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Science for Better Livelihoods in Dry Areas

Potentials of Geoinformatics application in mapping food and nutritional security

Innovation, Investment, Intervention and Impact

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Dec 3-5, 2016

Bangkok, Thailand

Regional Expert Consultation on Scoping, Prioritizing and Mapping of Crop-related Neglected and Underutilized Species under the FAO Regional Initiative on Zero Hunger Challenge

Role of Geospatial Science, Technology and Applications (GeSTA) in Dryland Systems

156 Remote sensing missions in orbit°
>12 Sensors potential in CRPs/IRPs, etc.
>6 are free

5 1) Ecological intensification, 2) Crop diversification, 3) Input use efficiency, 4) Reduced land degradation, and 5) Location specific interventions.

Ensuring **F**ood Security

Safeguarding **E**nvironmental Flows and ESs

Youth
Engaging and empowering young gen. by creating opportunities

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, land degradation and desertification, changing demographics, climate change adaptation and impacts

Quantification of dryland agricultural production and livelihood systems

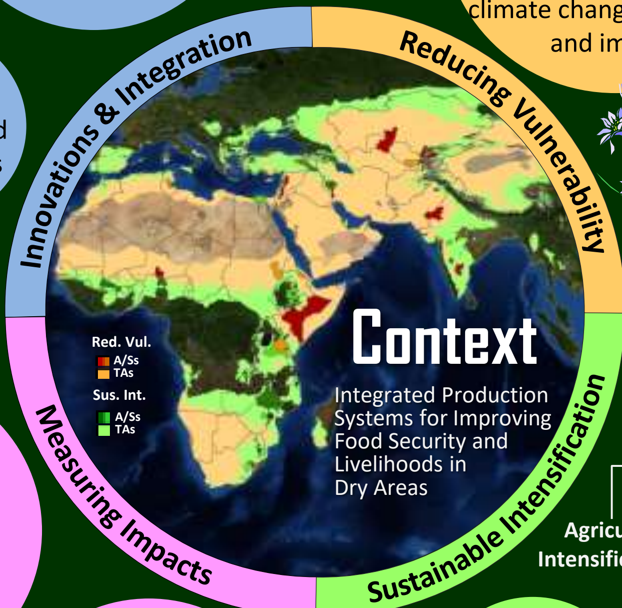
Characterization of vulnerable areas for increasing resilience and assist in identifying mitigation pathways with biophysical, socioeconomic and stakeholder feedback as well as specific needs & constraints

Cooperative Research and Partnerships

Current status, trends, extent, characteristics of crops, pattern, productivity, water use, livestock, biodiversity, soils, & climate

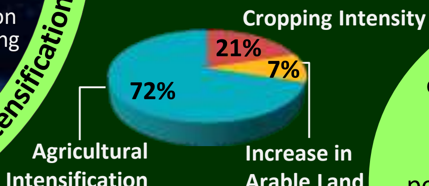
Gender
Address social inequities, greater roles and priorities

Drylands **41%** Earth's land area



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

increased **F**ood production potential sources



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

Farmers, stakeholders, policymakers, mobilization, & marketing

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

Location specific and ecological intensification

Delineation of potential, suitable areas for sustainable intensification, diversification of production systems

People **2.5b** Live in Drylands

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

Nutrition
Changing diet patterns, nutrition and health

Improved **L**ivelihoods

Livestock **1.5b** Depend on Drylands

geoagro.icarda.org

Efficiency
Productivity

CGIAR Research Program Dryland Systems
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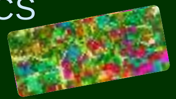
Earth Observation Systems for Agro-Ecosystem Research

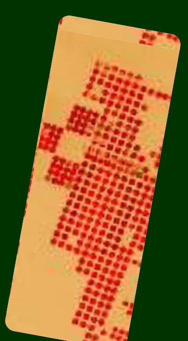
ACTIVE SATELLITE SENSORS AND CHARACTERSTICS



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)

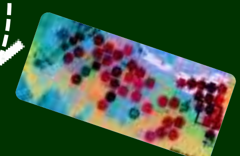


Satellite Sensors	Resolution			Swath (km)
	Spatial (m)*	Temporal (days)	Spectral (Bands)	
CARTOSAT-1	(2.5)	5	P	30
FORMOSAT-2	8 (2)	1	B, G, R , IR, P	24
SPOT-5	5, 20 (2.5, 5)	2-3	G, R, IR, SW, P	60 to 80
SPOT-6 (1.5)	6 (1.5)	2-3	B, G, R , IR, P	60
RapidEye	5	1	B, G, R, RE, IR	77
RESOURCESAT-1	5.8	5	G, 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

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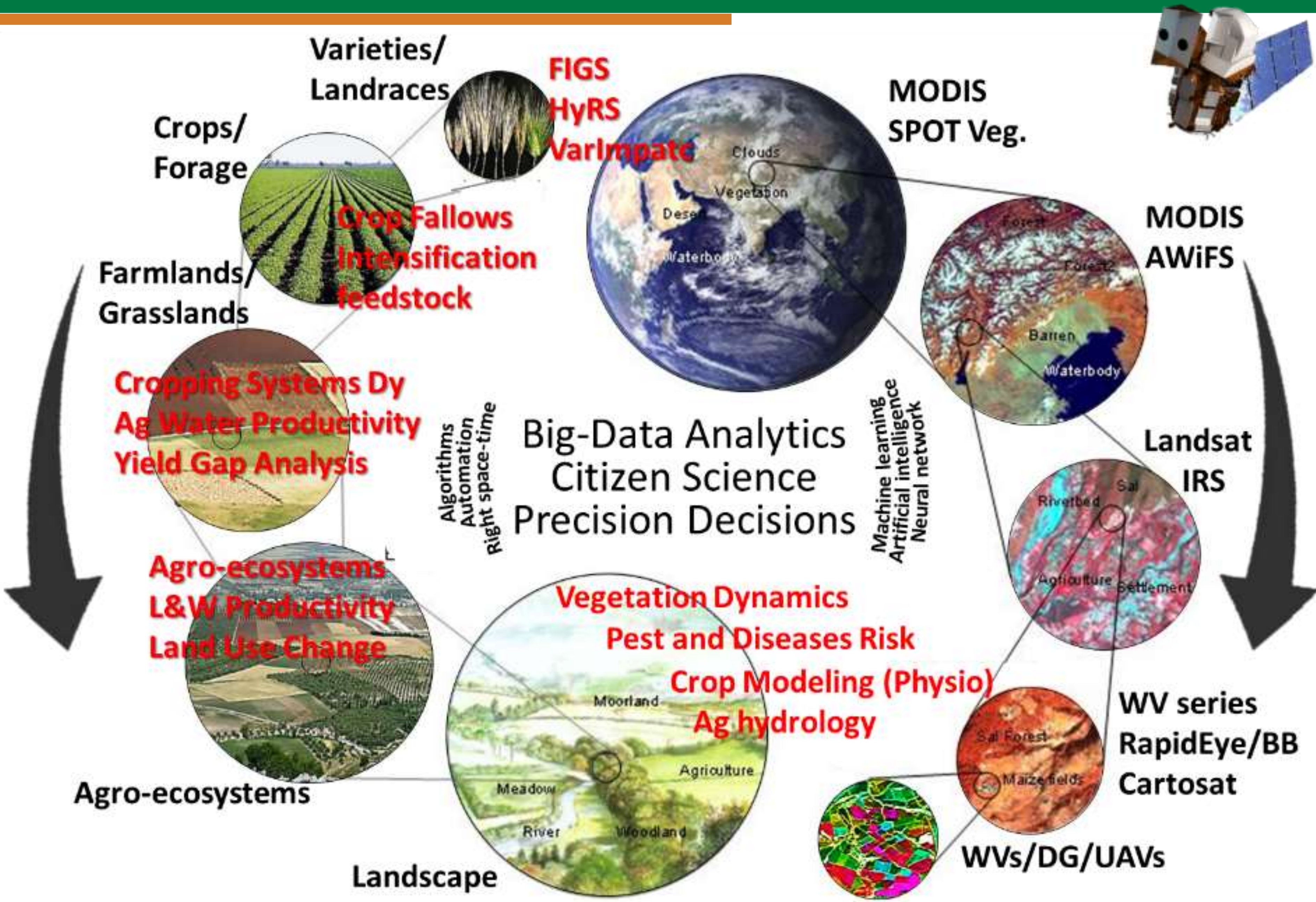
*=Resolution in parenthesis is panchromatic
+=Bands: B-Blue, G-Green, R-Red, IR-Infra Red, C-Coastal blue, Y-Yellow, SW-Shortwave Infrared, M-Mid infrared, P-Panchromatic, H-Horizonal, V-vertcial

