ICARDA

Science for resilient livelihoods in dry areas

Big Data and Digital Augmentation for Sustainable Agri-Food Systems

Spatial innovations for ecologically sustainable and economically viable solutions

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GEOAGRO

geoagro.icarda.org

UNITED NATIONS Office for Outer Space Affairs

May 5-10, 2019 Cluj-Napoca, Romania

GEOAGRO GBDX Leaflet amazon web services esri CGIAR Google Earth Engine

Platform for Big Data in Agriculture

CGIAR CSI Consortium for Spatial Information

icarda.org

International Center for Agricultural Research in the Dry Areas

cgiar.org

A CGIAR Research Center

CGIAR

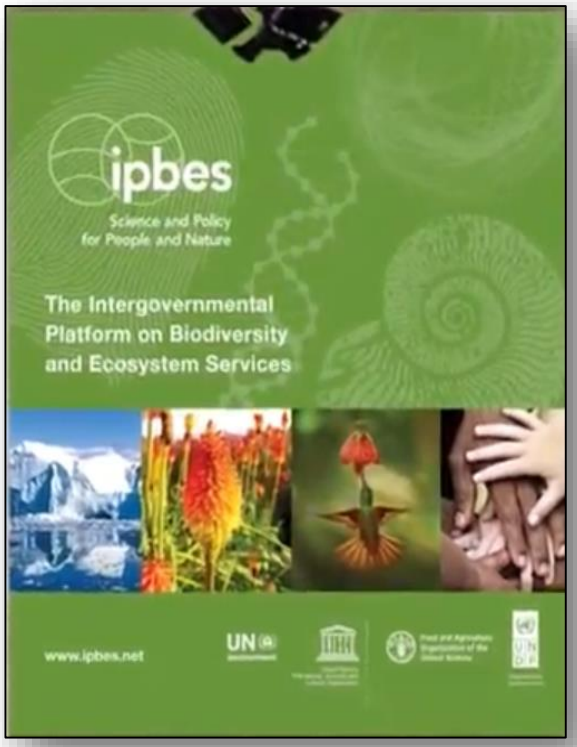
Food, Fiber, Packing > Problems

"the way people eat today is often unhealthy for them and for the planet"
- Kate Brauman

The unhealthy food is single largest source of problems in todays world.

"We can become healthier as an individuals by eating more **diverse diets**, with **more vegetables**, and we can also make the planet healthier by growing food that in more sustainable

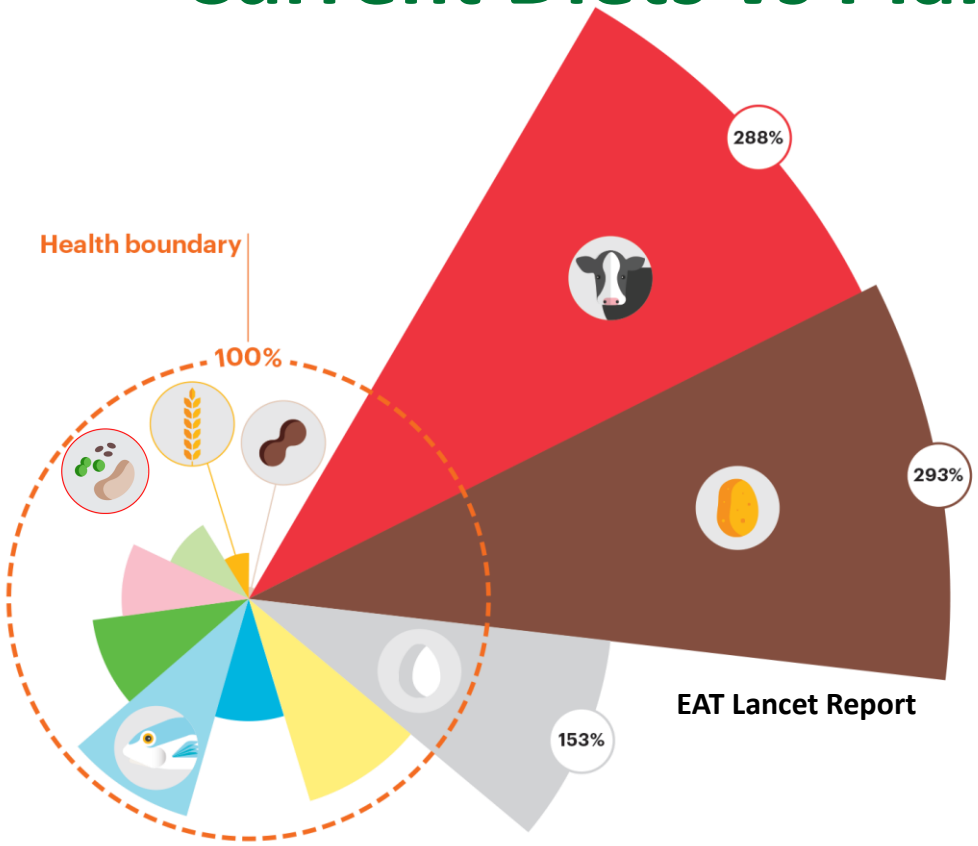
- UN Report 2019 Released May 6, 2019



We must **restore nature** and **drive innovation**. Only then will we leave future generations a **healthy** and **sustainable planet**. - Jonathan Baillie, National Geographic Society.

