-ecosystems
Environment
Climate Change

Remote Sensing
Navigation System
Spatial Decisions
Telecommunication

Comp. Geometry
Spatial Analysis
Spatial Data Mining

Spatial Database
Maps & Attributes

Spatial Models
Spatial Algorithms
Spatial Reasoning



Biodiversity and Crop Improvement

Land and Water Resources

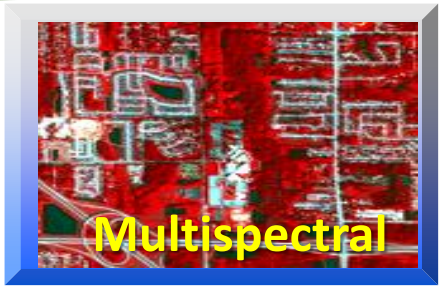
Crop and Livestock Productions

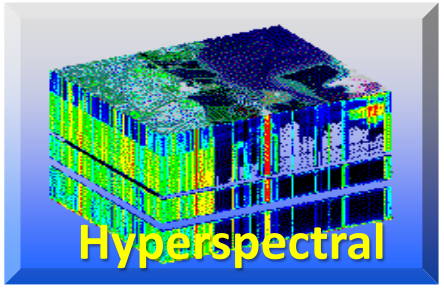
Socio-Economics, Markets and Policy

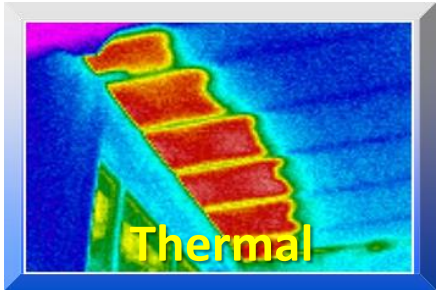
Recent Advances in Geoinformatics

Earth Observation

- **Increased Spatial Resolution**
  - ~50cm, 1m, 2.5m, 4m, 5m…
- **Increased Spectral Resolution**
  - hyperspectral, ultraspectral, thermal, SAR,..
  - specific bands for agricultural applications…
- **Increased Temporal Resolution**
  - daily @ higher spatial resolution…
- **Increased Computational speed**
  - high end PCs/WS, cloudC, multithreading…
- **Improved Image Processing Techniques**
  - VMs, Feature Ex, Fusion, KBCs, Decision trees…
- **Decreased Cost of the Hardware**
  - servers and storage systems …
- **Deceased Software cost:**
  - open source programs/OS …
- **Decreased RS Data cost**
  - free and open access data sharing…







Evolving pixels to specific needs!

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Science for Better Livelihoods in Dry Areas

Local to Global Scale

Satellite	Resolution(m)*	Pixels/ac	Pixels/ha	$/km^2
AVHRR	1000	0.004	0.01	Free
SPOT	1000	0.004	0.01	Free
MODIS	500	0.016	0.04	Free
Landsat	30	4.5	11.1	Free
PALSAR	10	40	100	Free
AWiFS	60	1.11	2.7	0.01
IRS Liss3	23.5	7.3	18.1	0.15
ASTER	15	18	44.4	0.04
IRS Liss4	5	160	400	1.19
Blackbridge	5	160	400	1.23
IKONOS	4	253	625	5.02
Cartosat1	2.5	640	1600	6.59
GeoEye1	2	1012	2500	12.5
WorldView2	2	1012	2500	14.5
PLEIADES	2	1012	2500	17

* Multispectral

Earth Observation Systems for Agro-Ecosystem Research

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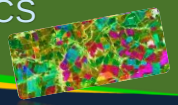
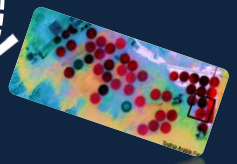
ACTIVE SATELLITE SENSORS AND CHARACTERSTICS





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

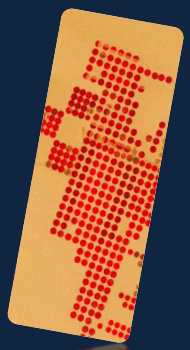
Medium resolution (5 - 30 m)

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

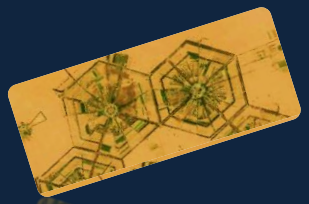
High Resolution (1 to 5 m)



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

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

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Satellite Sensors Interoperability

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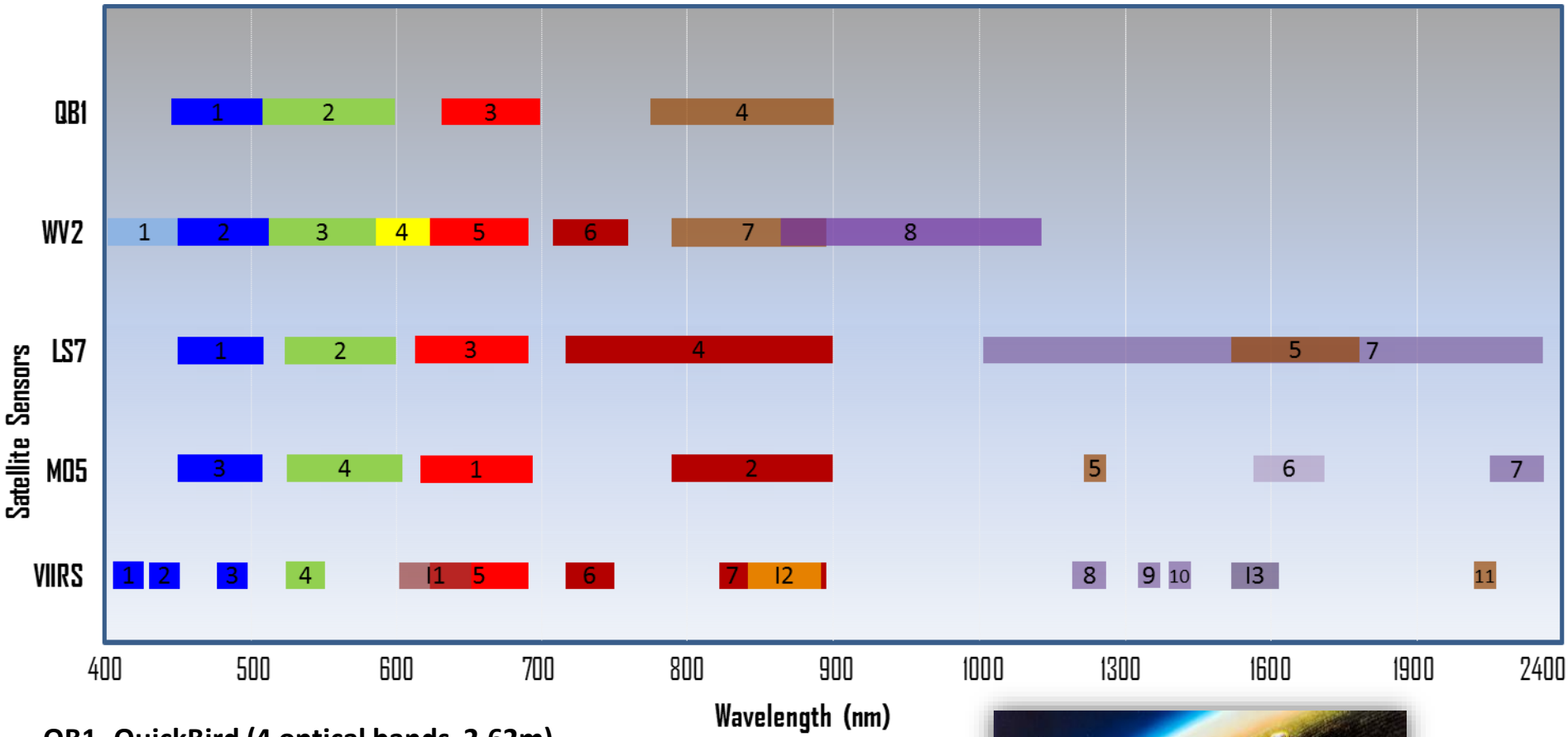
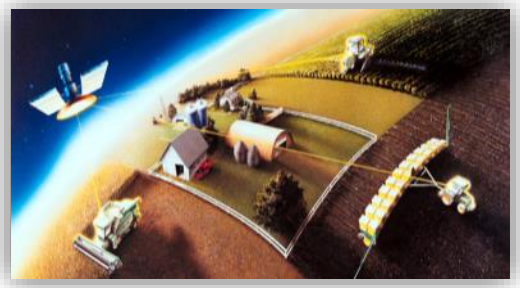
Science for Better Livelihoods in Dry Areas

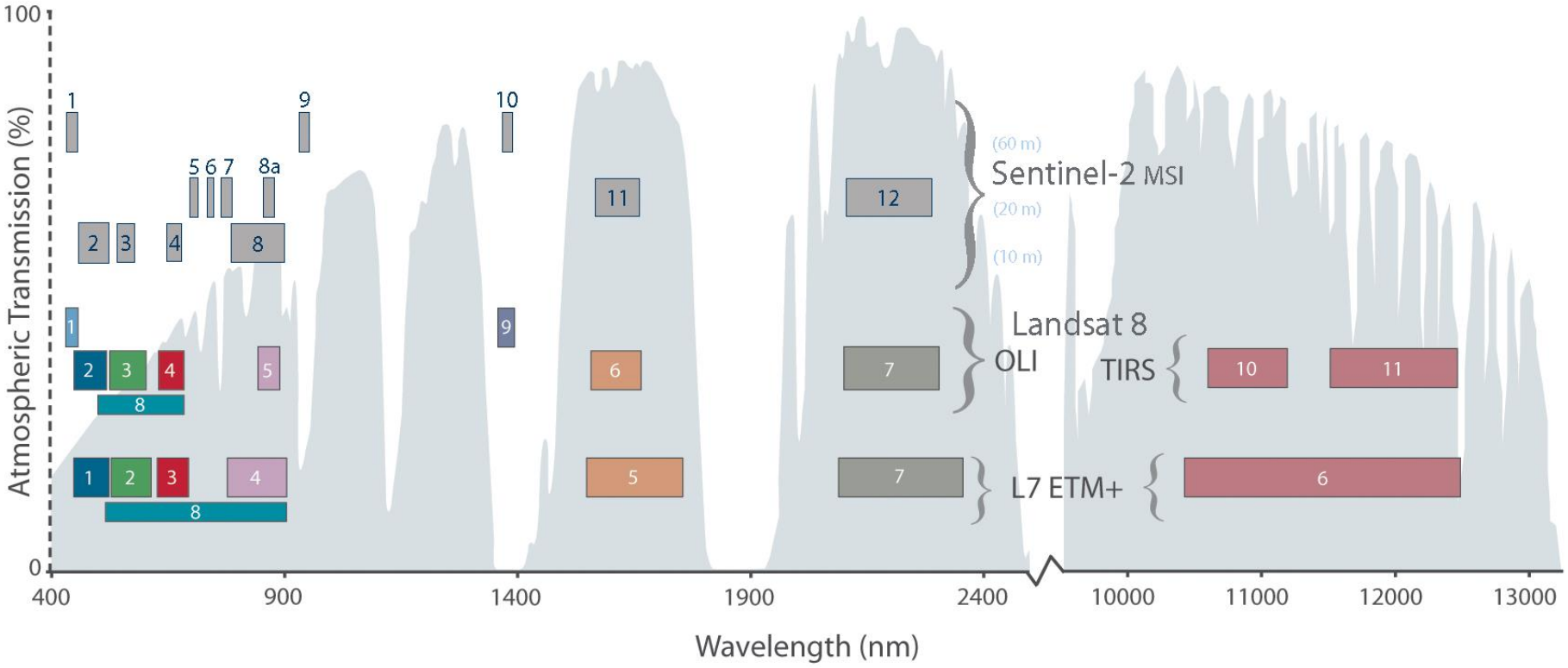
Options for Up/Down Scaling



QB1- QuickBird (4 optical bands 2.62m)
WV2-WorldView2 (8 optical bands, 2.4m)
LS7-Landsat ETM+ (6 optical bands, 30m)
MO5-MODIS MOD09A1 (7 optical bands, 500m)
VIIRS-NPOESS VIIRS (11 optical bands, 375-750m)