Across the scales

Scaling Trade-on/offs
Farmscapes to Landscapes



Sustainable Agro-Ecosystems

Pastoral Agropastoral Rainfed Tree-based Irrigated

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

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

Knowledge based prioritization (space & time) for building better strategy for food and nutritional security and resilience

Genetic Gains
Eco-Crop Zoning
Input Use Efficiency
Bridging Yield Gaps
Conservation Practices
Carbon Sequestration
Land Degradation
Technology Scaling

- food and environmental security
- resilience and risk reduction
- adaption and mitigation
- citizen science and collective actions
- trade, social security and stability

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Agro-ecosystems mapping and monitoring

Mapping and monitoring of agro-ecosystems

1. **Crop types** (e.g., major crops, extent, changes)
2. **Crop associations (**e.g., mixed and integrated crops)
3. **Cropping intensity** (e.g. number crops, sequence)
4. **Crop suitability/crop ecozones** (e.g., Lentils in rice-fallows; nativity)
5. **Crop yield** (e.g., biomass, yield gaps, potetnail, CO_2 seq.)
6. **Water productivity** (e.g., water use efficiency, wpm, gaps)
7. **Land degradation** (e.g., soil salinity, abandonment)

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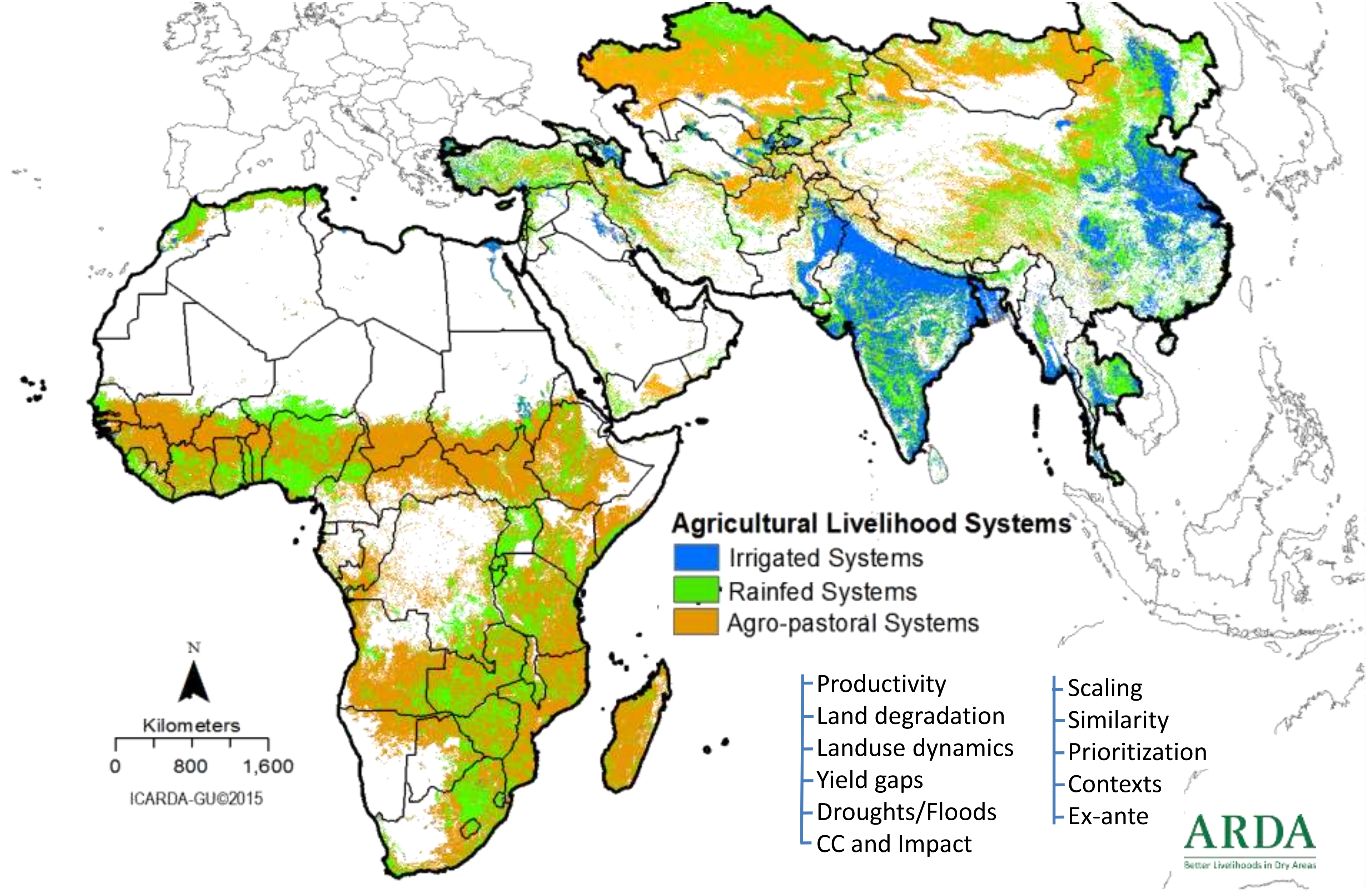
Mapping and Monitoring Major ALS