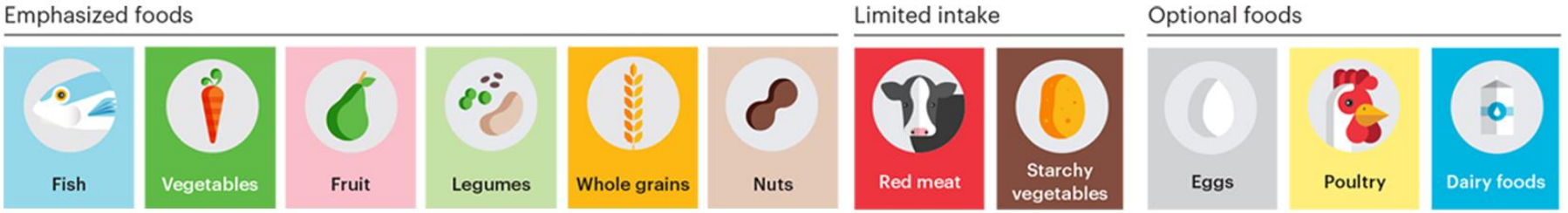
https://www.bbc.com/news/science-environment-48169783

Current Diets vs Planetary Health

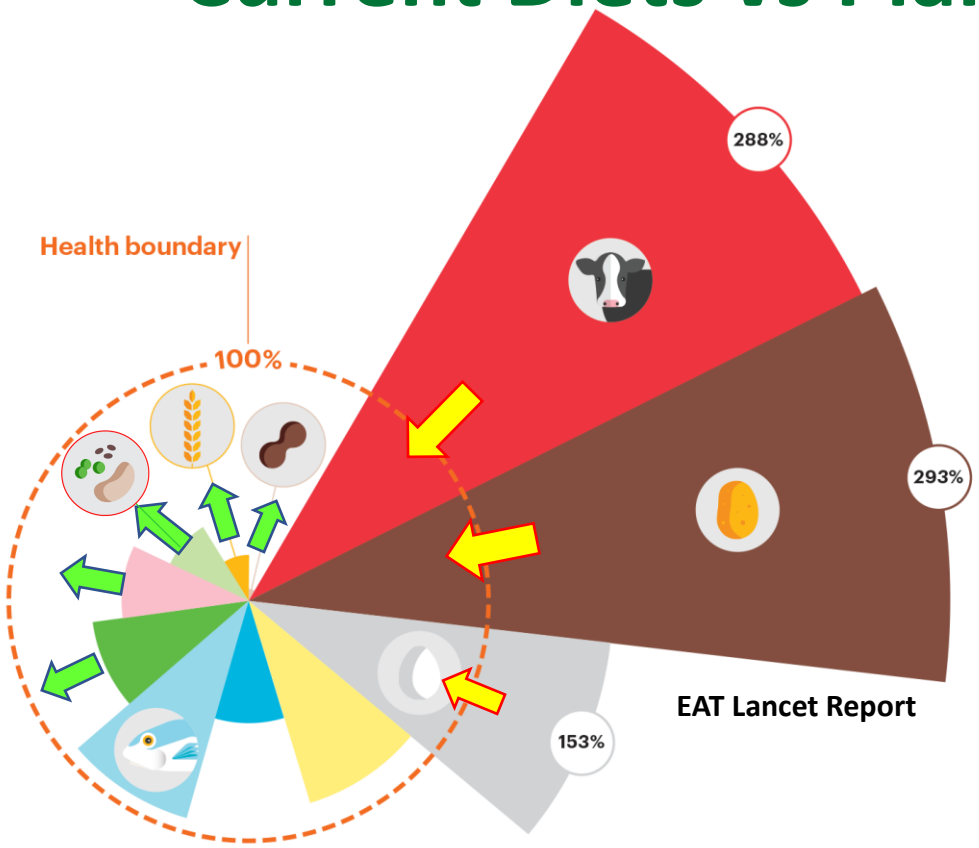


EAT Lancet Report

Moving from narrow sense economic benefit to a new ecologically sound functional system for well being…

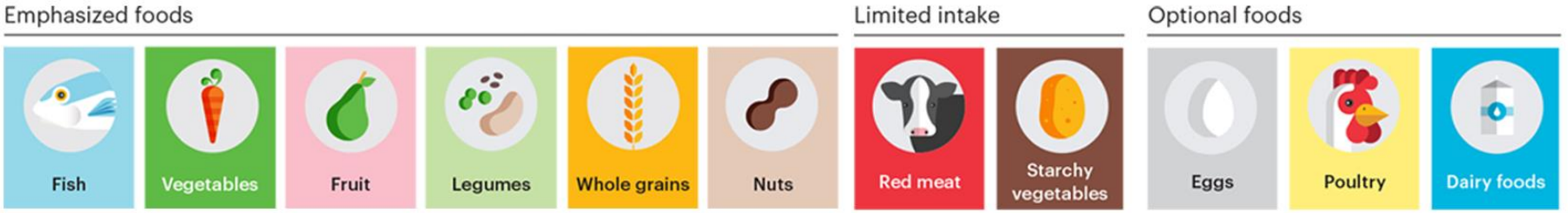


Current Diets vs Planetary Health



EAT Lancet Report

…with diversified cropping systems, conservation, rotation, nutrition focus >> **“more health per acre”**