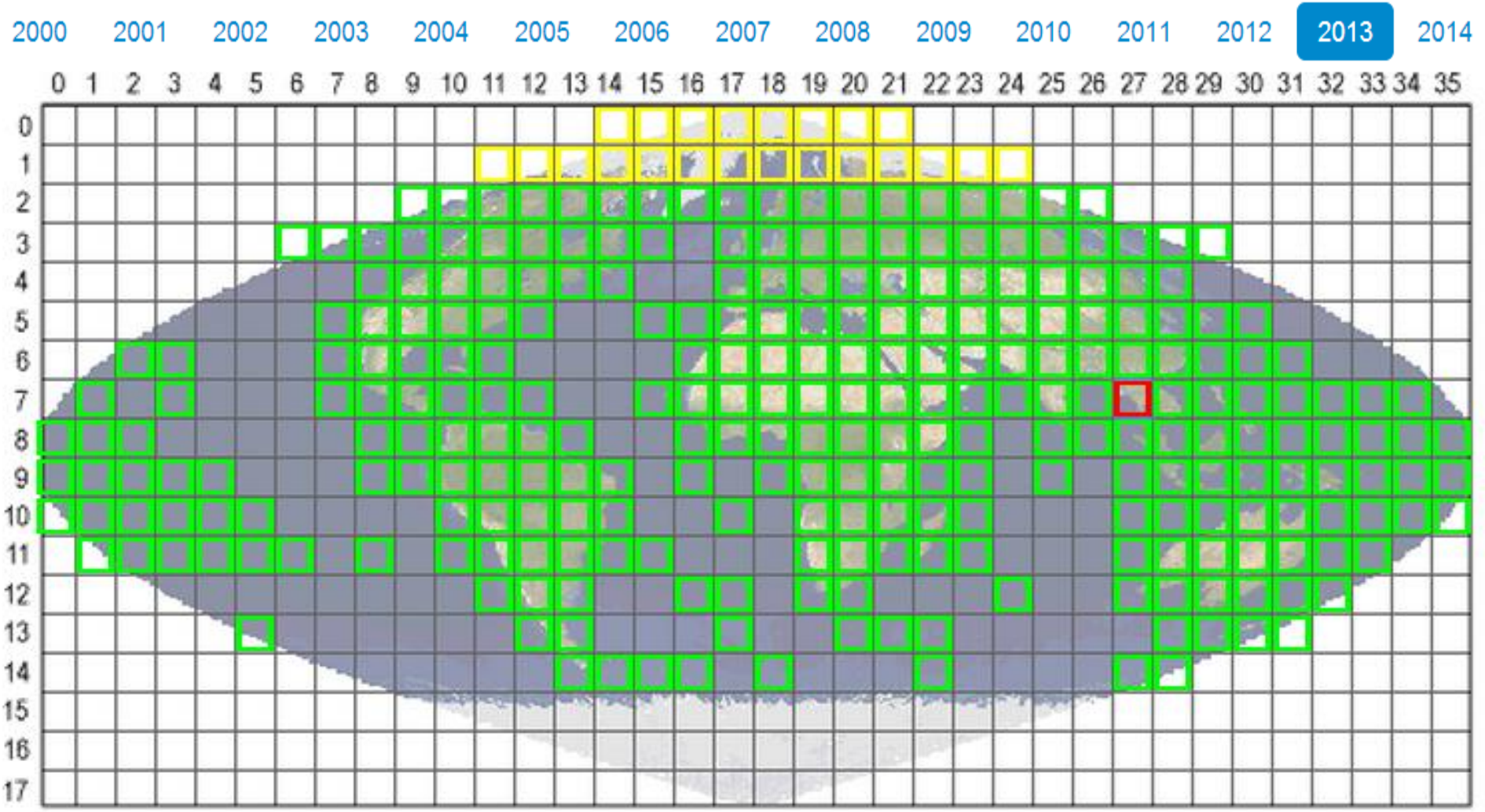


Comparison of Landsat 7 and 8 bands with Sentinel-2



Global and Regional: MODIS

@ 250/500-m spatial resolution



Regional and National: Landsat

@ 30-m spatial resolution

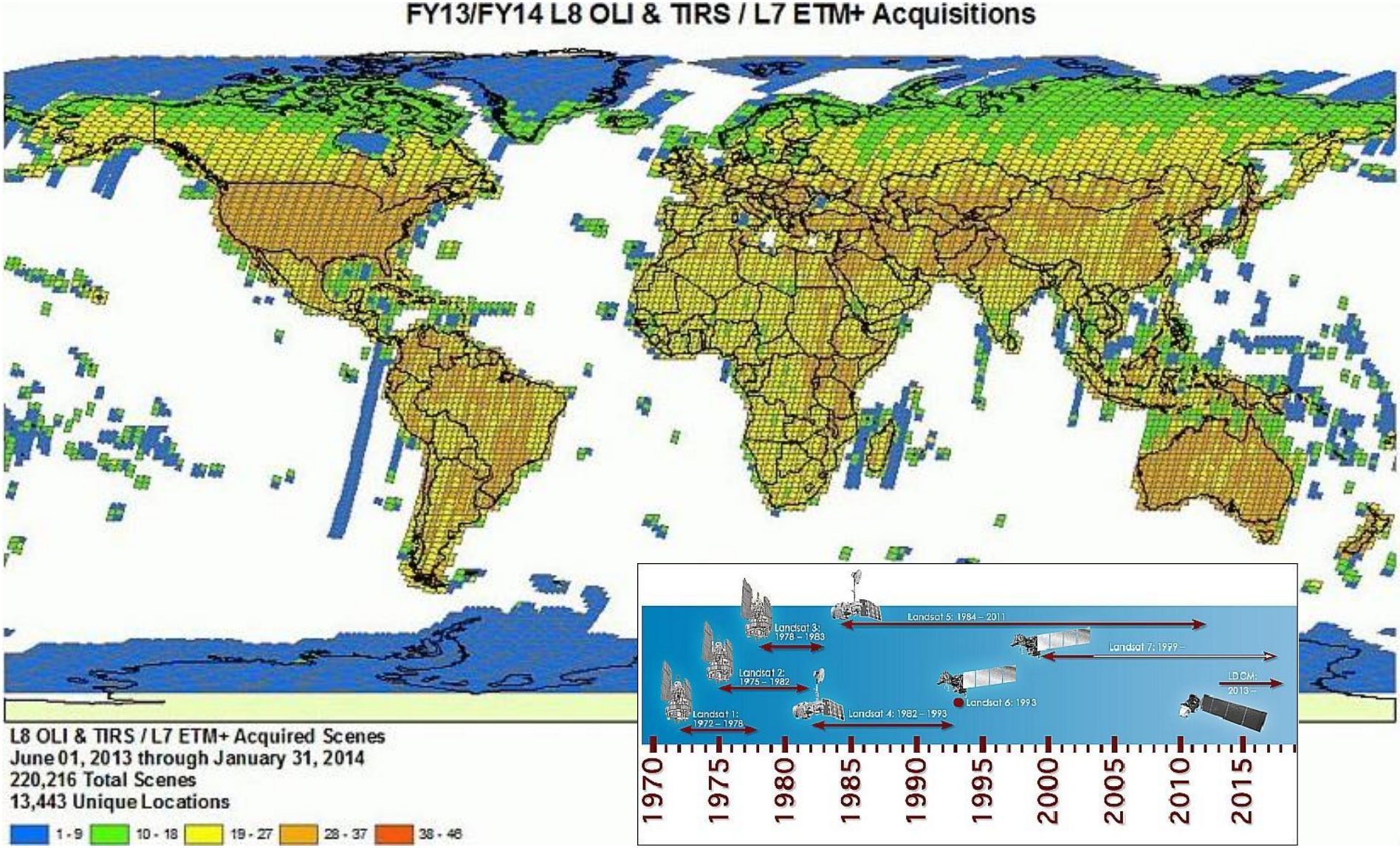
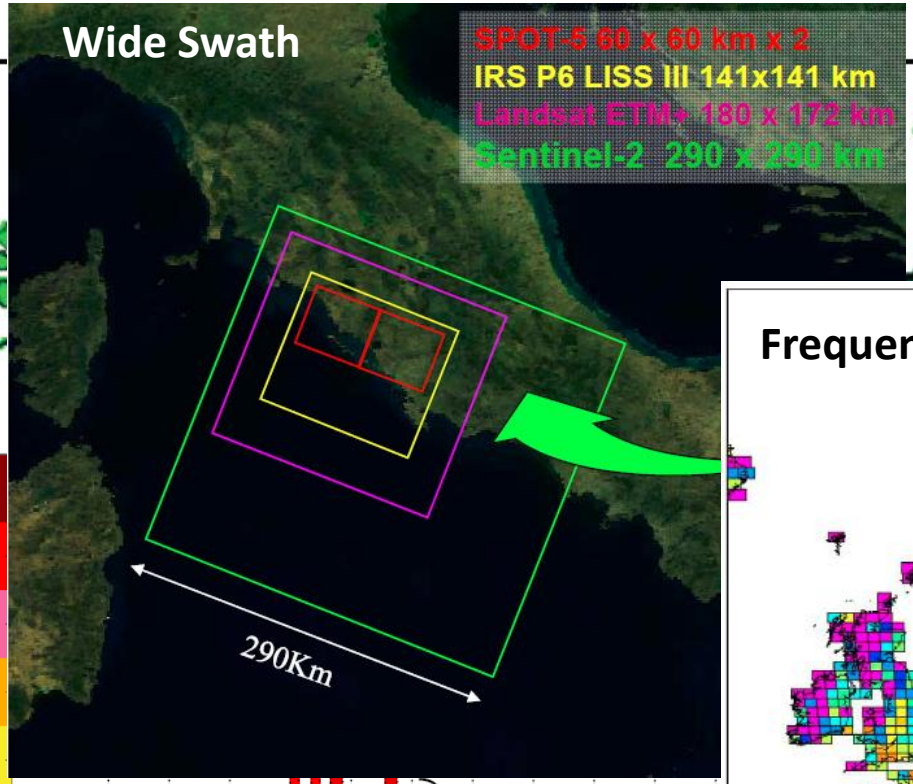
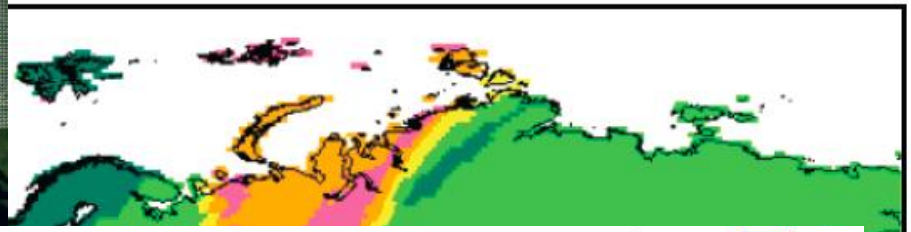