Farmscape to Landscapes



- Productivity
- Land degradation
- Landuse dynamics
- Yield gaps
- Droughts/Floods
- CC and Impact

- Scaling
- Similarity
- Prioritization
- Contexts
- Ex-ante

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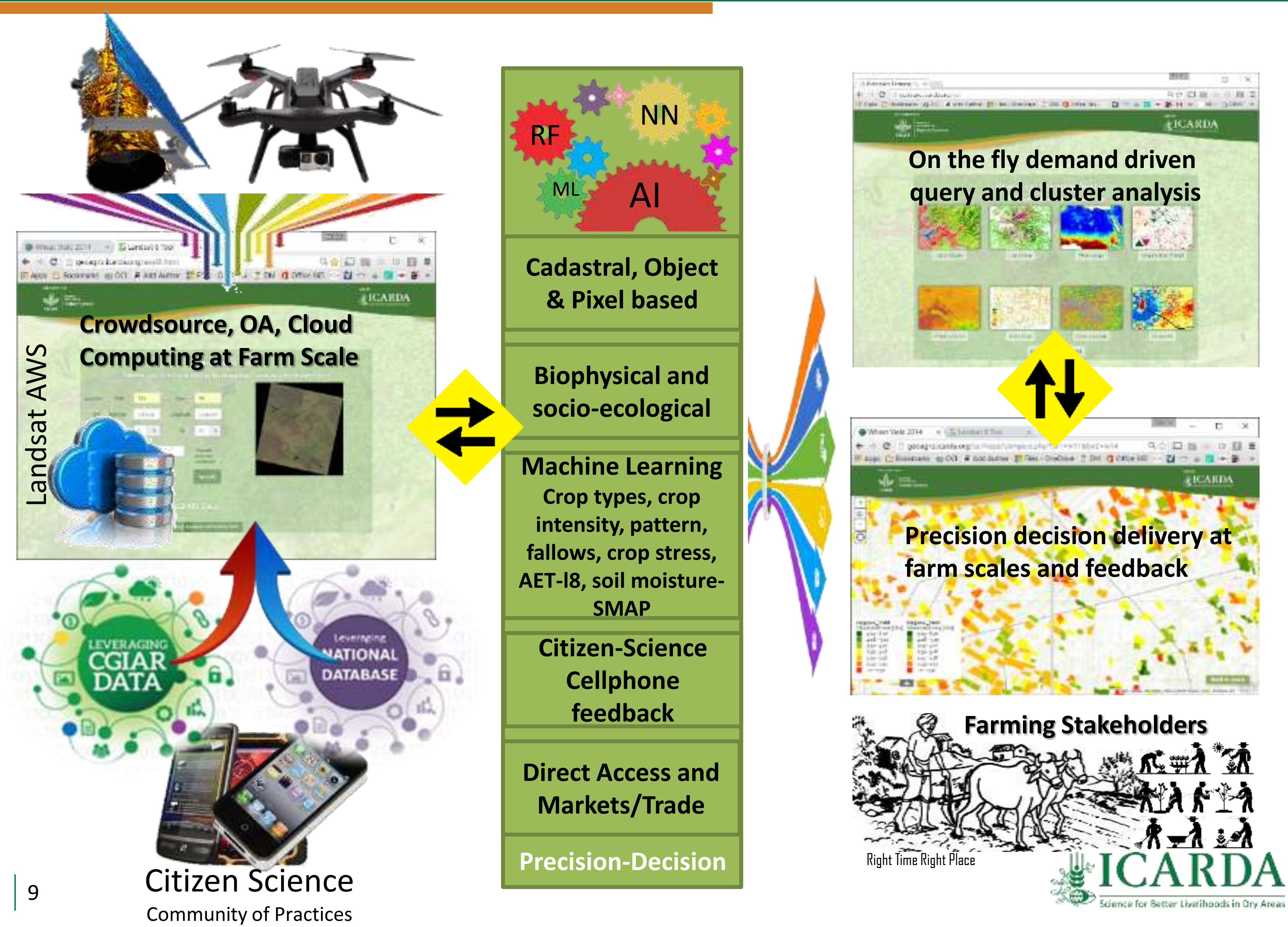
Digital Agriculture Platform

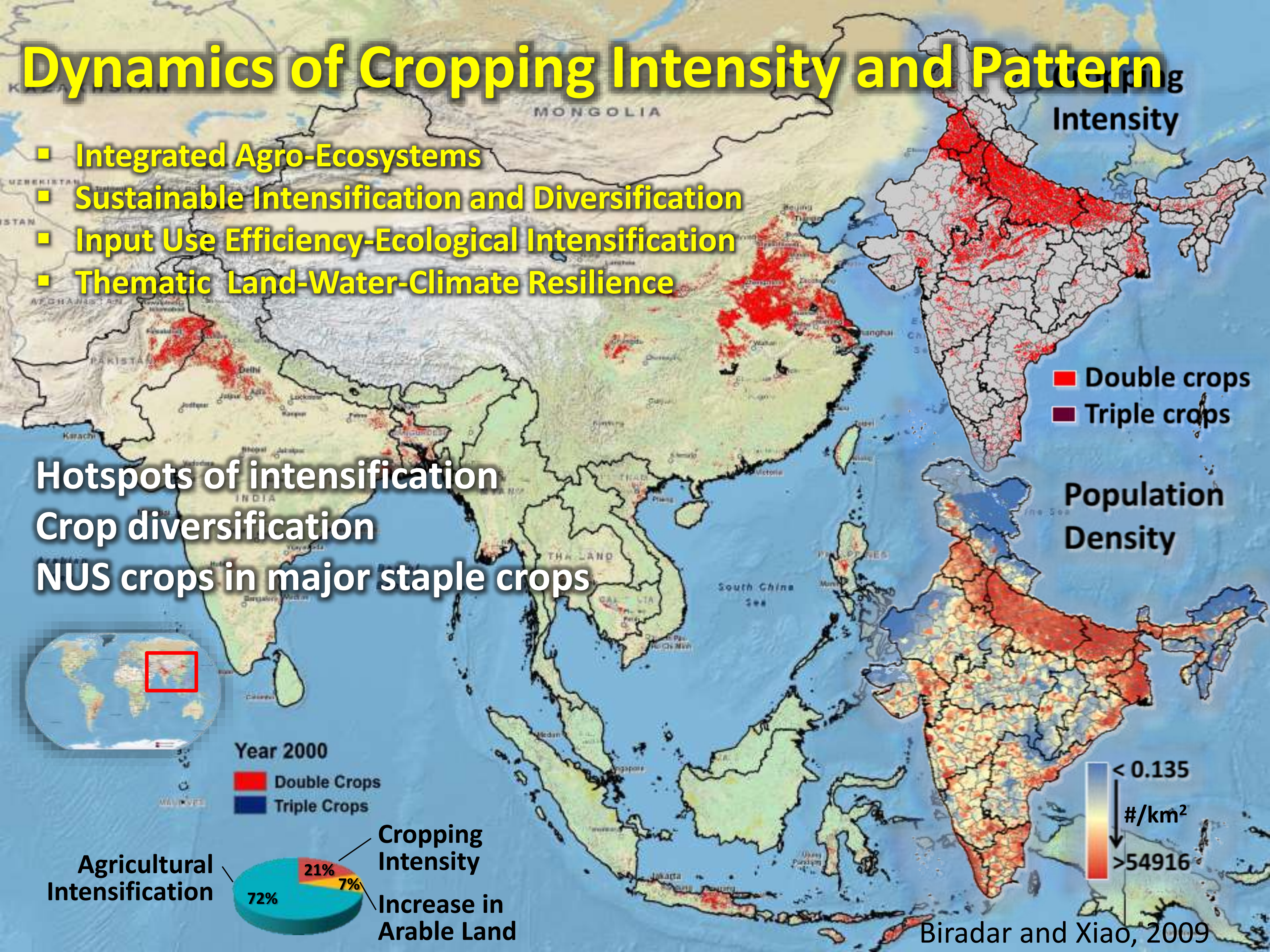
Image Based, Open Source Precision Decision at Farm scales