Changing diet pattern >> cropping systems >> Sustainable living

Sustainable alternatives for future food systems

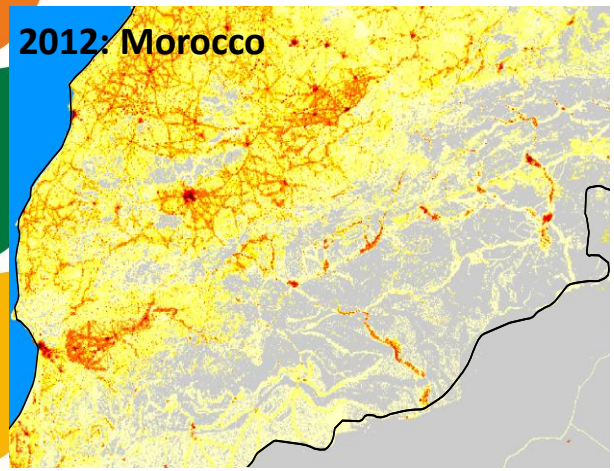
Pulses for the people and planet

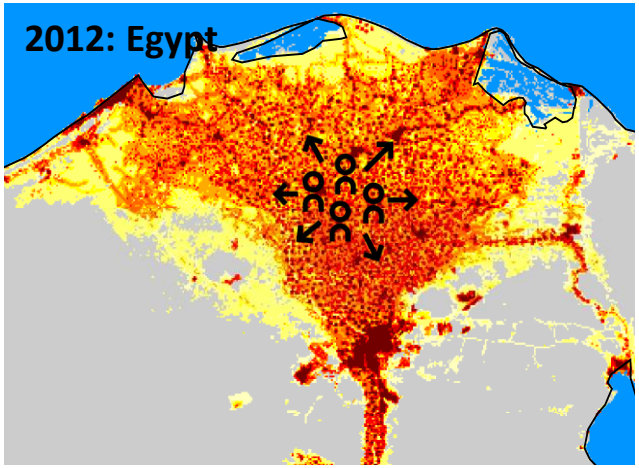
	Daal/Falafal	Chicken	Mutton	Beef
Water used	1,250 liters	4,325	5,520	13,000

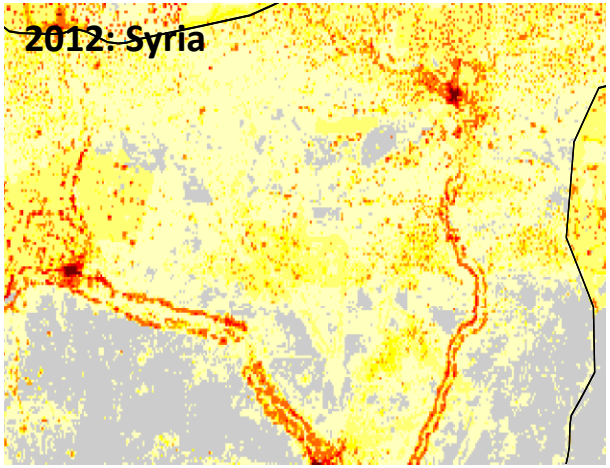
There is a need for paradigm shift from **more calories per acre to more health per acre.**

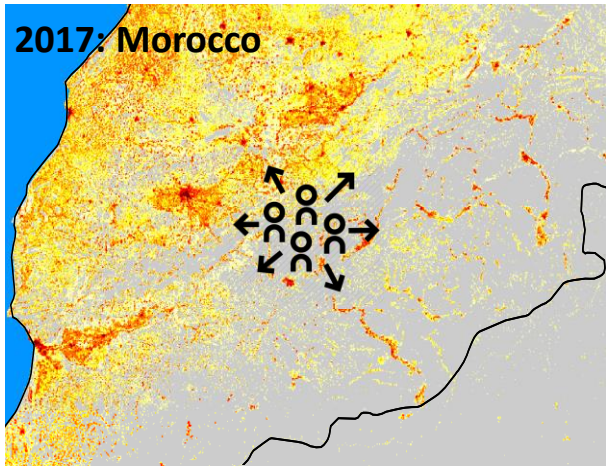
Changing diets, demography and agri-food systems

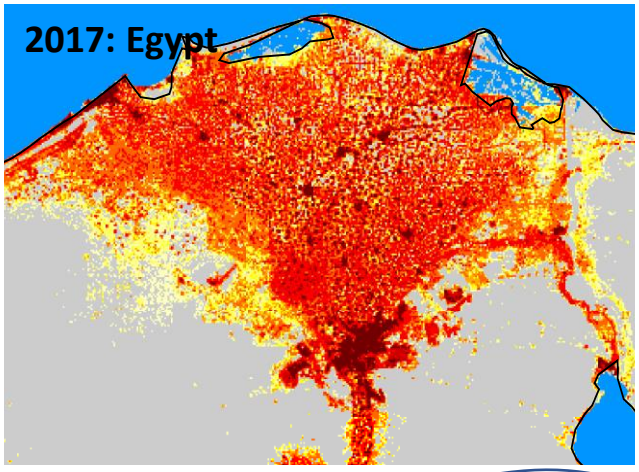
>> need better understanding the nexus between food, water, energy, economy and health