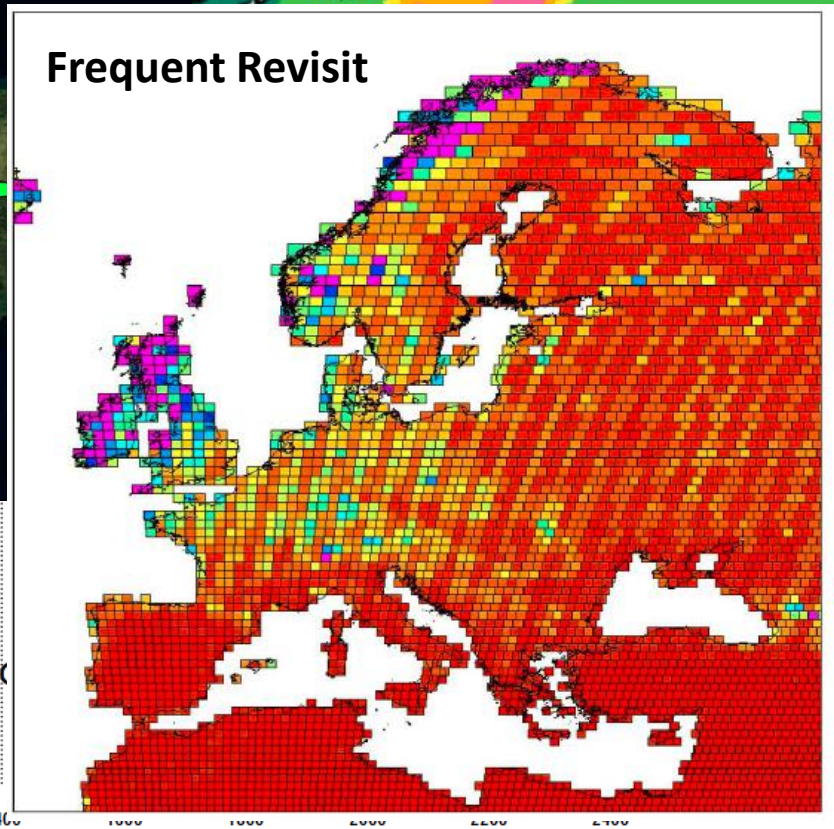
image credit: NASA

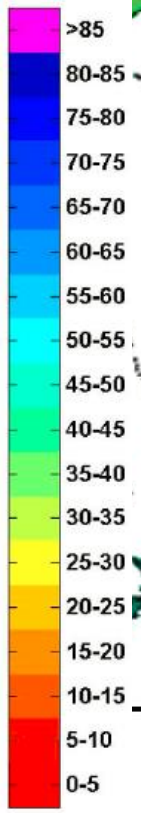
National and Subnational: Sentinel2

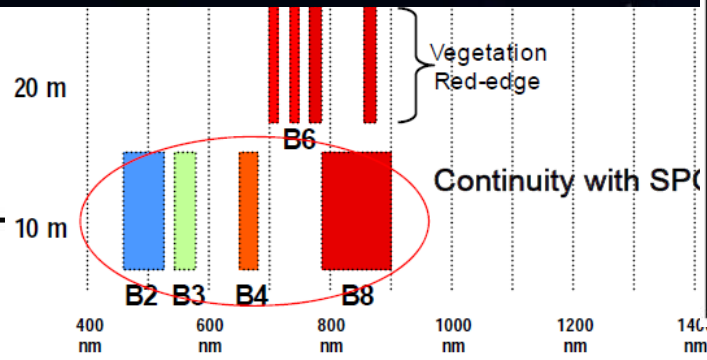
@ 10/20/60-m spatial resolution











Source: ESA/ESTEC

Very High Resolution (VHR) Satellites

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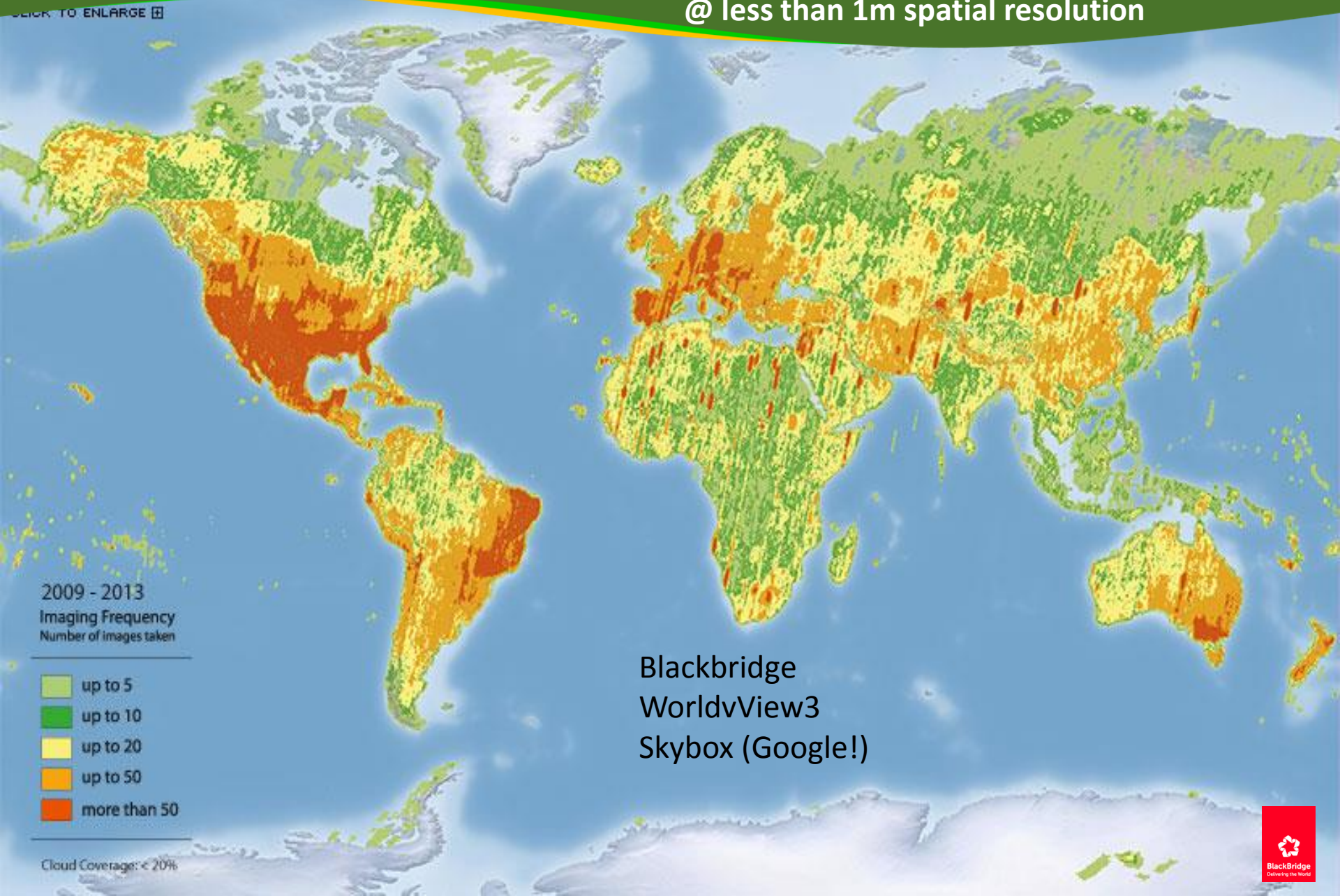
Science for Better Livelihoods in Dry Areas

@ less than 1m spatial resolution

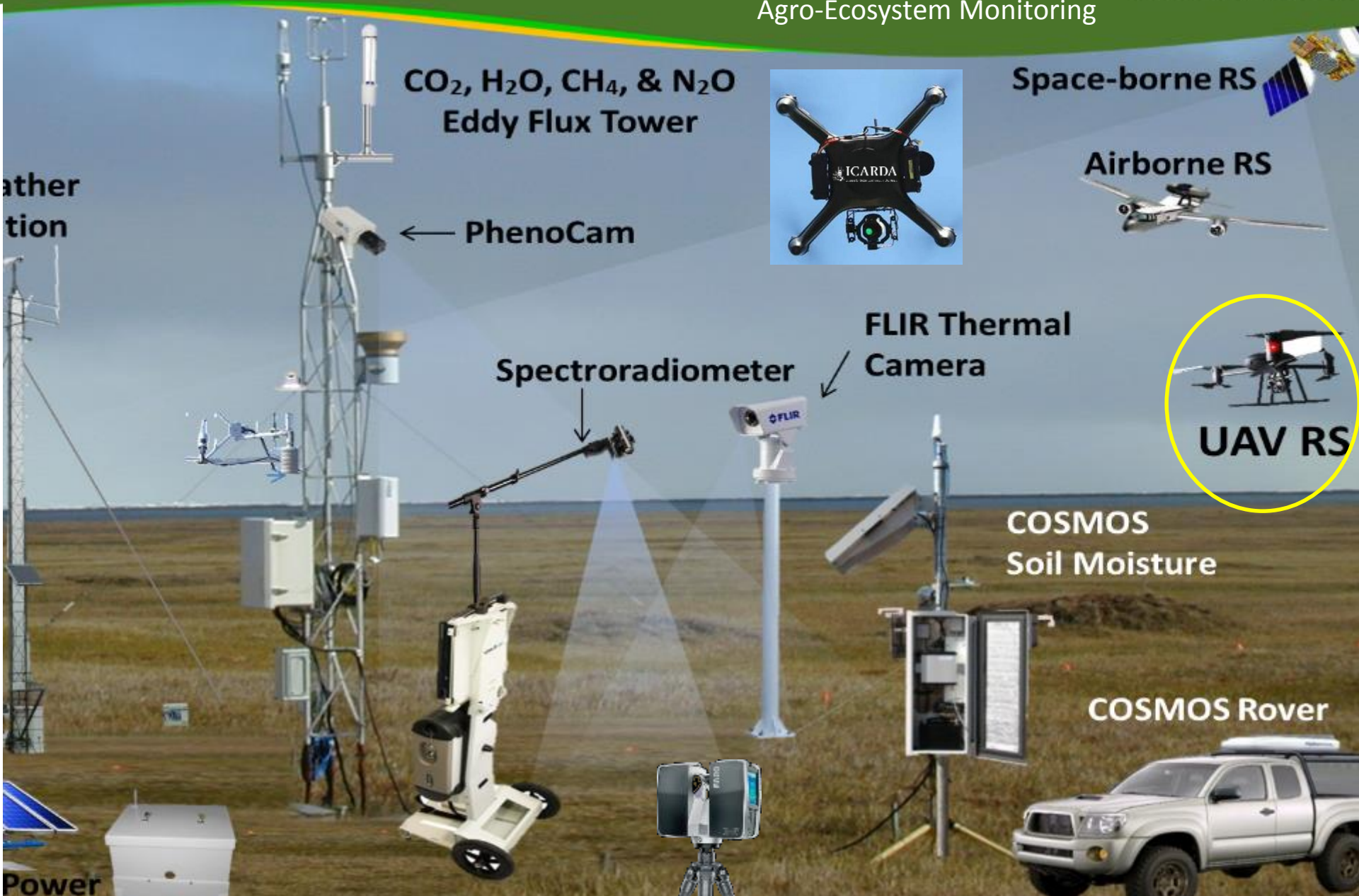


Blackbridge
WorldvView3
Skybox (Google!)

BlackBridge
Delivering the World

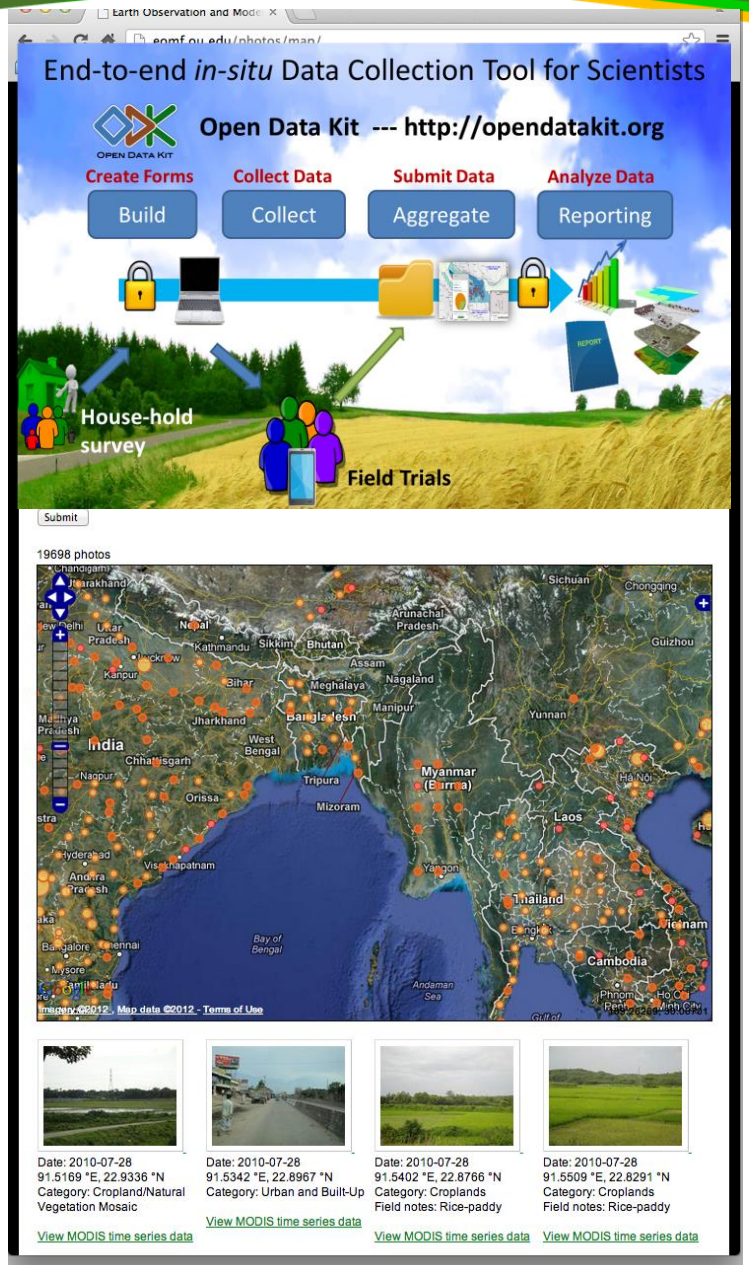
Integrated Earth Observation System

Demonstrated Example for
Agro-Ecosystem Monitoring

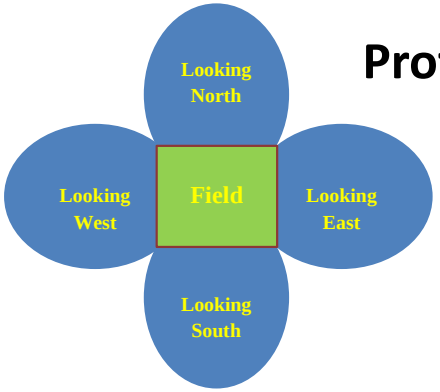


Citizen Science and Community RS

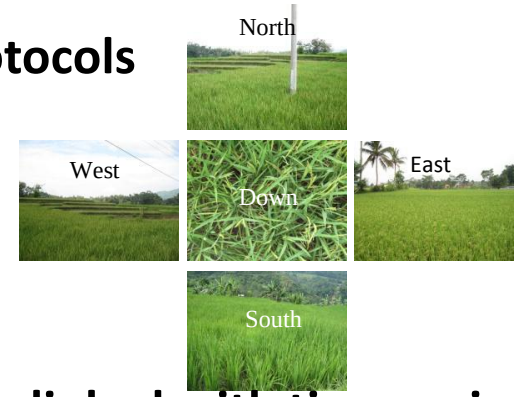
Georeferenced Field Photos



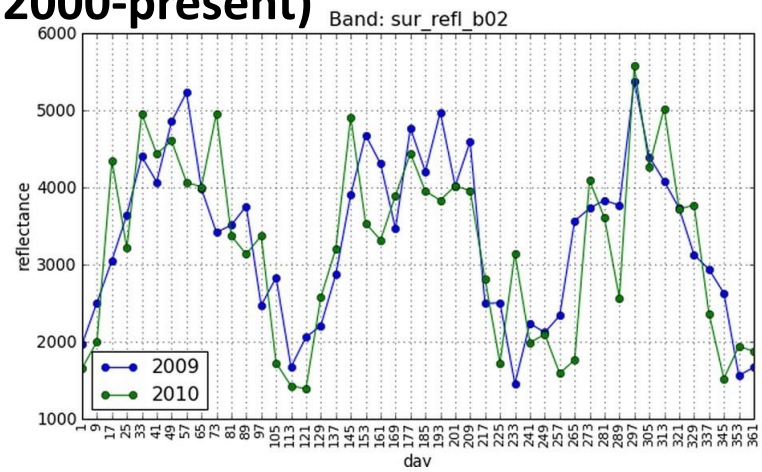
1. Apps "Field Photo" and
2. OA Geo-ref. field photo library
3. Images (MODIS, Landsat, PALSAR)



Protocols

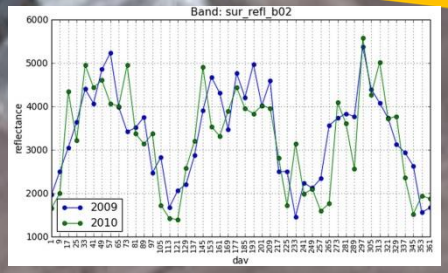


Individual photos are linked with time series MODIS data (2000-present)



Open Access without personal info

CGIAR RESEARCH PROGRAM ON Dryland Systems



Show Legend

Overlays
- Photos Layer
- Target Areas
- CRP Activity
- Erak Watershed
- El-Khresh Field
- Erak Field

Data Table

Show 10 entries

Search:

ID	Longitude	Latitude	Altitude	Date	Actions
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a384d1d5-6f5e-4d26-b137-57d848caa8aa	35.7435396966	31.6170065152	827.7000000000	2014-04-12 13:25:57	Zoom To | Show Photos
2b470642-4087-457f-8620-9dc709892a0c	35.7441195566	31.6194619518	1067.2000000000	2014-04-12 13:14:35	Zoom To | Show Photos
43c485f4-05e0-48db-a8dd-f3b41d1c7d51	35.7869502436	31.6719519440	800.0000000000	2014-04-12 12:57:02	Zoom To | Show Photos
5300eed4-552c-49f4-a10b-5545c7b85362	35.7779035717	31.6694164183	833.1000000000	2014-04-12 12:53:47	Zoom To | Show Photos

Showing 1 to 10 of 57 entries

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Agricultural Livelihood Systems