Dynamics of Cropping Intensity and Pattern

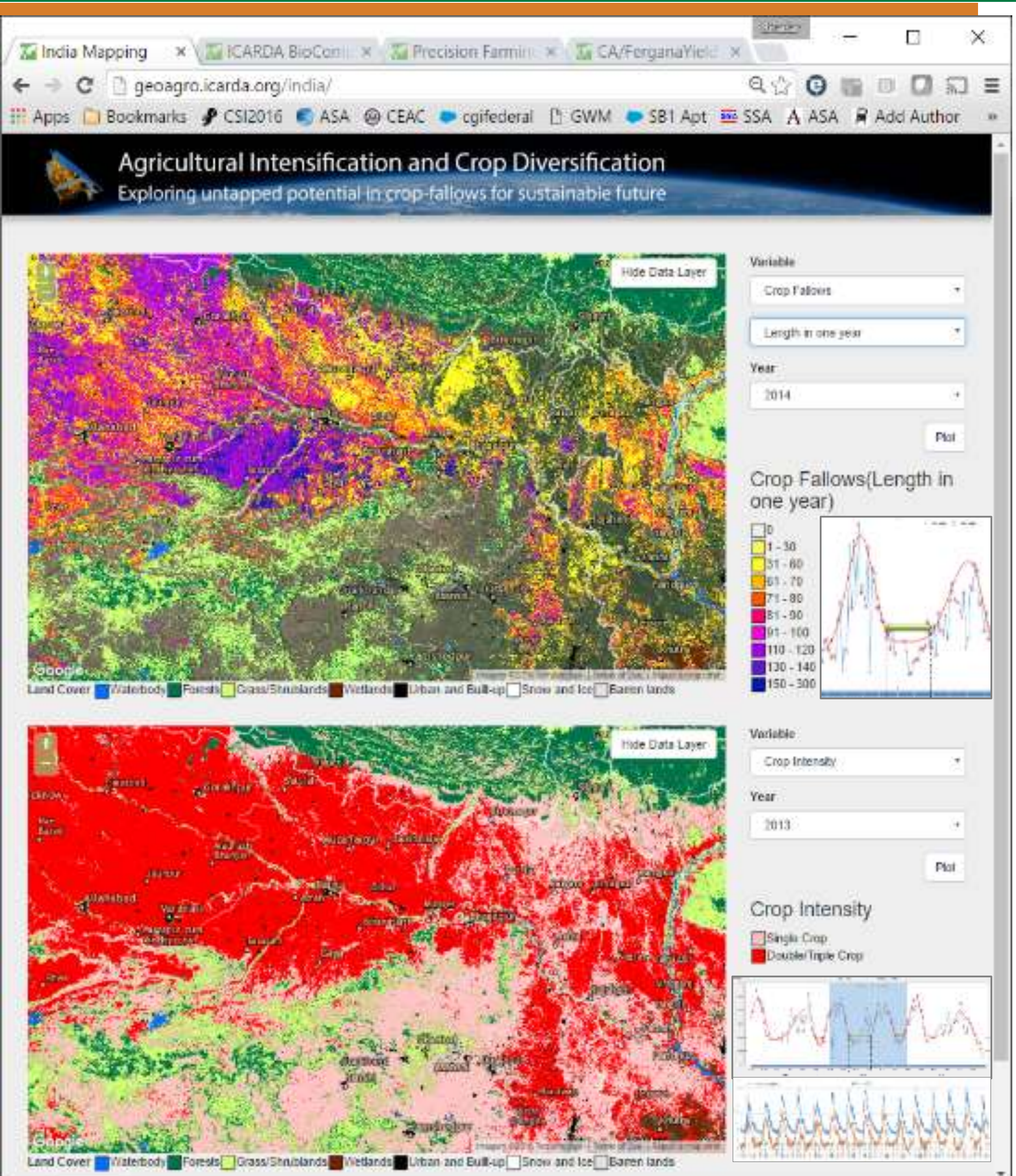
- Integrated Agro-Ecosystems
- Sustainable Intensification and Diversification
- Input Use Efficiency-Ecological Intensification
- Thematic Land-Water-Climate Resilience

Hotspots of intensification
Crop diversification
NUS crops in major staple crops

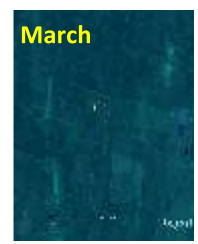


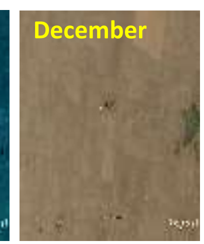
Biradar and Xiao, 2009

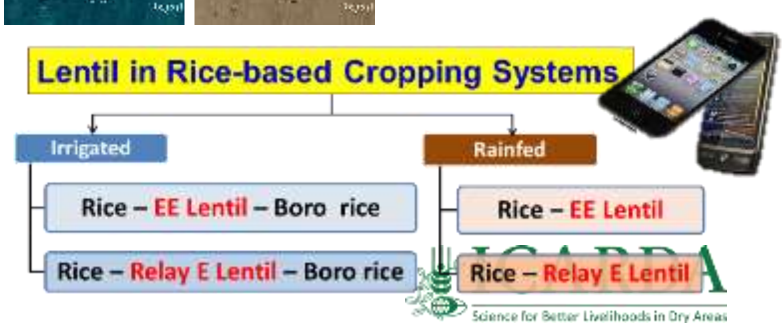
Agricultural Intensification & Crop Diversification