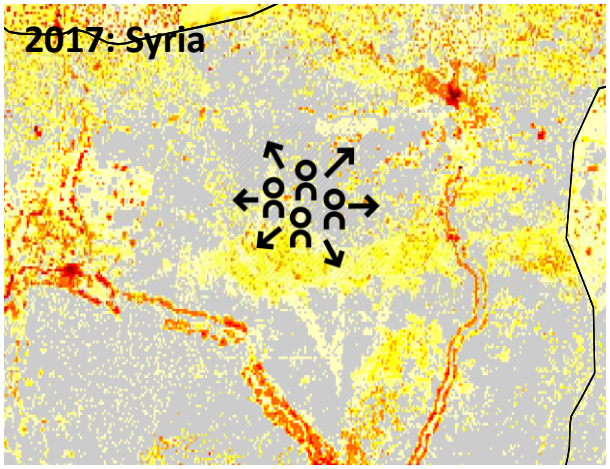








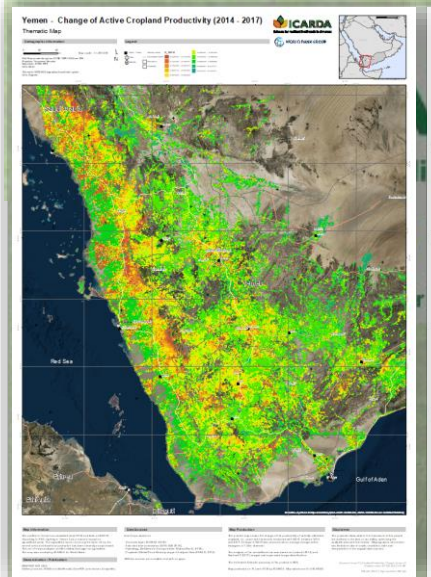


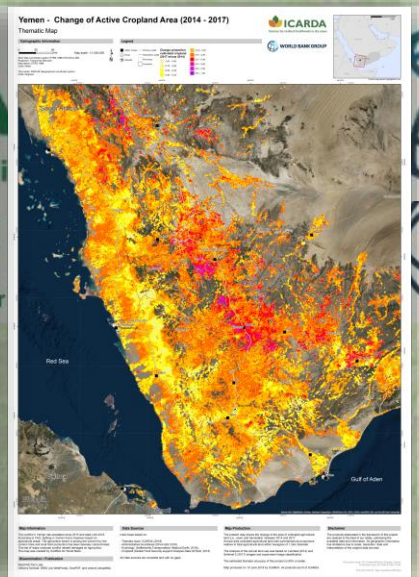


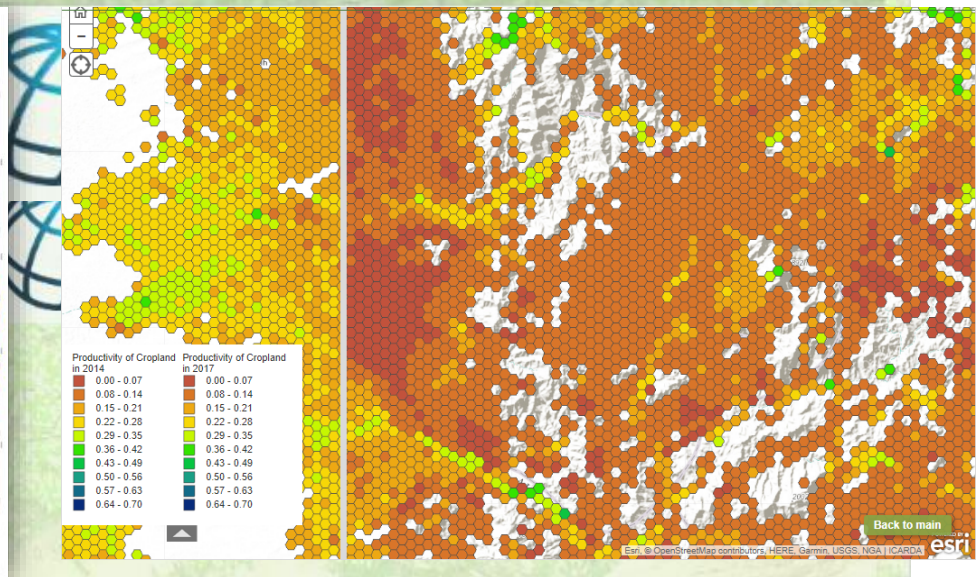
Key factors: the way we eat, we grow, we live

Increasing land degradation and fragile ecosystems

>>need monitoring them for development

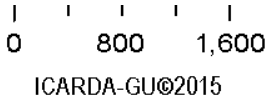


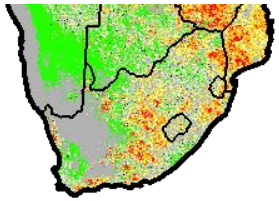




Impact on the land use change and planetary health

>> land use pattern, water balance and climate





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

Data driven decisions for diversified systems

>> with farm focus (rural welfare)

Geo Big Data for building inclusive agroecosystems for ecologically sustainable and economically viable options for more food, nutrition and health

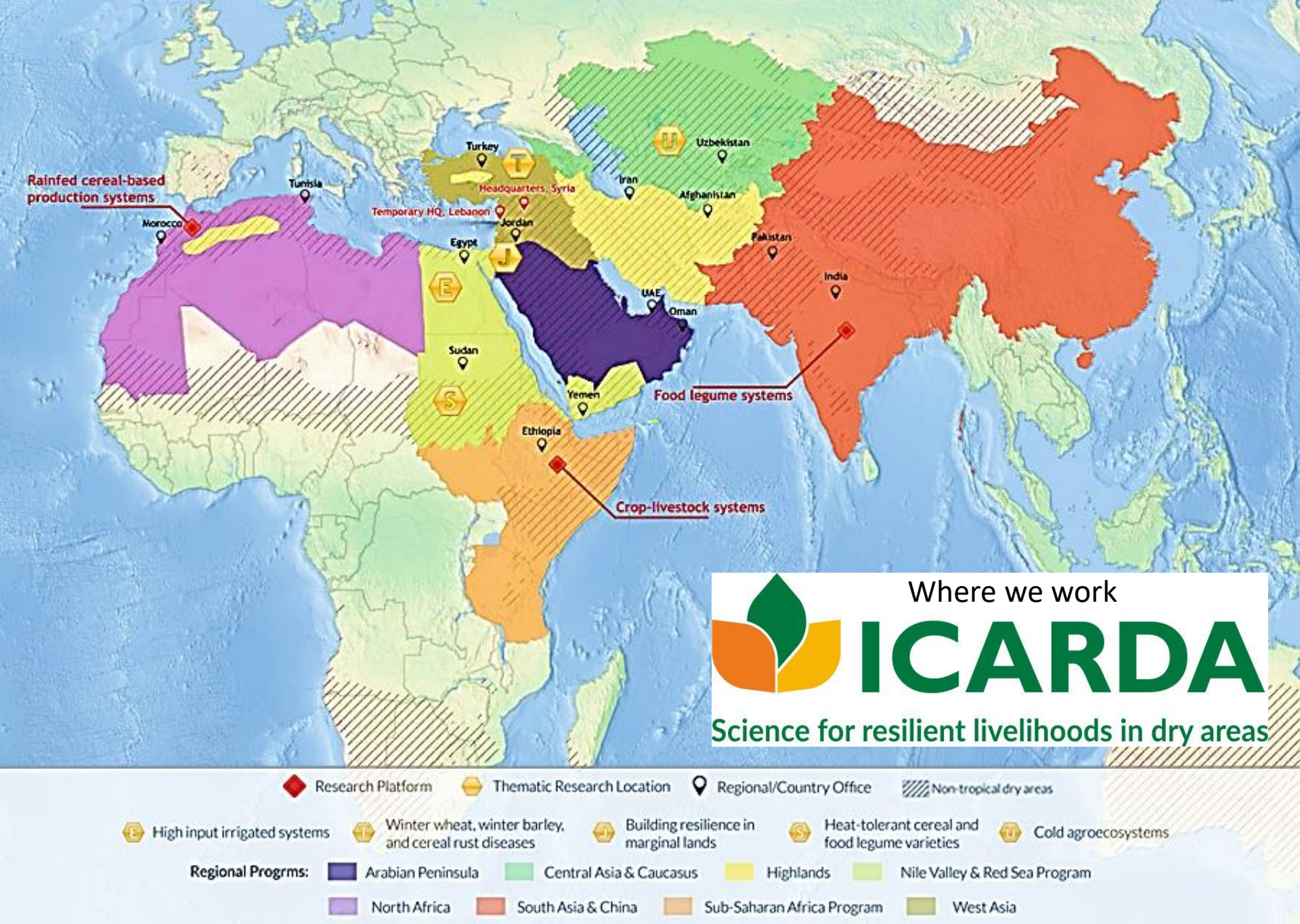
Ecological intensification
Target specific interventions
Bridging the gaps
Inputs use efficiency
Agricultural policy
Halt degradation
Technology scaling