Pastoral | Agropastoral | Rainfed | Tree-based | Irrigated

Thank You

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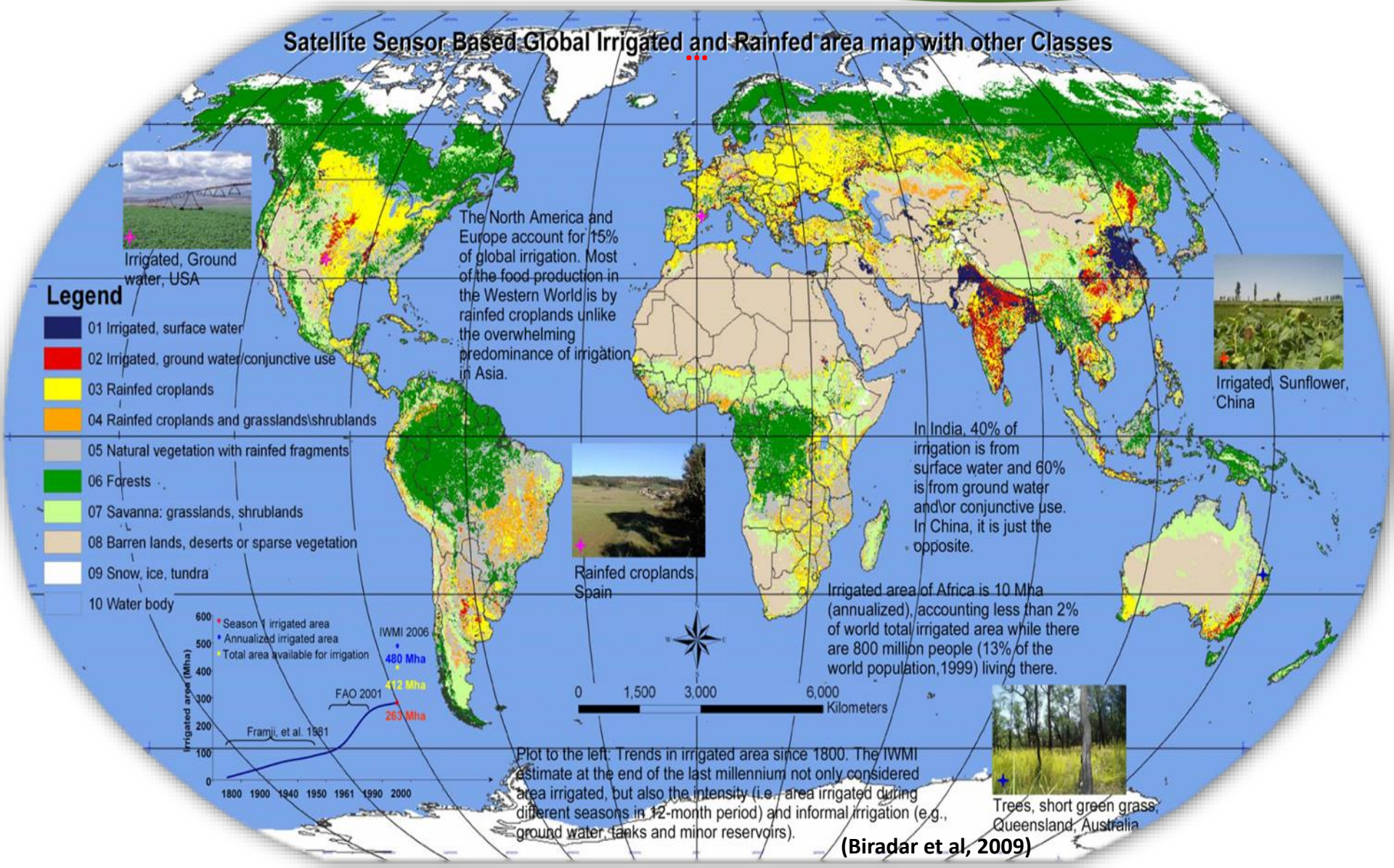
If time left?

Some Examples

Global Food Production Systems



(Biradar et al, 2009)

Changing Cropping Intensity

Integrated Production Systems
Diversification & Intensification
Crop Fallow Areas
Conservation Agriculture
Thematic Land Suitability
Climate Change Impact?

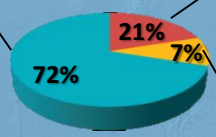
Cropping Intensity

Double crops
Triple crops

Population Density

< 0.135
#/km²
>54916

Year 2000
Double Crops
Triple Crops



Agricultural Intensification

Cropping Intensity

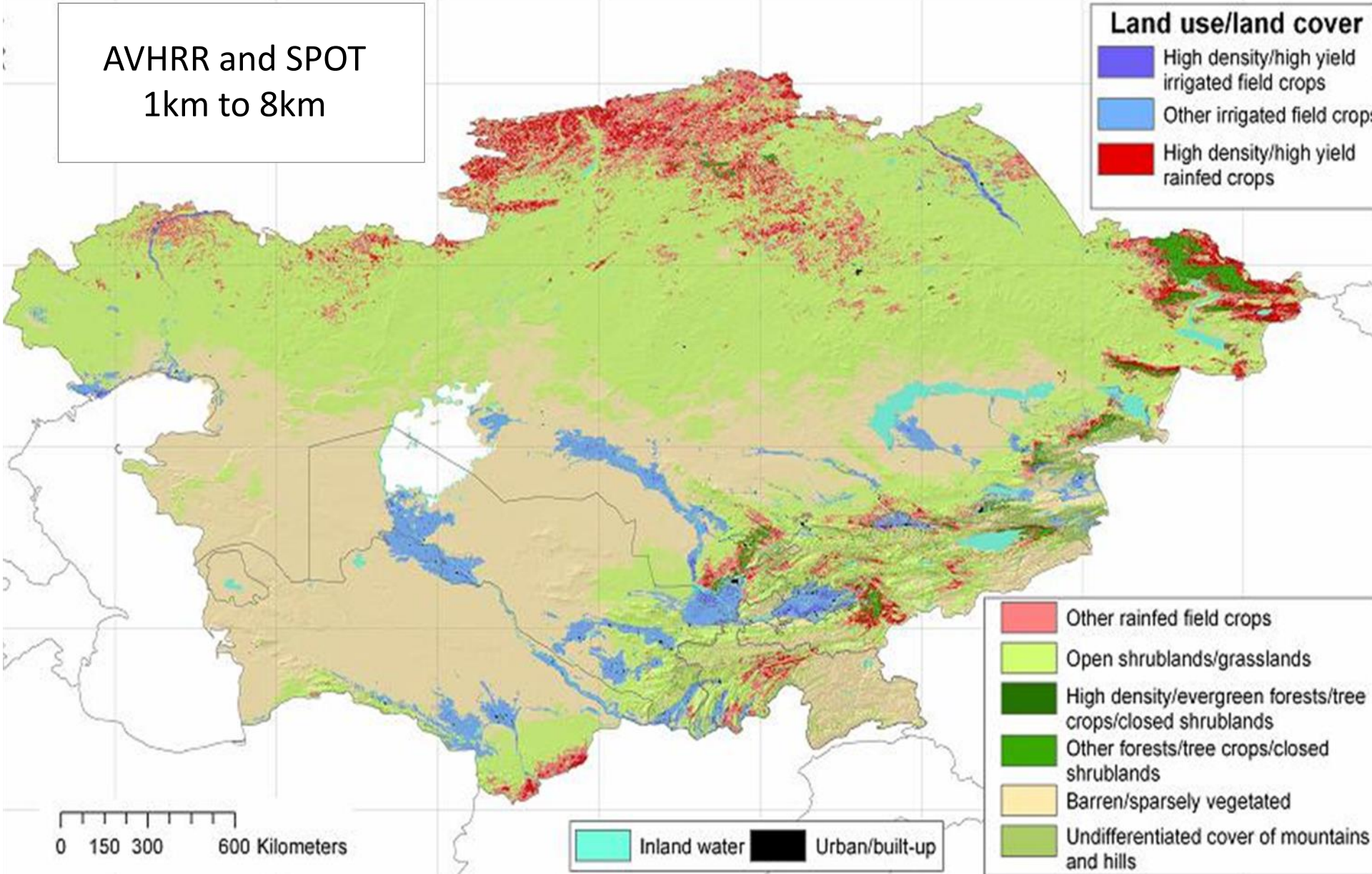
Increase in Arable Land

(Biradar & Xiao, 2010)

Land use and land cover

at lower spatial scales

AVHRR and SPOT
1km to 8km



Land use and land cover

at higher spatial scales

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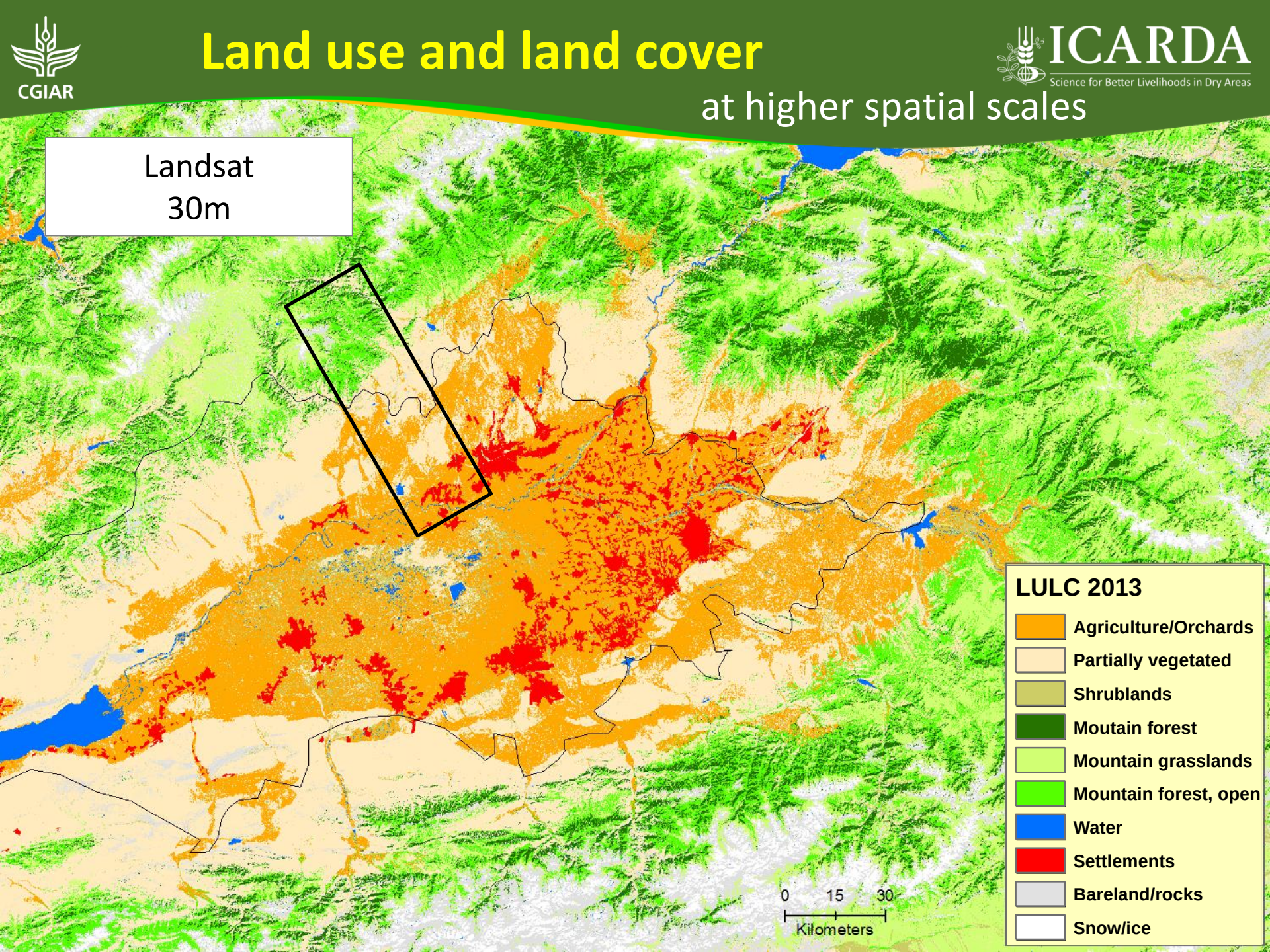
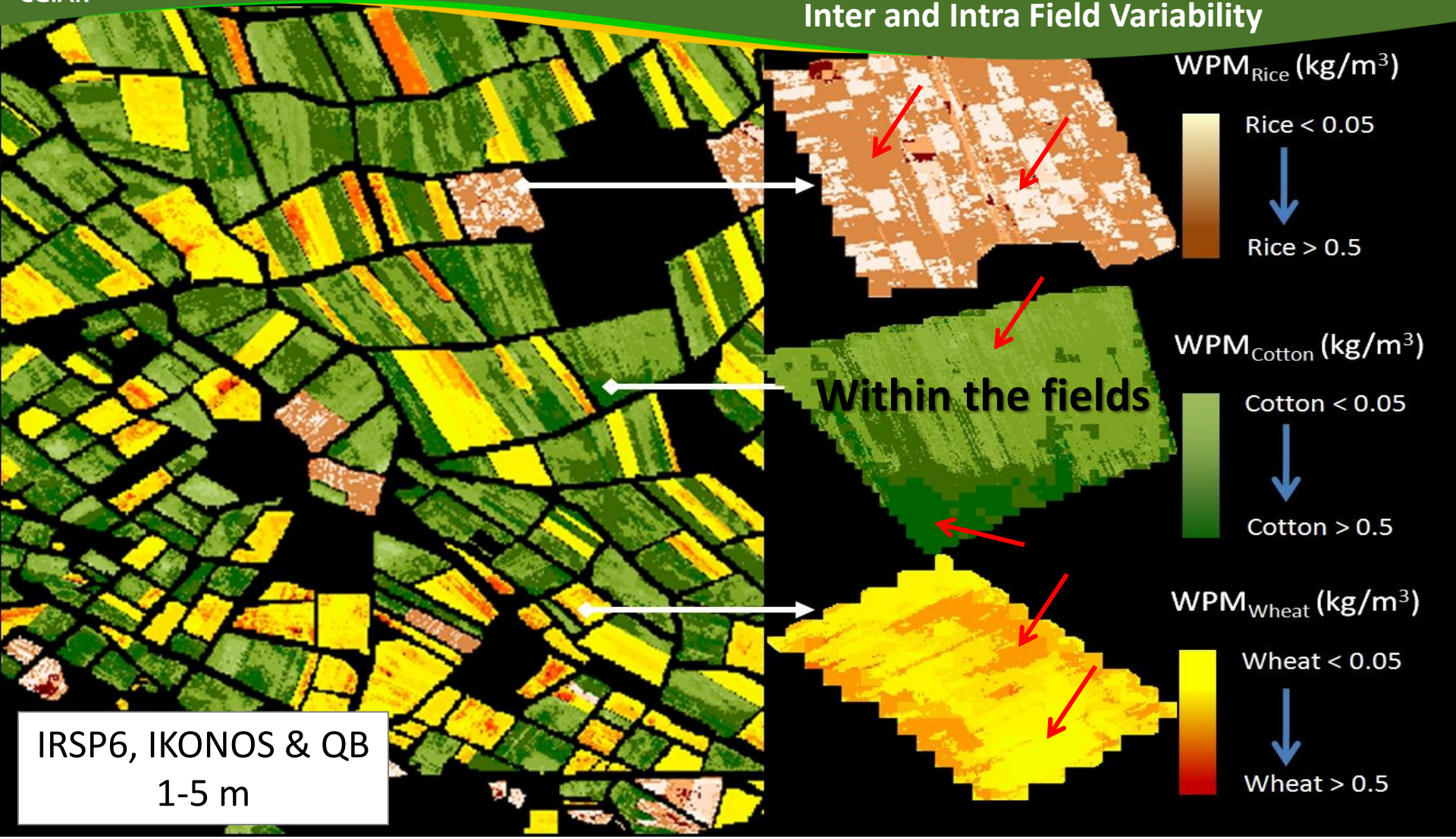
Landsat
30m



Yield/Productivity Gaps

Inter and Intra Field Variability



Water productivity (WP) is defined as the kg of yield produced/m^3 of water used or, alternatively, as value in $ of yield produced/m^3 of water used.