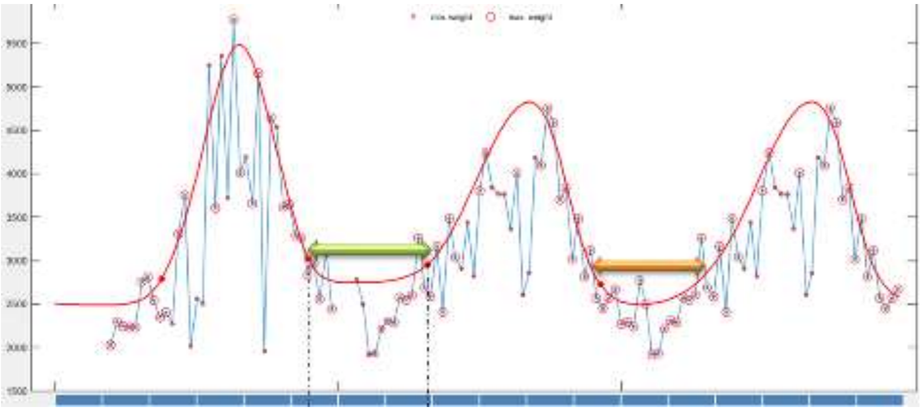
Mapping Crop and variety specific target areas and implementation



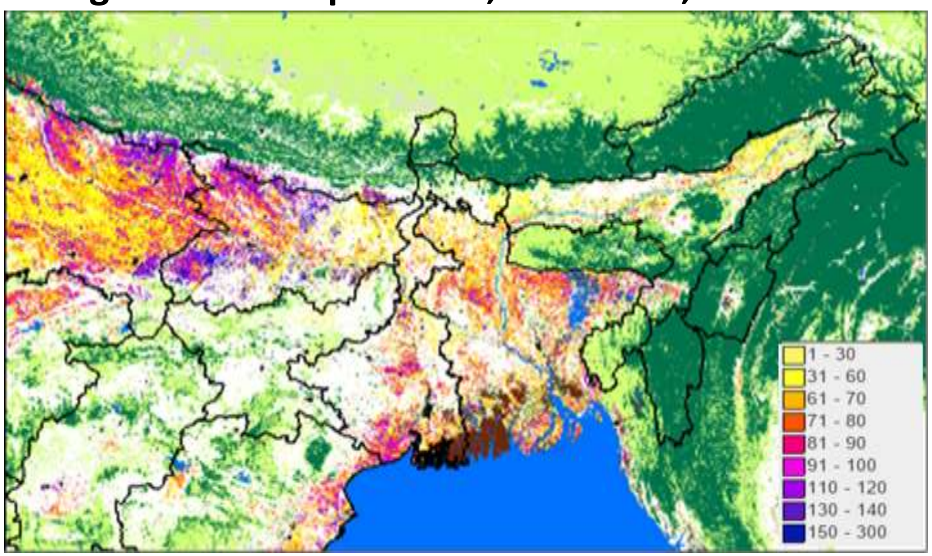




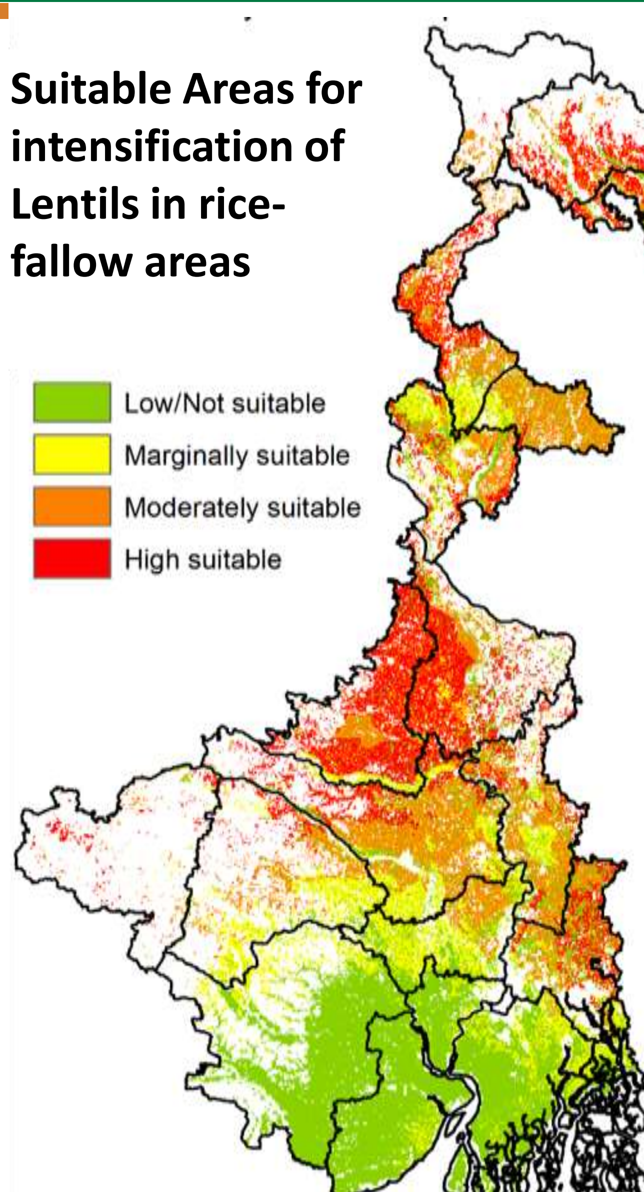
Agricultural Intensification & Crop Diversification



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



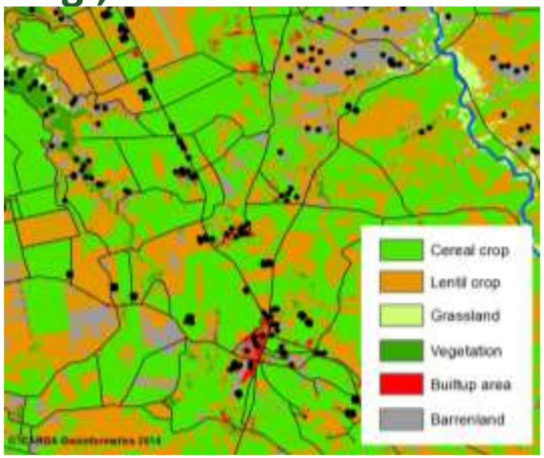
Suitable Areas for intensification of Lentils in rice-fallow areas