- 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


Rainfed cereal-based production systems
Morocco
Tunisia
Turkey
Headquarters, Syria
Temporary HQ, Lebanon
Jordan
Egypt
Iran
Uzbekistan
Afghanistan
Pakistan
India
UAE
Oman
Sudan
Yemen
Ethiopia
Food legume systems
Crop-livestock systems
Where we work
ICARDA
Science for resilient livelihoods in dry areas
Research Platform
Thematic Research Location
Regional/Country Office
Non-tropical dry areas
High input irrigated systems
Winter wheat, winter barley, and cereal rust diseases
Building resilience in marginal lands
Heat-tolerant cereal and food legume varieties
Cold agroecosystems
Regional Progrms:
Arabian Peninsula
Central Asia & Caucasus
Highlands
Nile Valley & Red Sea Program
North Africa
South Asia & China
Sub-Saharan Africa Program
West Asia

Integrated Agroecosystems combining **Component** Research & **Systems** Research

A multi-scale and multi-criteria R4D

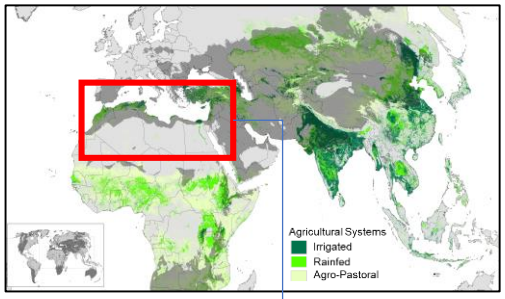
Global

Country

Region

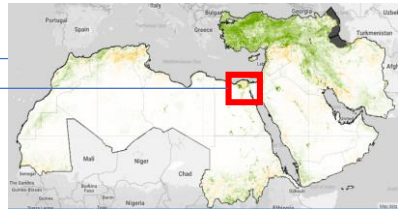
Landscape

Fiel
d

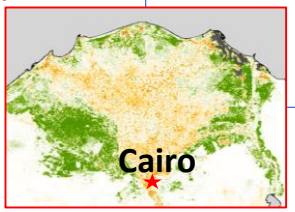


Climate (Variability and Change)

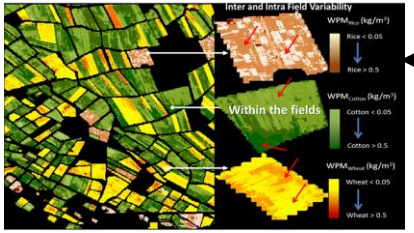
Nutrition Security and Sovereignty



Un-employment
Poverty



NRMs



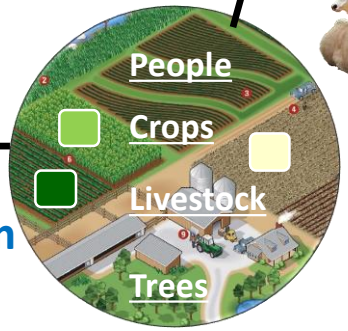
Functional Productivity

Supply Chain

Down

Out

Up



Farm

Agricultural Systems
Irrigated
Rainfed
Agro-Pastoral

New 9: 5 SRPs + 4 CCTs

Strategic Research Priorities

Adoption of the SRPs in operational projects

Genetic Resources: Mini… …iversity to develop germplasm resistant to heat, drought, cold, disease, hi… …tional public goods (open access)

Adaption to Climate… : Conventional and molecular breeding to develop climate-smart cr… …ck

Building resilience: Ir… …ivestock farming systems to address economic, social, and environmental …

Promoting value cha… …cies: Agriculture as an income-generating business for many poor sr… …seholds

Enhancing water, la… …tivity: Rainfed, irrigated, and agro-pastoral farming; Reversal of enviro… …l degradation; Enhance intensification