WP of Cotton	0.42 kg/m^3	0.50 USD/m^3
WP of Wheat	0.60 kg/m^3	0.33 USD/m^3
WP of Rice paddy	0.50 kg/m^3	0.10 USD/m^3

Productivity Gaps & Economic Impacts

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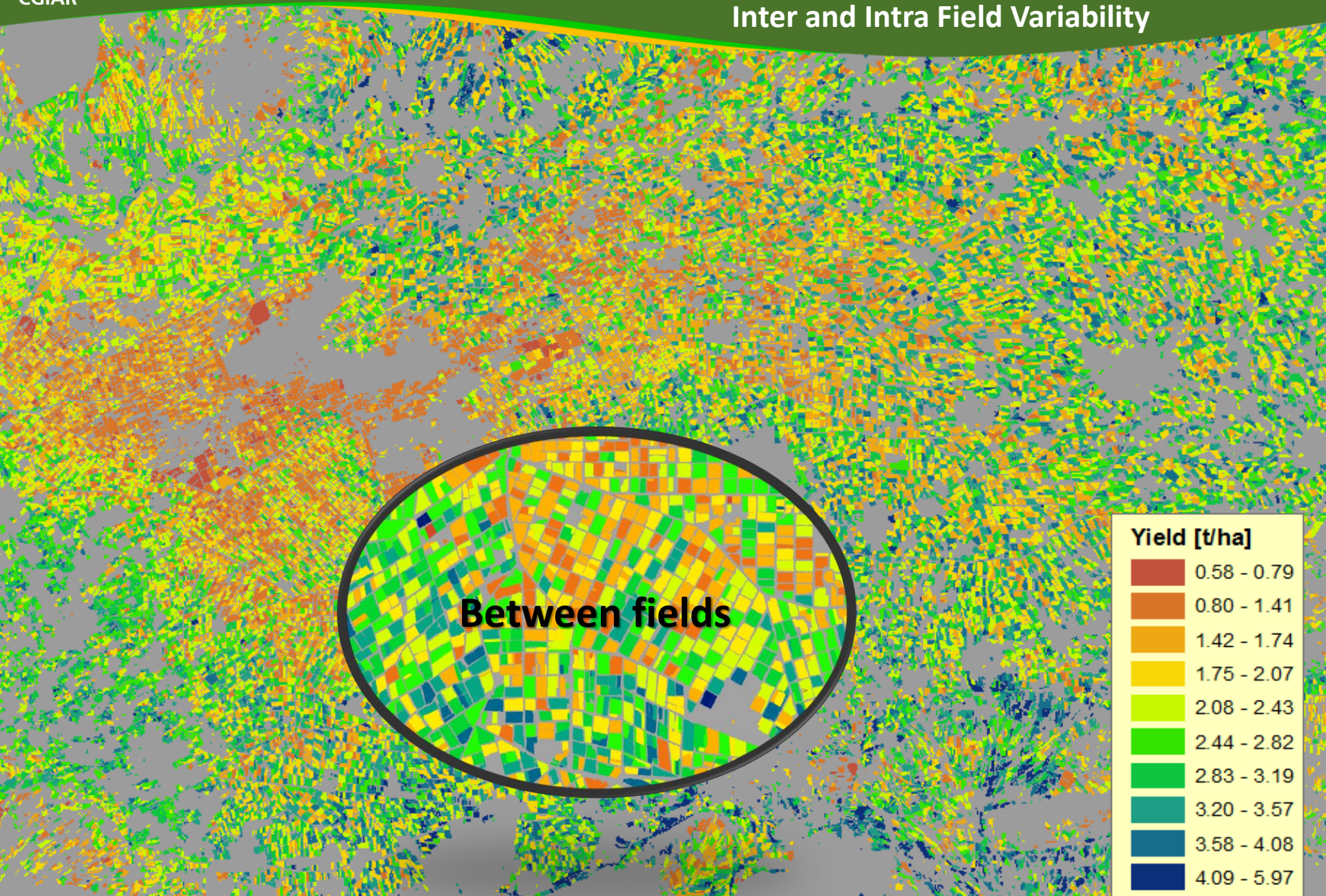
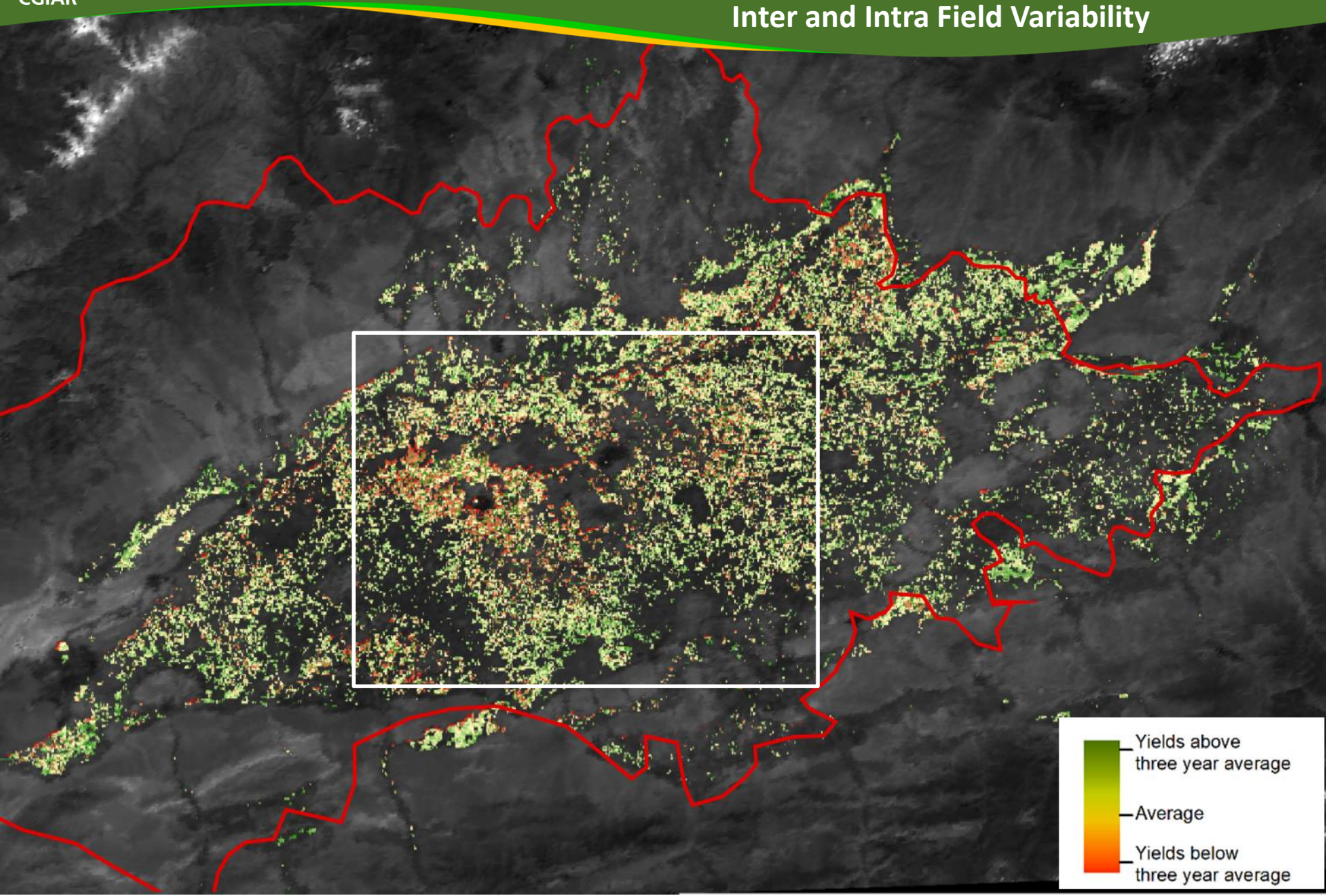
Inter and Intra Field Variability



Dynamics of Degradation?

Inter and Intra Field Variability



Impact of investment

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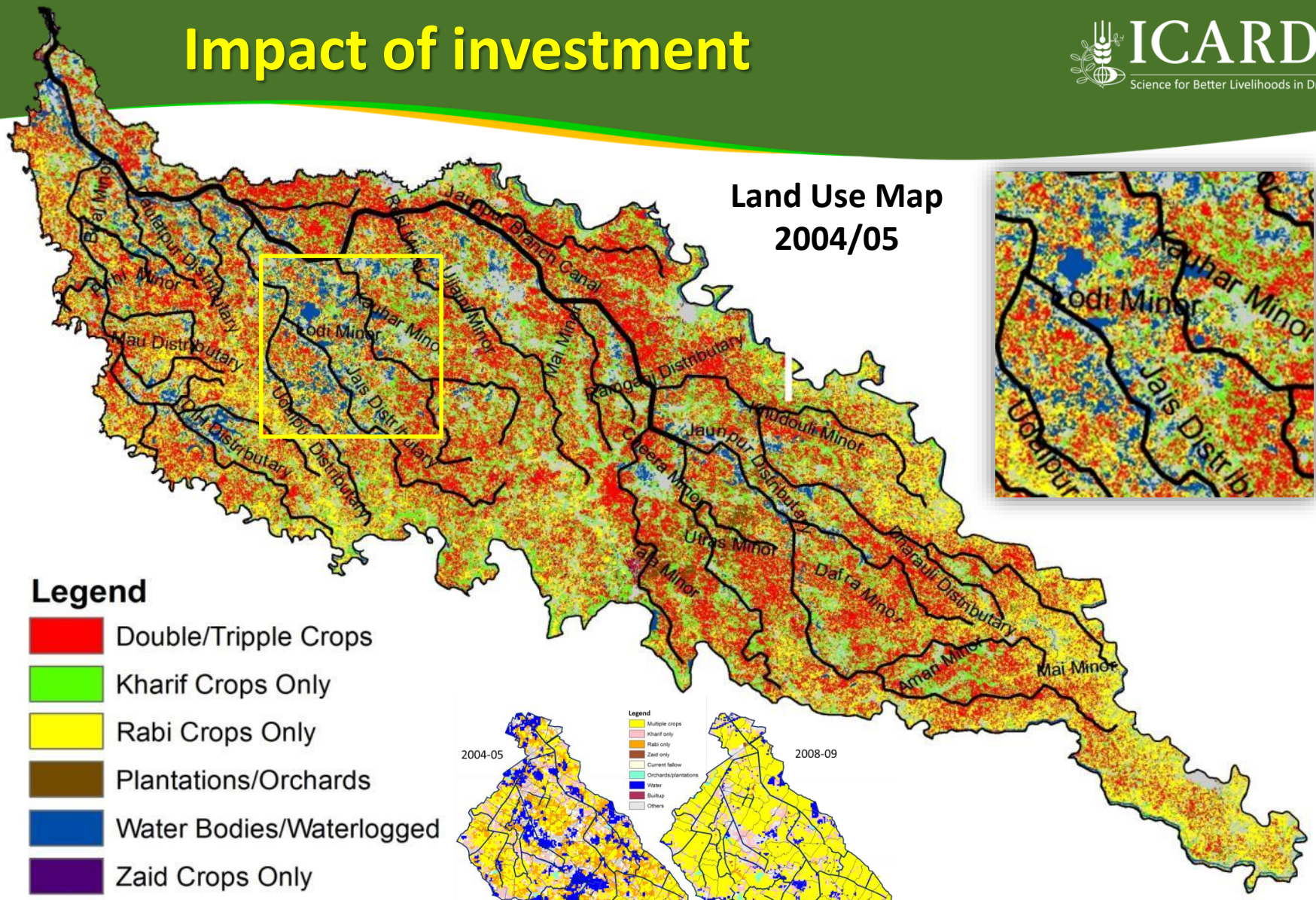