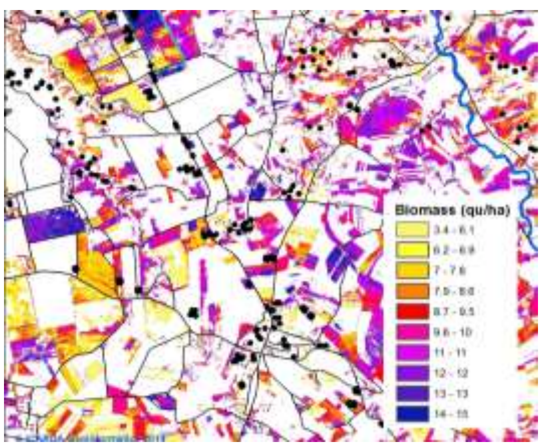


Crop types, sequence and productivity

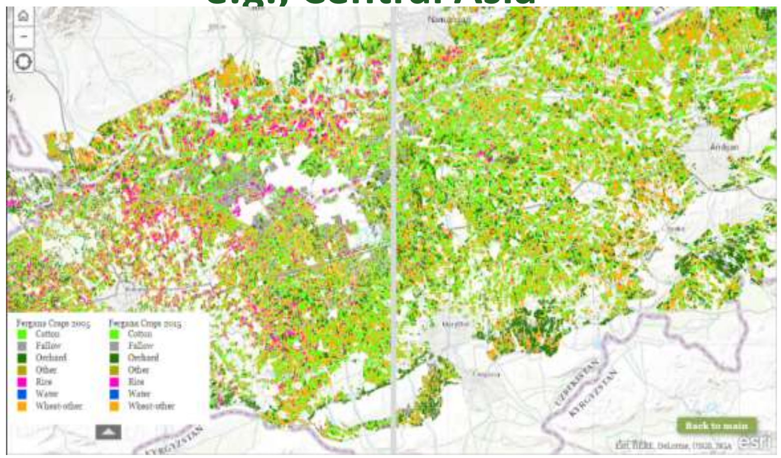
Mapping crop types, sequence and water use

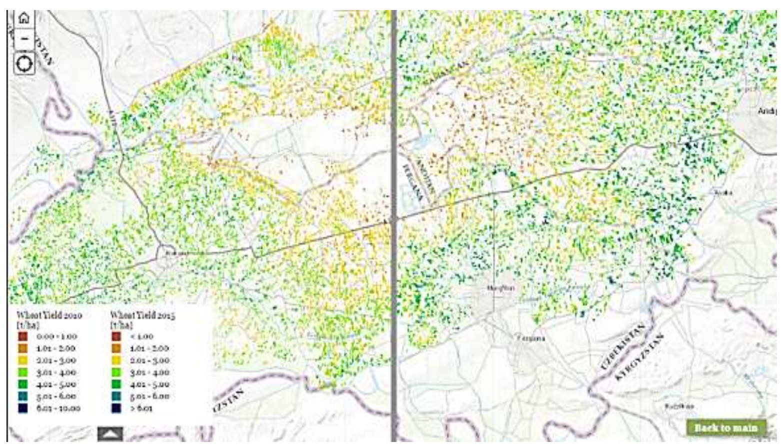
e.g., Morocco



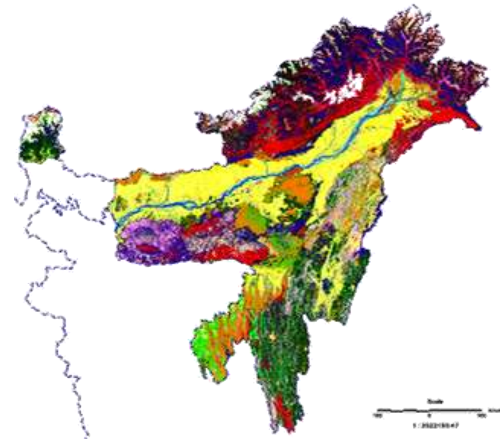


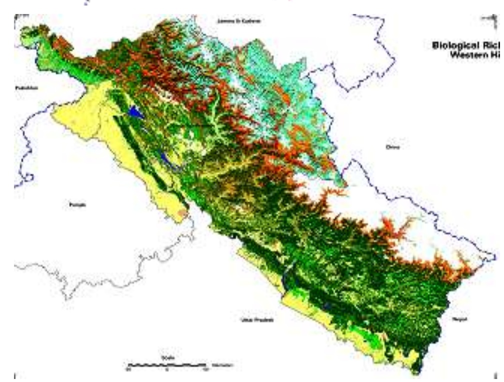
e.g., Central Asia





e.g., SA





DOS-DBT, BISIndia

Biradar et al., 2015; Low et al., 2016; Patil et al., 2016, BCLL, 2007

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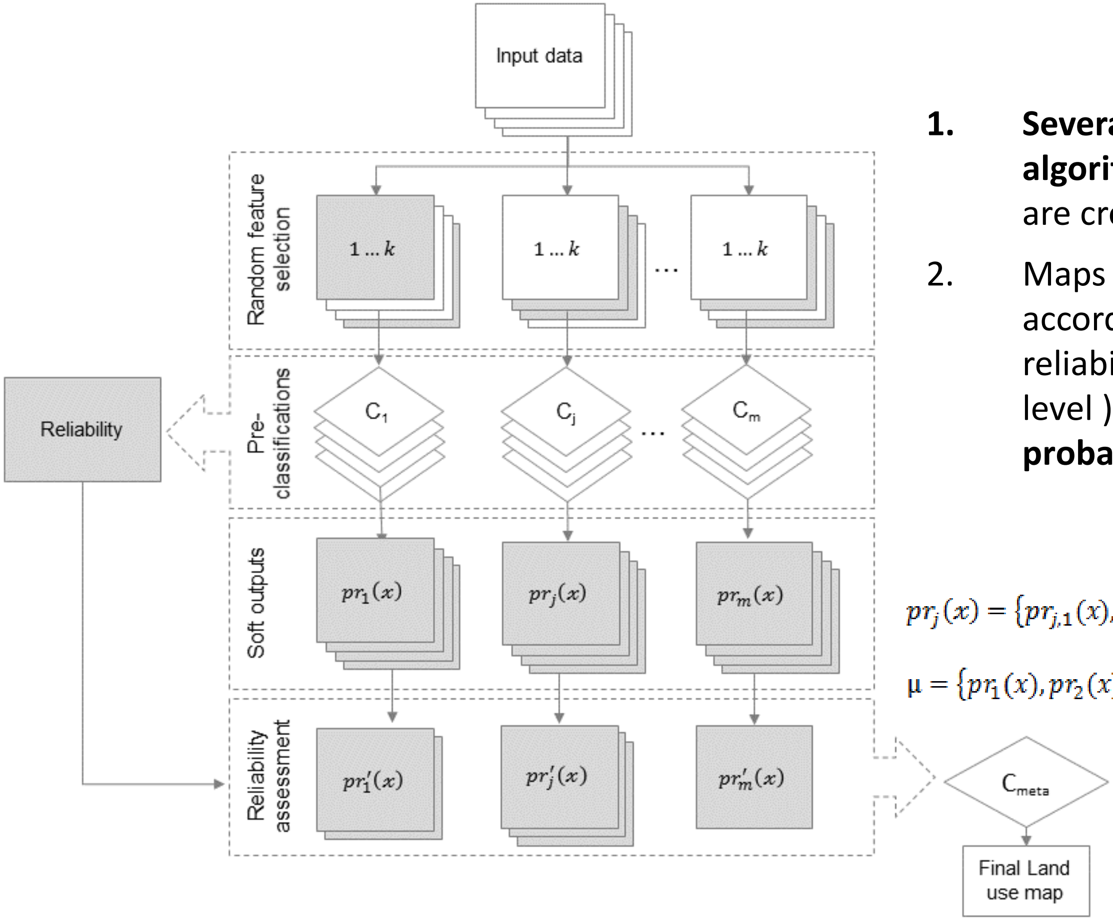
Crop type mapping