GEOAGRO

Big Data

ICTs

Data growing exponentially

>> it demands new technical and strategic approaches untap its huge potential

GEOAGRO

44 zettabytes

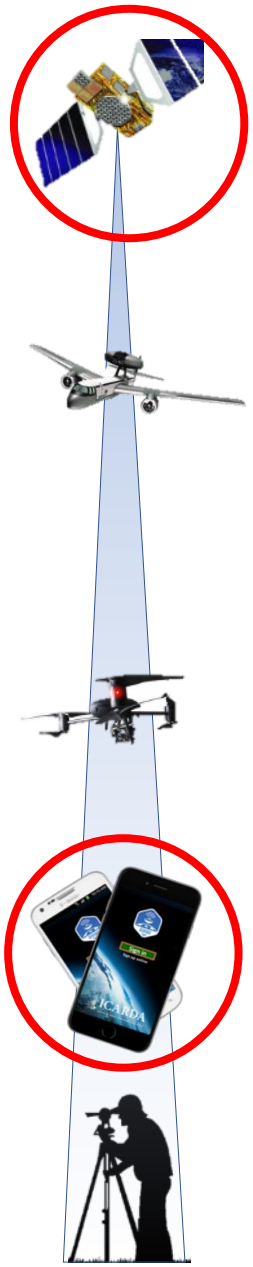
unstructured data

You are here

structured data

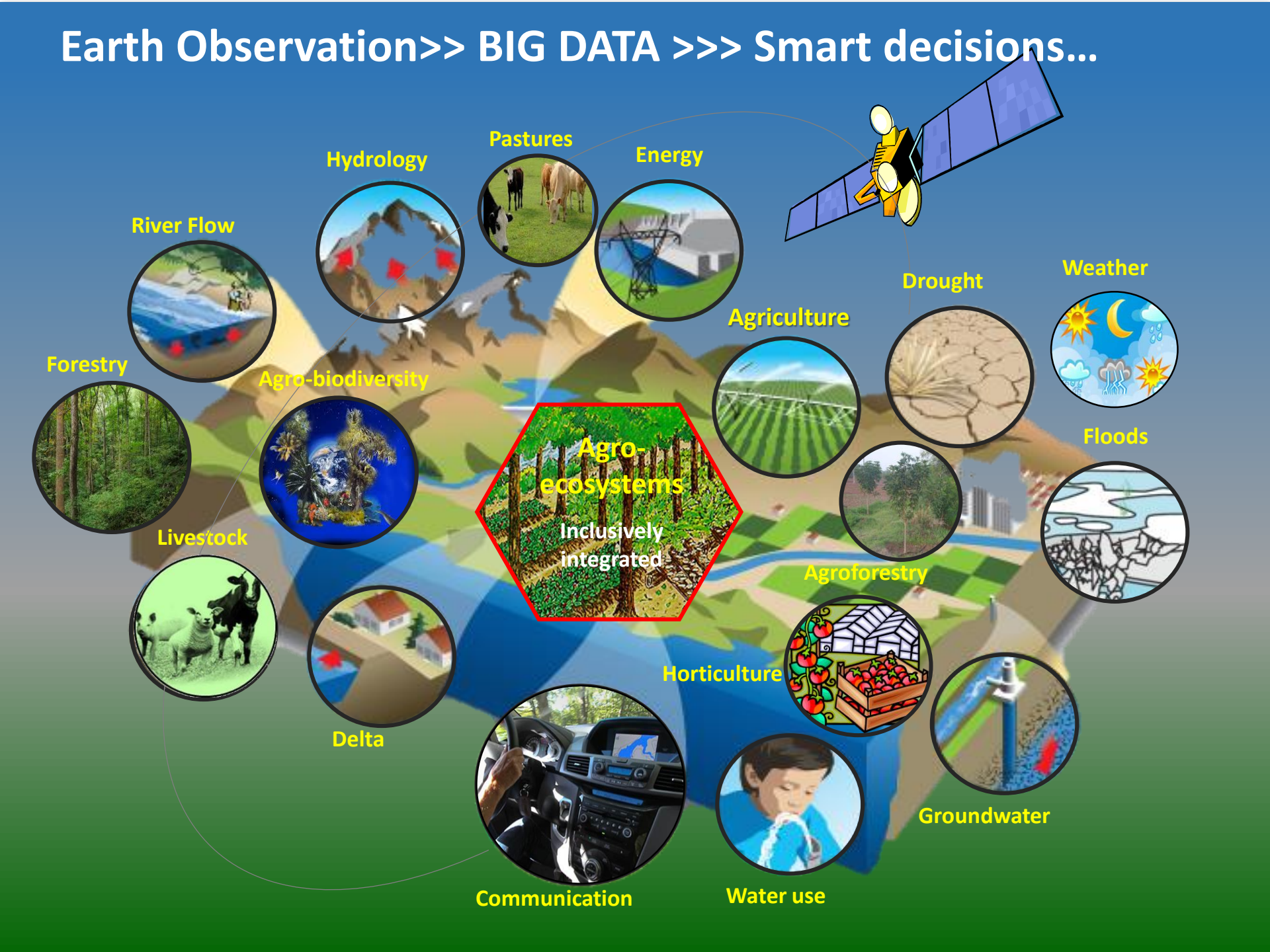
icarda.org

2010 2018/2019 2020

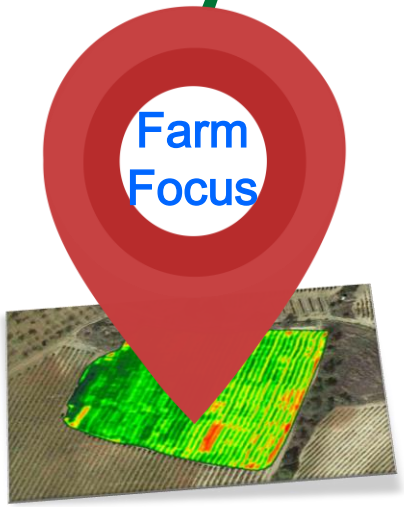


Source: Robin Lougee IBM Research

Earth Observation>> BIG DATA >>> Smart decisions…



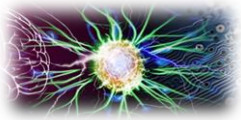
New era of analytics



Conscious Systems Era

Local intelligence

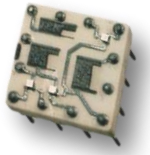
Cognitive Systems Era



Data driven

Programmable Systems Era

Tabulating Systems Era



BACK TO THE FUTURE

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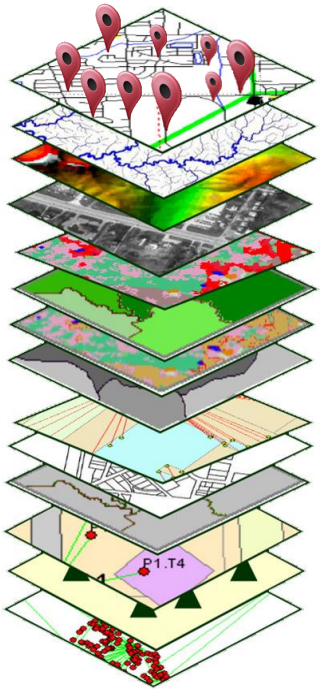
Digital Augmentation