Irrigation Induced Salinity Control and Reclamation Project

Impact of investment

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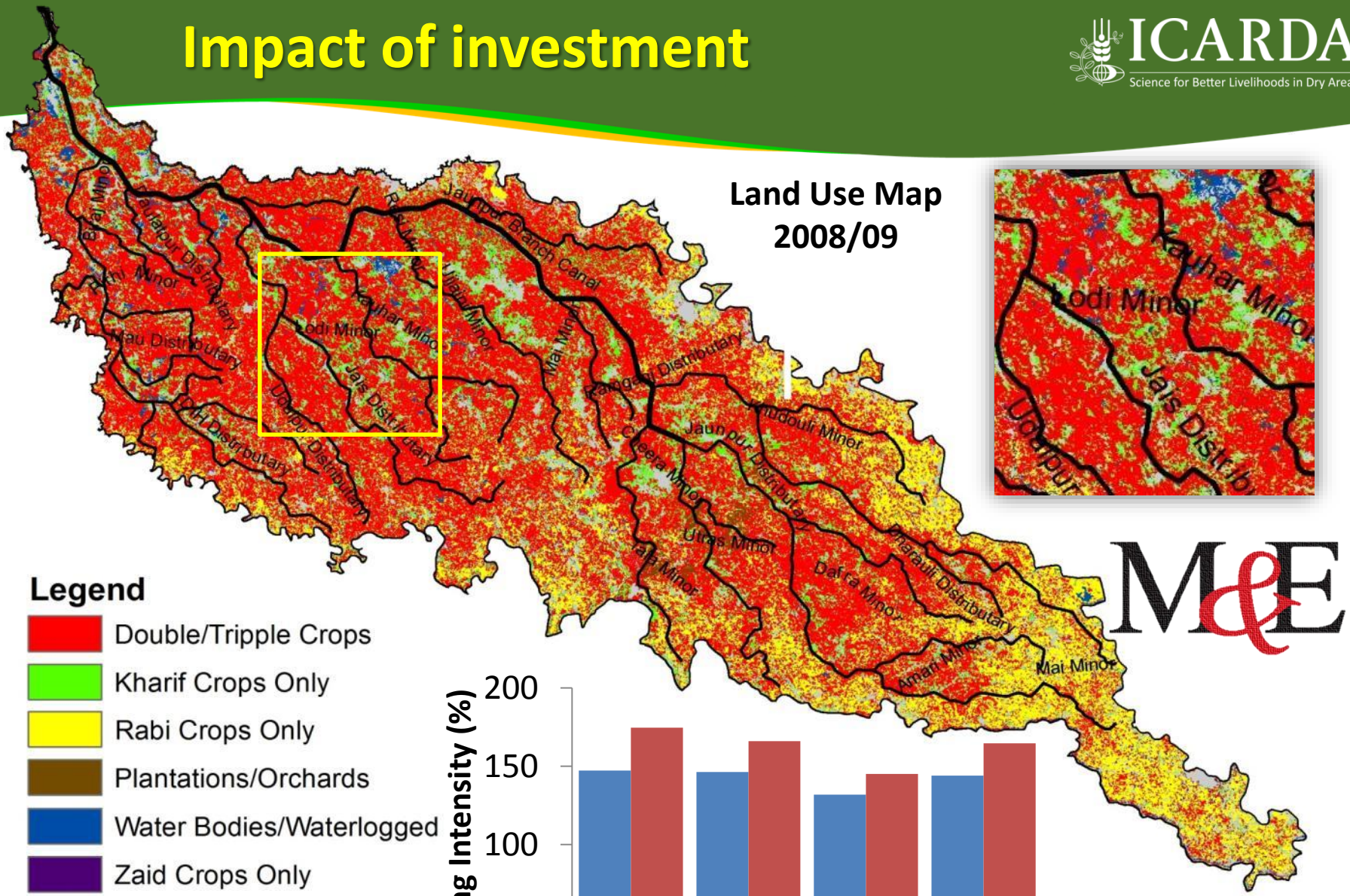

Mapping Agriculture: Scaling Trade-offs

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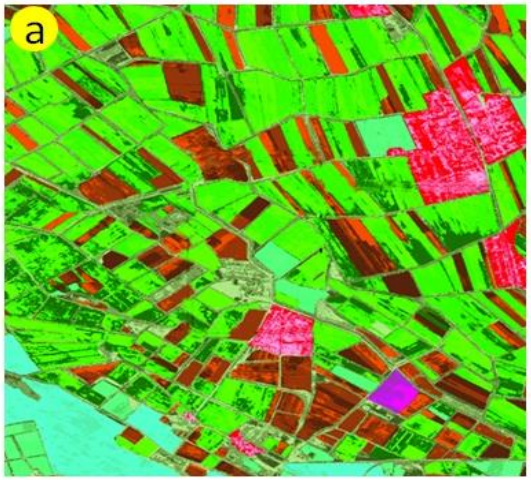
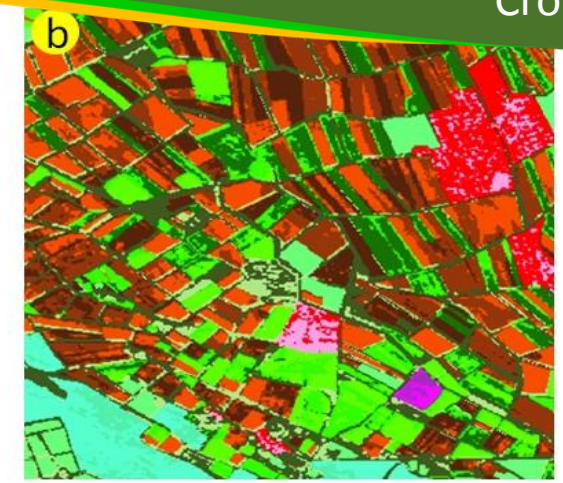
Crop Types



- Cotton (low vegetation)
- Cotton (medium vegetation)
- Cotton (high vegetation)
- Rice paddy (low vegetation)
- Rice paddy (medium vegetation)
- Rice paddy (high vegetation)
- Fallow fields (sparse vegetation)
- Fallow fields (wet soil)
- Fallow fields (dry soil)
- Other LULC (Canals and Trees)
- Other LULC (Woody shrubs and grass)
- Other LULC (roads, bare soil)
- Home gardens and plantations)
- Home gardens and fallow)
- Home gardens and settlements
- Settlements and avenue trees
- Settlements and home gardens
- Settlements (mostly buildings)
- Abandoned (saline soils and halophytes)
- Abandoned (bare soil)

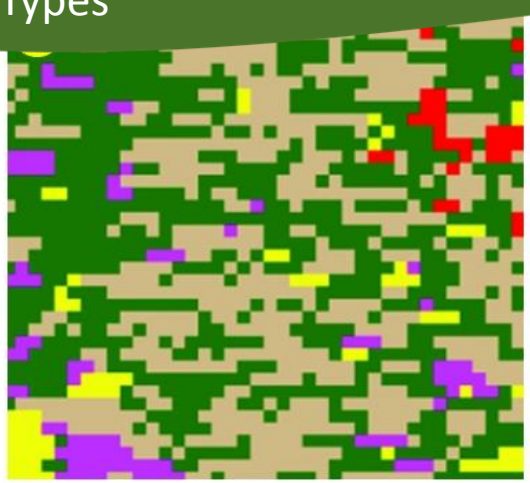
a. Quickbird 2.4m



- Wheat (low vegetation)
- Wheat (medium vegetation)
- Wheat (high vegetation)
- Rice paddy (fallow)
- Fallow fields (sparse vegetation)
- Fallow fields (wet soil)
- Fallow fields (dry soil)
- Home gardens and plantations)
- Home gardens and fallow)
- Home gardens and settlements
- Other LULC (canals, tree and woods)
- Other LULC (grass, roads and bare soil)
- Settlements and avenue trees
- Settlements (mostly buildings)
- Abandoned (saline soils and halophytes)
- Abandoned (bare soil)

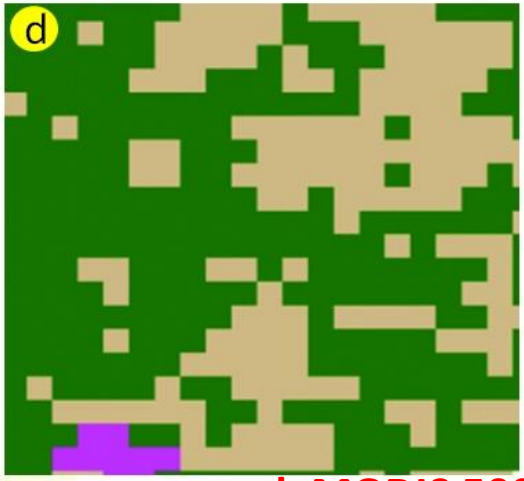
b. IRS P6 23.5m

What scale?



- Cotton
- Rice paddy
- Fallow fields
- Other LULC and abandoned
- Settlements

c. MODIS 250m



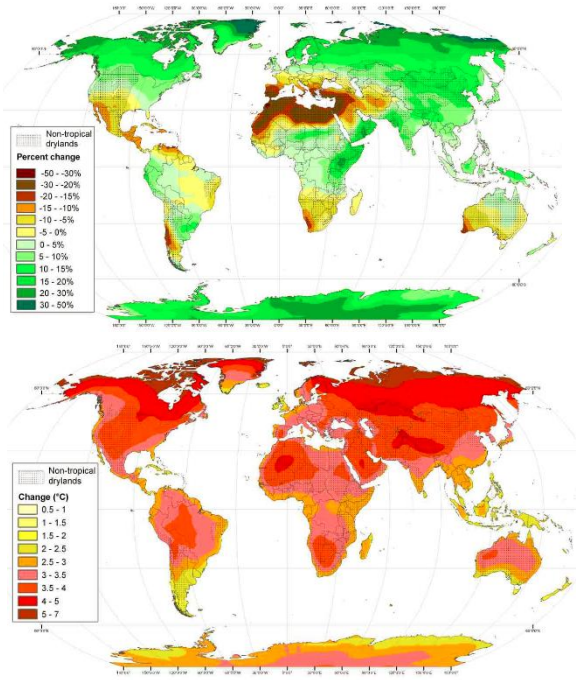
- Cotton
- Fallow fields and other LULC
- Abandoned and other LULC

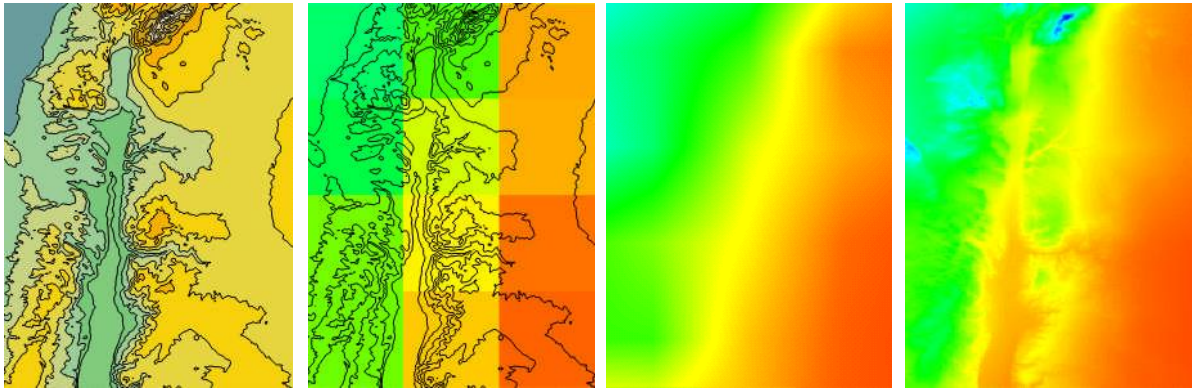
d. MODIS 500m

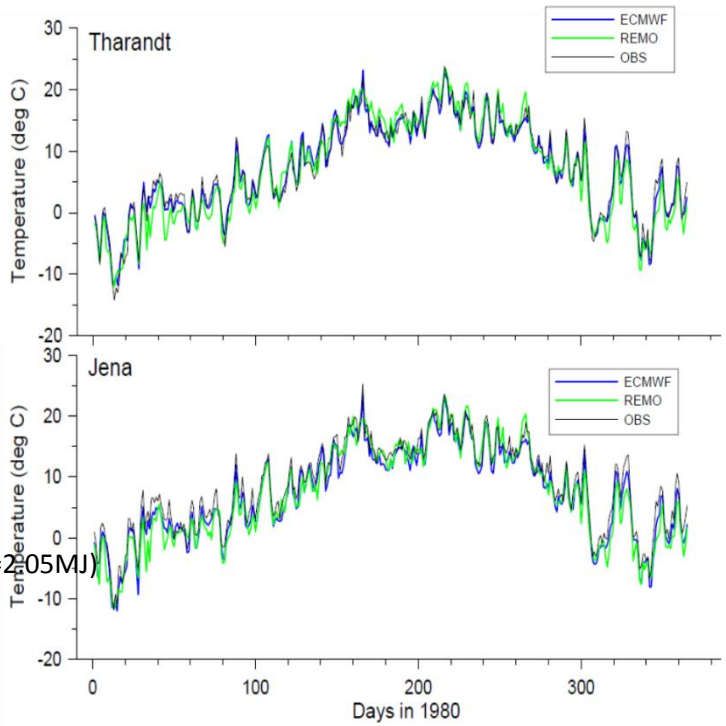
Climate Variables

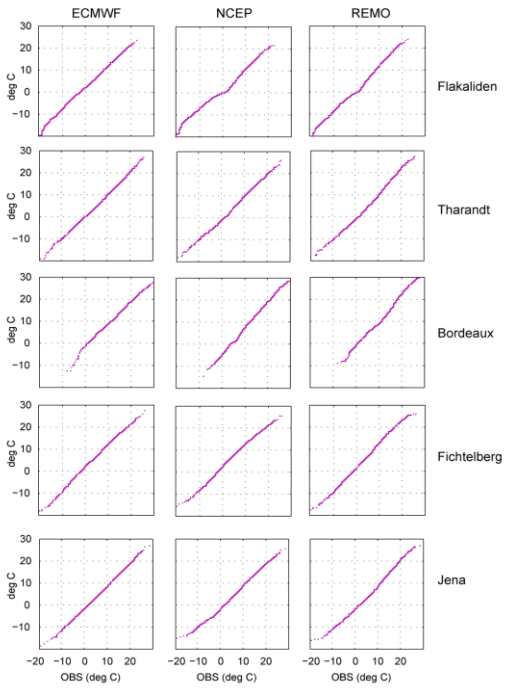
1979/2013 to 2080/2099

1km, Daily, 21 bioclims









a. tmax---maximum temperature at 2 meter (degC)
b. tmin---minimum temperature at 2 meter (degC)
c. precip---precipitation (mm)
d. ABSH---absoluate humidity(kg/m3 scaled by 106)
e. RHY---ralative humidity(%)
f. PAR---photosynthesis active radiation (mol PPFD=2.05MJ)
g. uwind---wind at east-west direction(m/s)
h. vwind---wind at north-south direction(m/s)
i. VPD---vapor pressure deficit(Pa)