Crop mapping based on **decision fusion**, i.e., combination of different classifier algorithms



1. **Several** crop maps based on **different classifier algorithms** and **randomly selected feature sets** are created
2. Maps are **combined** by weighting each input map according to (i) **global accuracy** assessment (= reliability check) and local (i.e., pixel or object level) estimation of a-posteriori **classification probability**

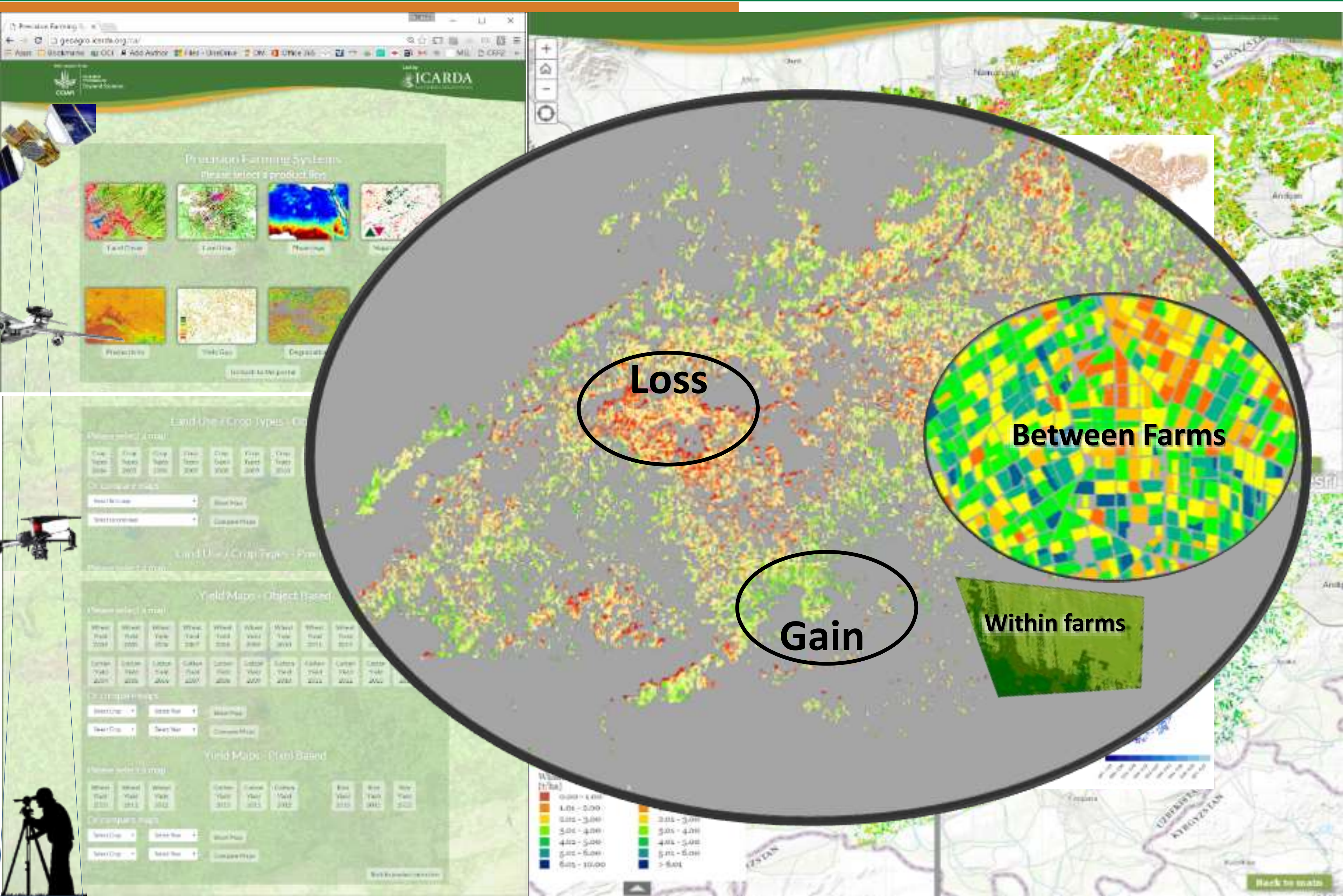
$$pr_j(x) = \{pr_{j,1}(x), pr_{j,2}(x), \ldots, pr_{j,i}(x), \ldots, pr_{j,n}(x)\}\ ,\ i = 1 \ldots n$$

$$\mu = \{pr_1(x), pr_2(x), \ldots, pr_j(x), \ldots pr_m(x)\},\ j = 1 \ldots m$$

Löw, et al. 2015. Decision fusion and non-parametric classifiers for land use mapping using multi-temporal RapidEye data. ISPRS J. Photogramm. Remote Sens. 108, 191–204.