Combining Big Data Science and Citizen Science to accelerate diversified intensification

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

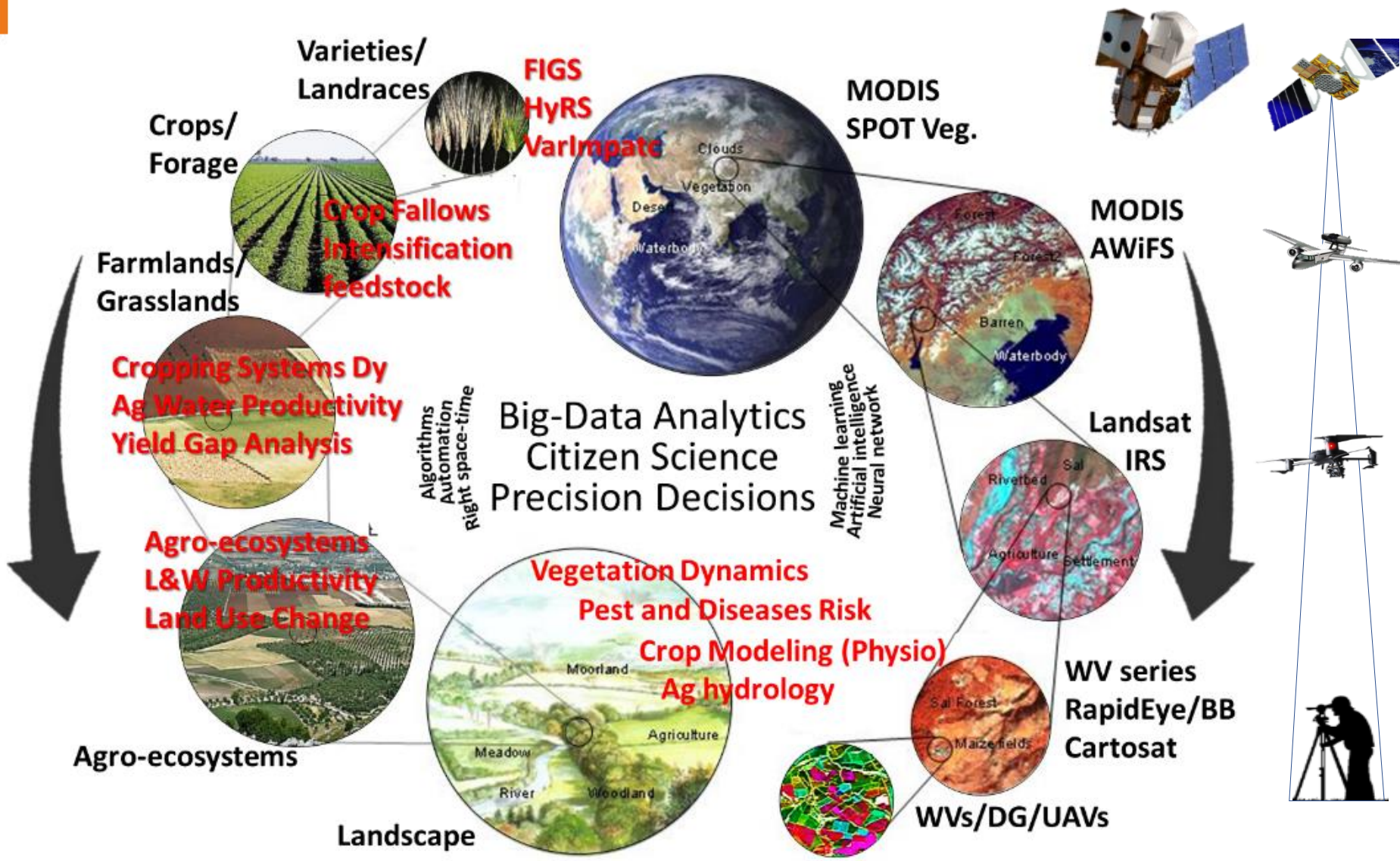
Scalability

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

Geo-taging and Agro-tagging

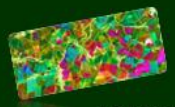
Cross-cutting disciplines and trade offs

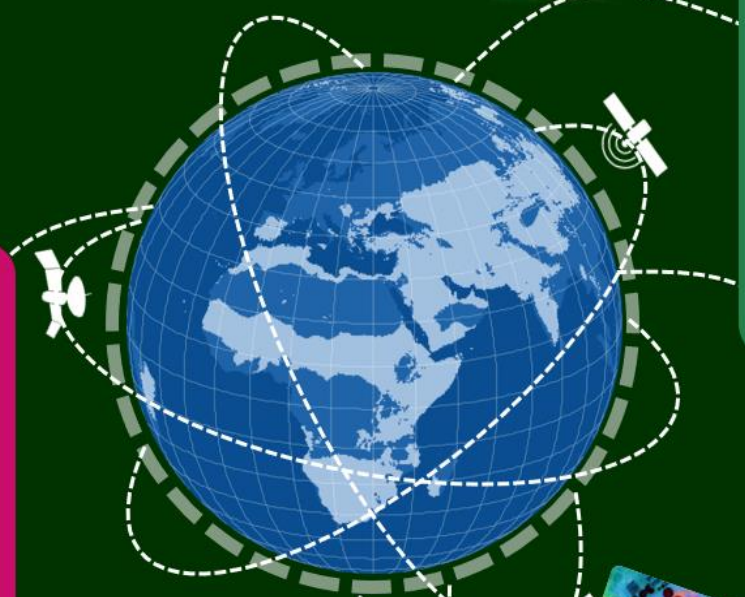
Role of Earth Observation to overcome the limitation and gaps