Climate Extremes

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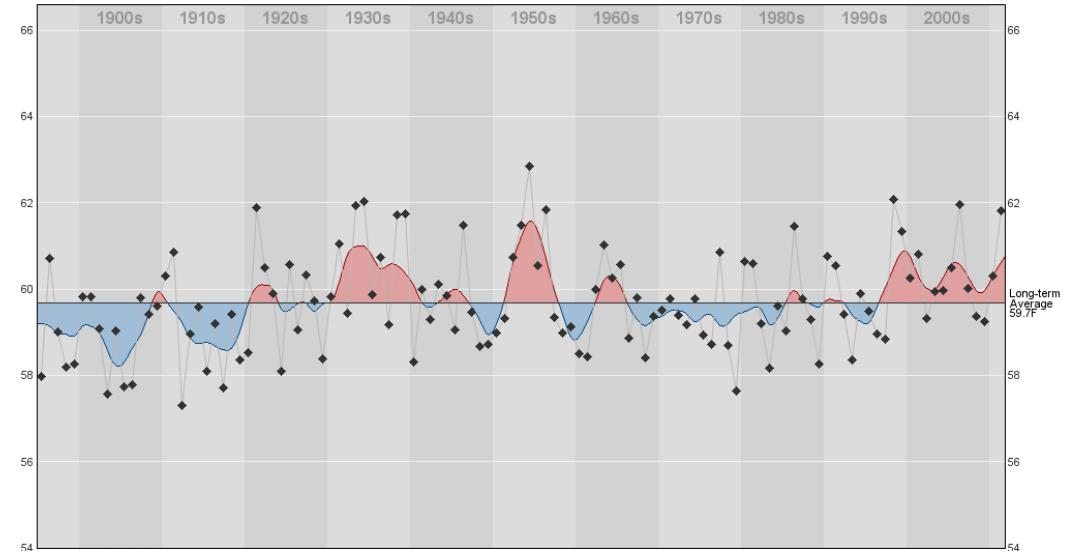
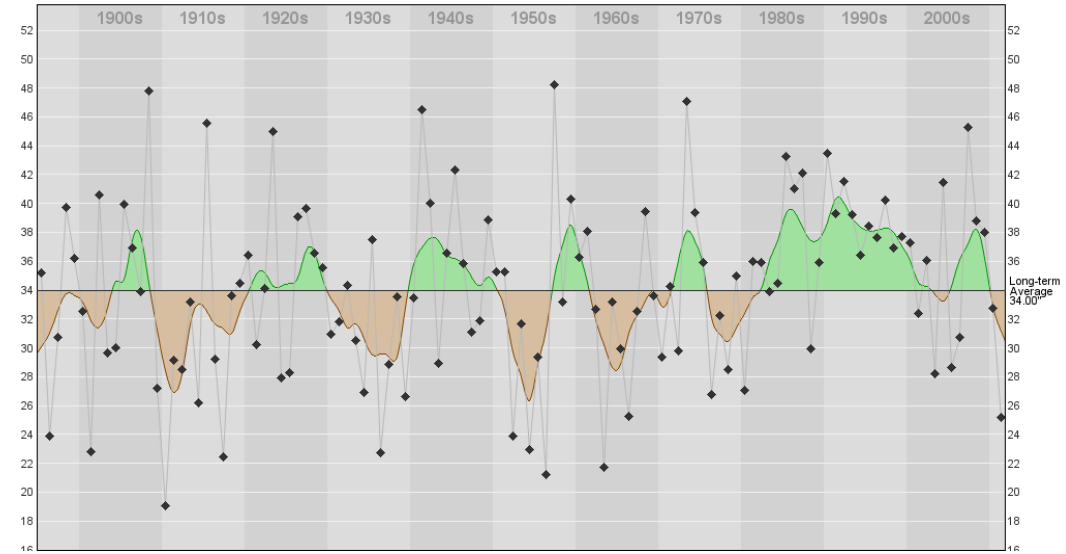
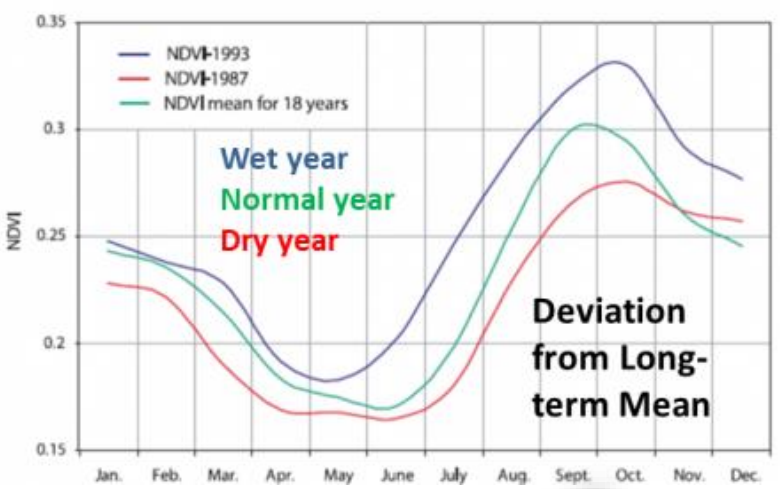
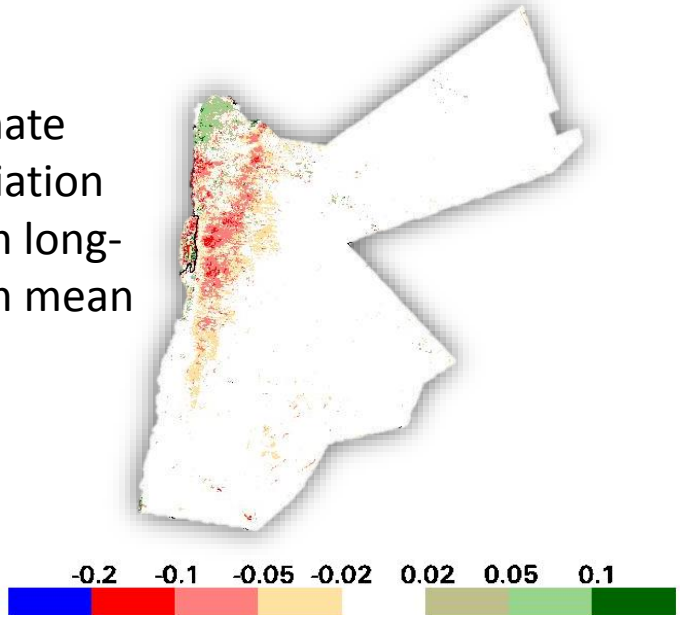
National to Local Scale







Climate Deviation from long-term mean



Mapping Pest & Disease Risk

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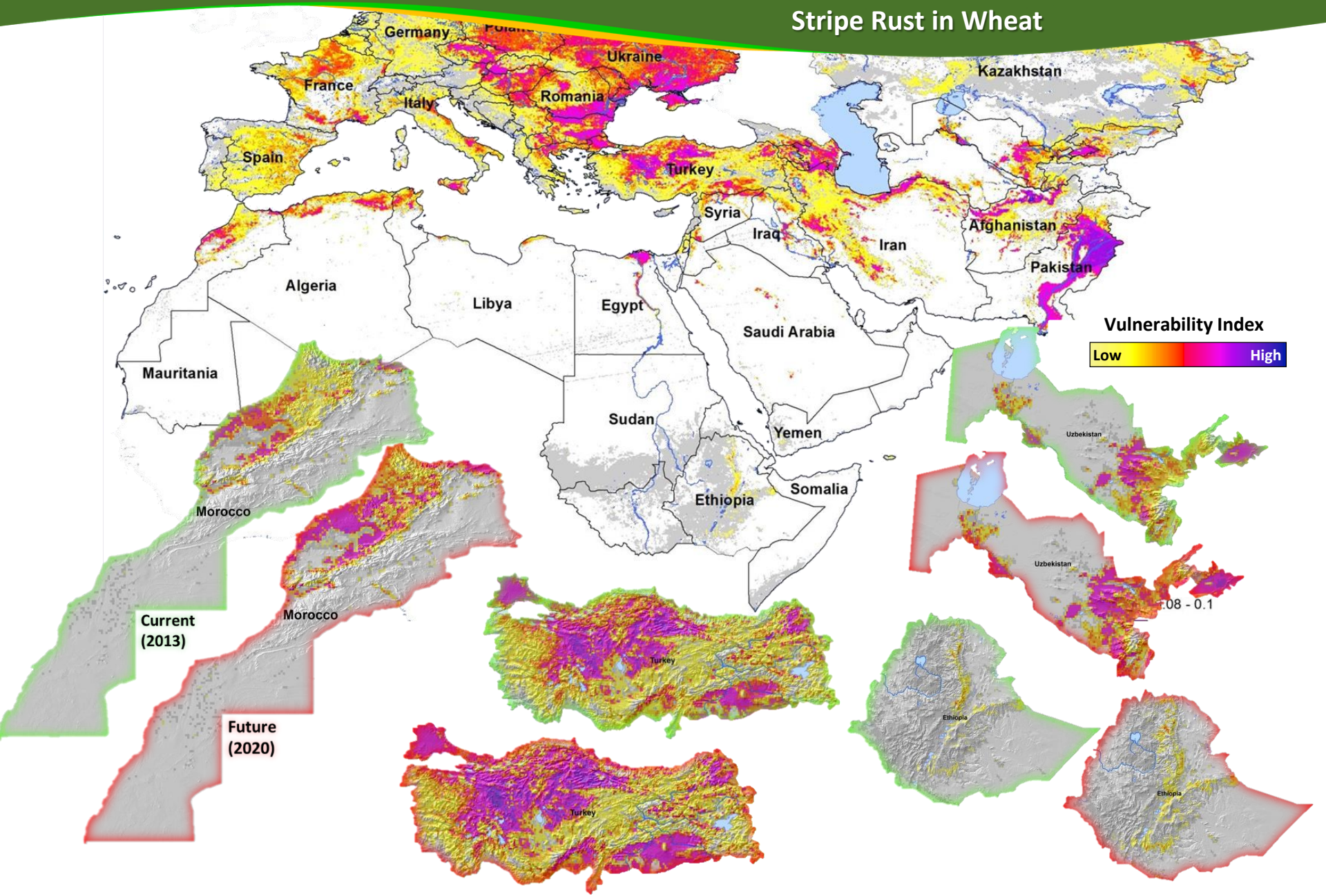
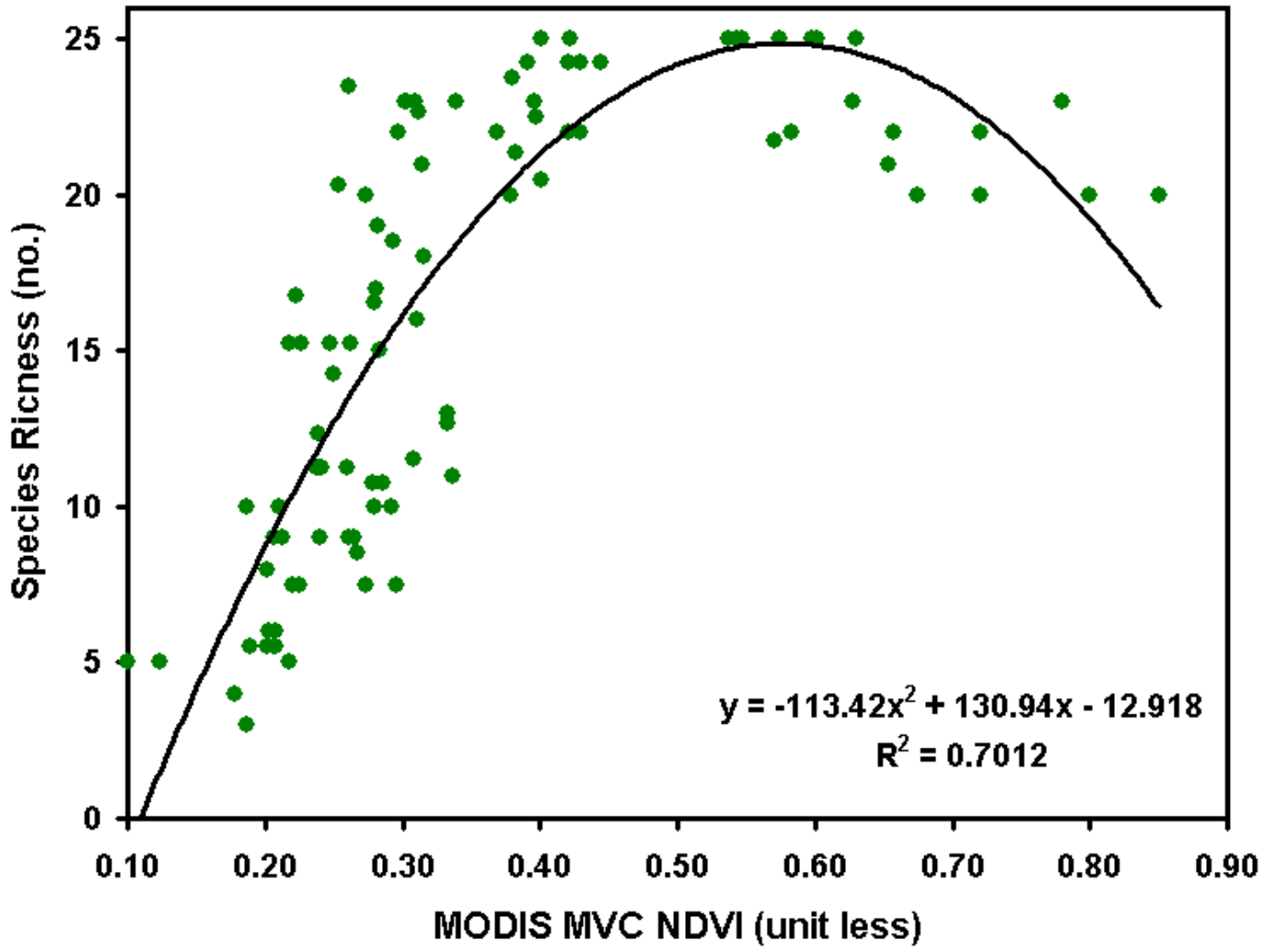
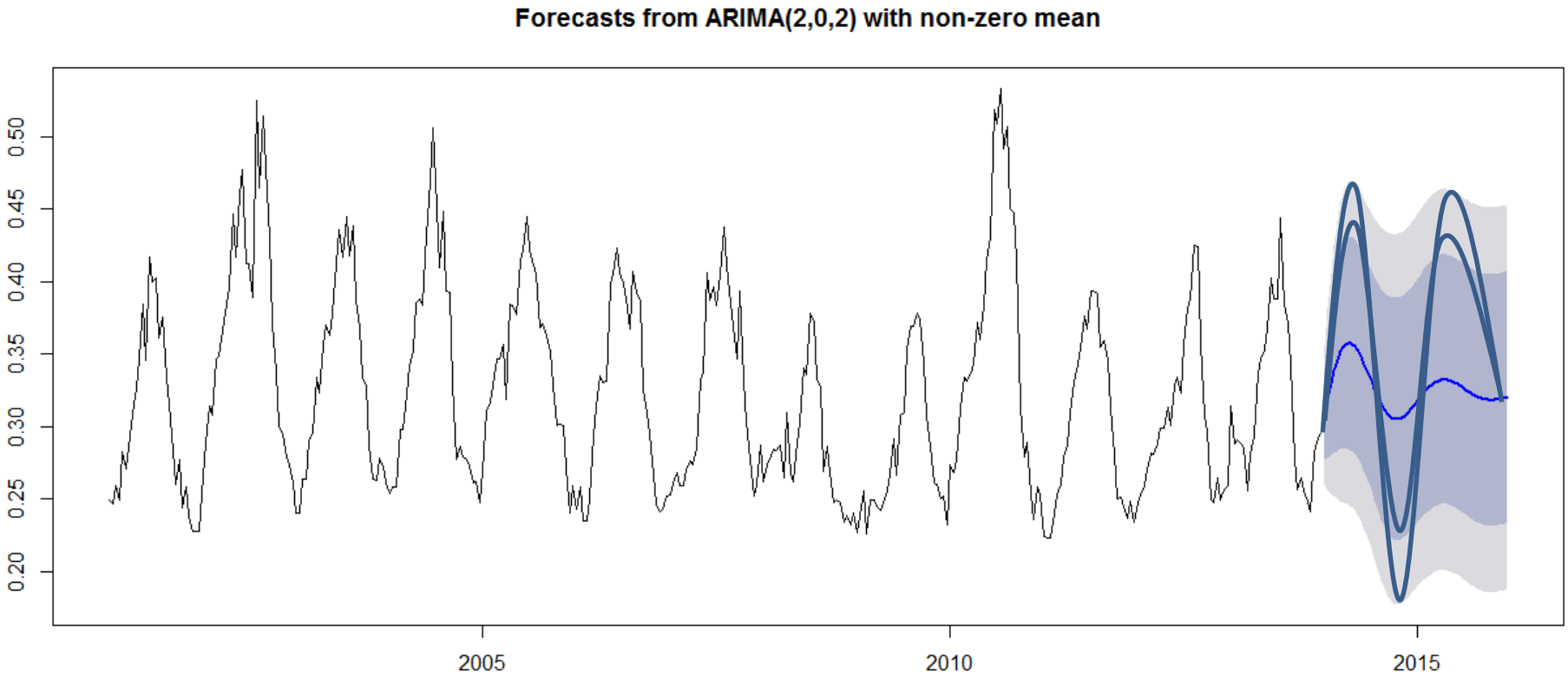