EOS in Precision Decisions

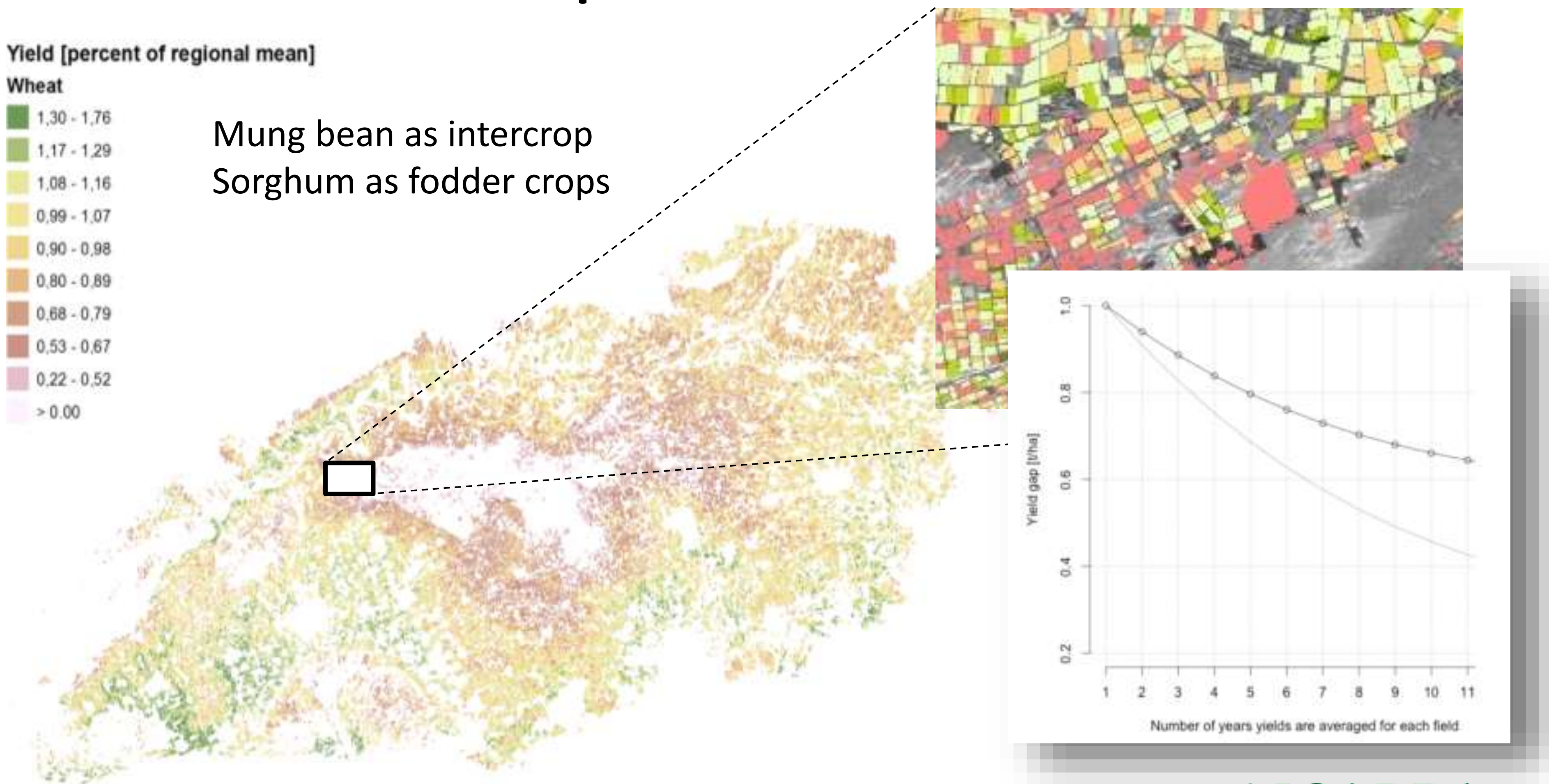
operational mapping, monitoring and rural advisory



Mapping the gaps and priorities

Yield gaps and land potential: identify potential areas for intensification and crop diversification

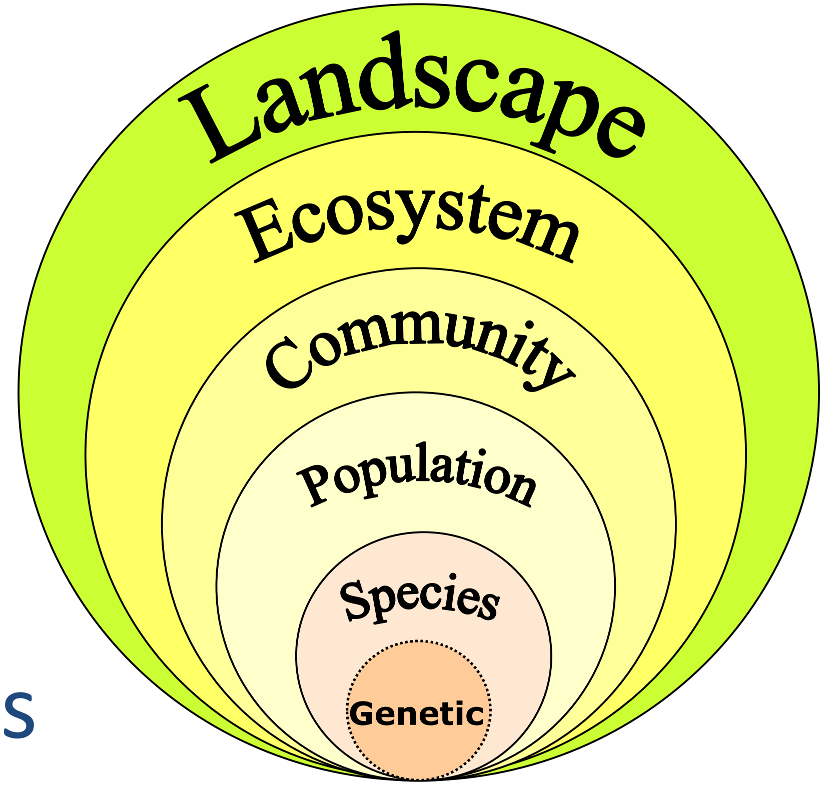
Mung bean as intercrop
Sorghum as fodder crops



Löw, Biradar, et al. 2016. Assessing gaps in irrigated agricultural productivity through satellite earth observations – A case study of the Fergana Valley, Uzbekistan

Mapping of Underutilized Crop Species (NUS)

1. Roots and Tubers
2. Cereals and millets
3. Fruits and Nuts
4. Vegetables
5. Food Legumes
6. Spices and condiments



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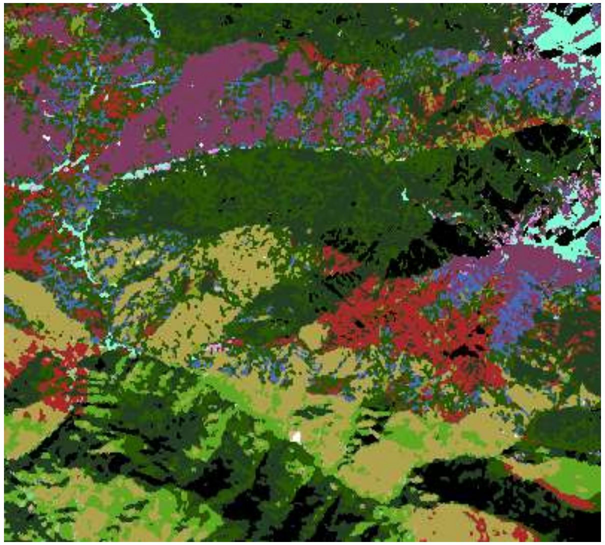
Way Forward

Mapping of Crop-related Neglected and Underutilized Species (NUS)

- Use of high resolution EOS images
- Data fusion and crop phenology
- Landscape ecological concepts and species association for mapping eco-zones (hotspots) of the NUS
- Geotagging and community (citizen science) based approach for mapping of the NUS growing regions
- Mapping potential areas for infusion of the NUS crops in major staple crops



Biradar et al., 2007.

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in an inch of land and bunch of crop

avoid the unmanageable and
manage the unavoidable

-IPCC Confronting Climate Change:

Where much gain is expected?

Is that from genetic? 15-20

Is that from agronomy? 50-60

Is that from socio-economy? 20-35 (policy)

Thank You

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