Vegetation vs. Species Richness



Climate Change Impact?

ARIMA (Autoregressive Integrated Moving Average) model analysis for the period of 2000 to 2013 to forecast



Potential Data Sets

Variable	*Definition*	*Spatial distribution*	*Source/Derivatives*
ALS	CRP-DS's ALS types	Pixel explicit	Major ALS: Irrigated, Rainfed, and Agro-pastoral
DRYLANDS	aridity index and drylands	Pixel explicit	ICARDA
CROPLANDS	Croplands probability	Pixel explicit	From MODIS
GPP/NPP	VPM Simulation	Pixel explicit	From MODIS and Climate Data
MARGINAL	Marginal lands	Pixel explicit	GMIA, GMRCA, IASSA, FAO
YIELD GAPS	Ratio Actual/Potential	Pixel explicit	IASSA, FAO, ICARDA*
FIGS	Accessions	Pixel explicit	ICARDA
CLIMATE-TREND	Long-term trends and bioclimatic variables	Pixel explicit	ECMWF and CRU
VEGETATION TREND	Long-term trends and deviations	Pixel explicit	From MODIS and AVHRR
BROAD-COVER	Broad class of land cover	Pixel explicit	Different sources available, but aggregated categories
PHENOLOGY	Start and End of Season, LGP, Crop Int., etc.	Pixel explicit	From MODIS time series
TREE-COVER	Tree density	Pixel explicit	MODIS-based and AVHRR-based
SLOPE	Surface slope (degree)	Pixel explicit	Calculated from SRTM 90m
SOIL-CONST.	Soil combined quality	Pixel explicit	From FAO-IIASA GAEZ 2008
DIST-ROAD	Distance to main road (km)	Pixel explicit	From global road network to generate
DIST-TOWN	Distance to district capital (km)	Pixel explicit	Use global settlement points
WATER- PROXIMITY	Proximity to water body (m)	Pixel explicit	Calculated from global water resource
POPULATION	Density, Urban/Rural, Male/Female, Age Group, Change,	Pixel explicit	From CIESIN datasets
GDP-CAPITA	Average GDP per capita	Pixel explicit	Gridding based on WB and CIESIN
GDP-GROWTH	Mean growth rate of annual GDP during period	Pixel explicit	Gridding based on WB and CIESIN
POVERTY	Poverty index	Nation/pixel explicit	Derived from WB and CIESIN
AGRI POVERTY	Ag resource poverty	Pixel explicit	ICARDA
PER CAPITA WATER	Green and blue water per person	Pixel explicit	ICARDA
WUE in Drylands	Water use efficiency	Pixel explicit	ICARDA*
SIMILARITY	Matching factor for outscalling	Pixel explicit	ICARDA*

Geoinformatics in Integrated Systems Approach

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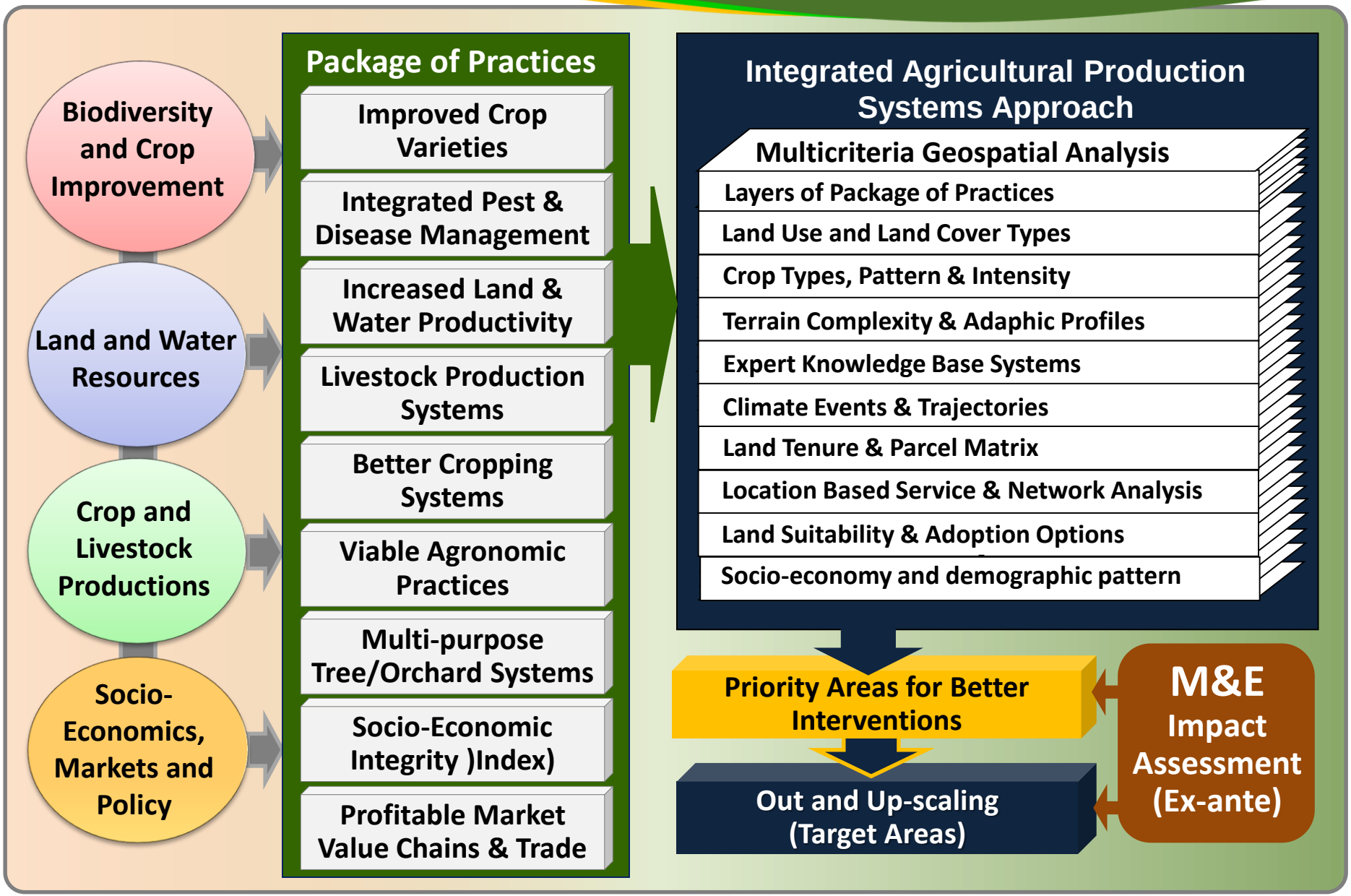
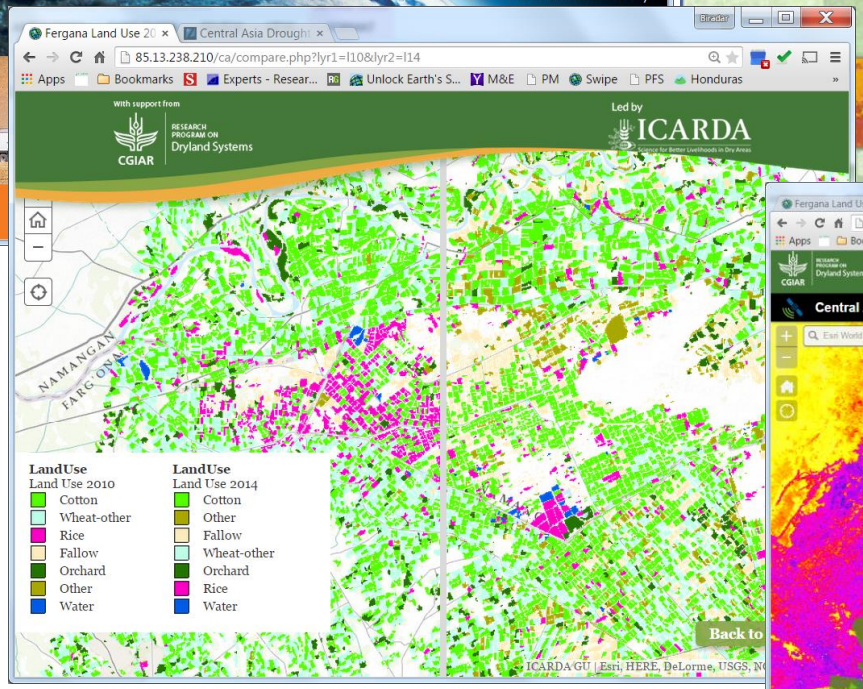
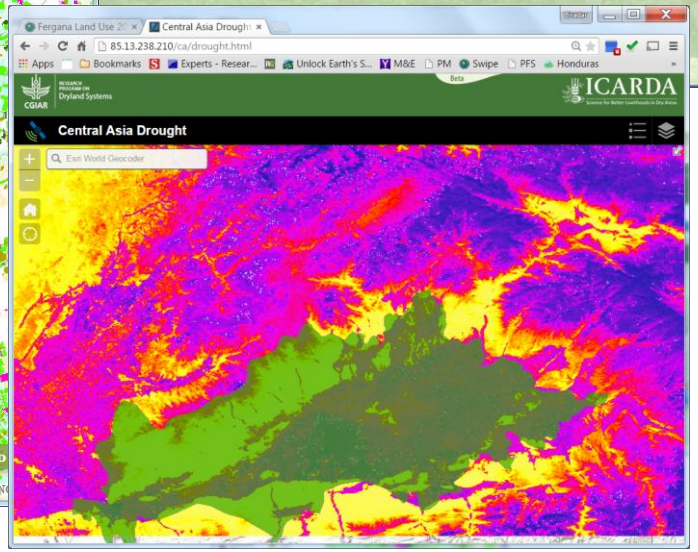
Innovation Platforms



RS Image Based Precision Farming System

Rural Advisory





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Thank You

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