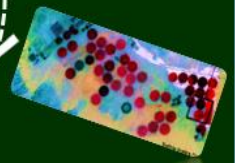


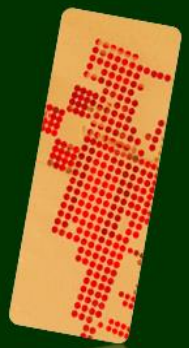
Earth Observation Systems for Agro-Ecosystem Research

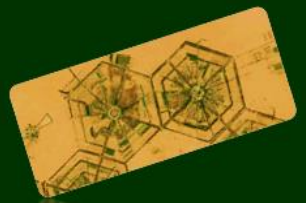
ACTIVE SATELLITE SENSORS AND CHARACTERSTICS











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)	5	B, G, R, IR	96
BEIJING-1	32 (4)	1	B 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	618
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

ICARDA

Science for Better Livelihoods in Dry Areas

Technologies are mature to make better decisions

>> but need strong, committed and collective actions to see the results

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

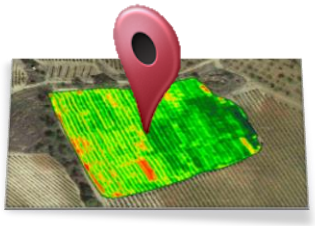
Smart phone enabled apps and cloud web-GIS for decision making at point, farm and administrative units

AWS Google Earth Engine

Paradigm shift towards economically viable ecologically sustainable options

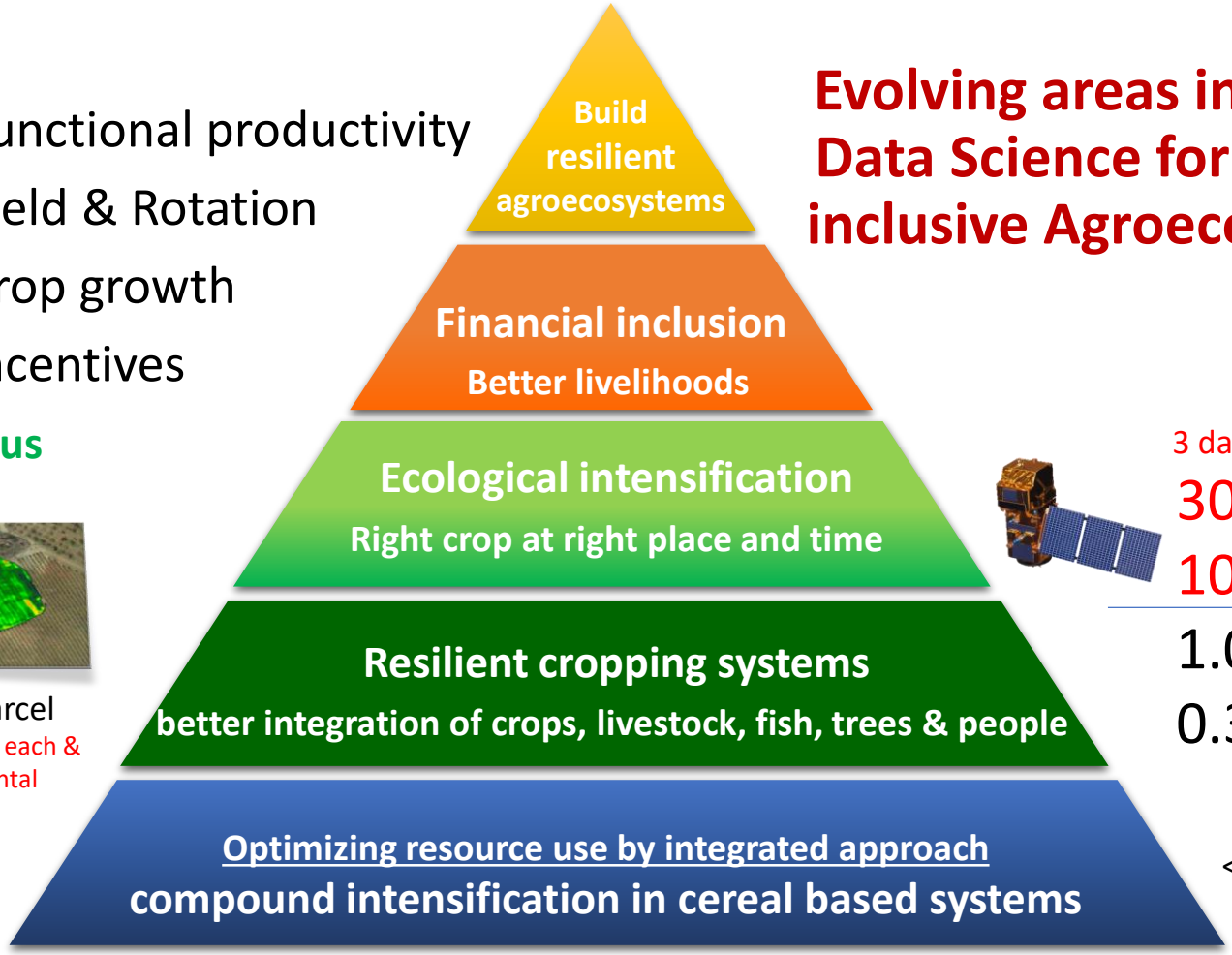
1. Functional productivity
2. Yield & Rotation
3. Crop growth
4. Incentives

Farm Focus



Pixel/Farm/Parcel

A single entity for each & every developmental entry point



Evolving areas in Geo Big Data Science for building inclusive Agroecosystems

3 days revisit

30m

10m

Open source

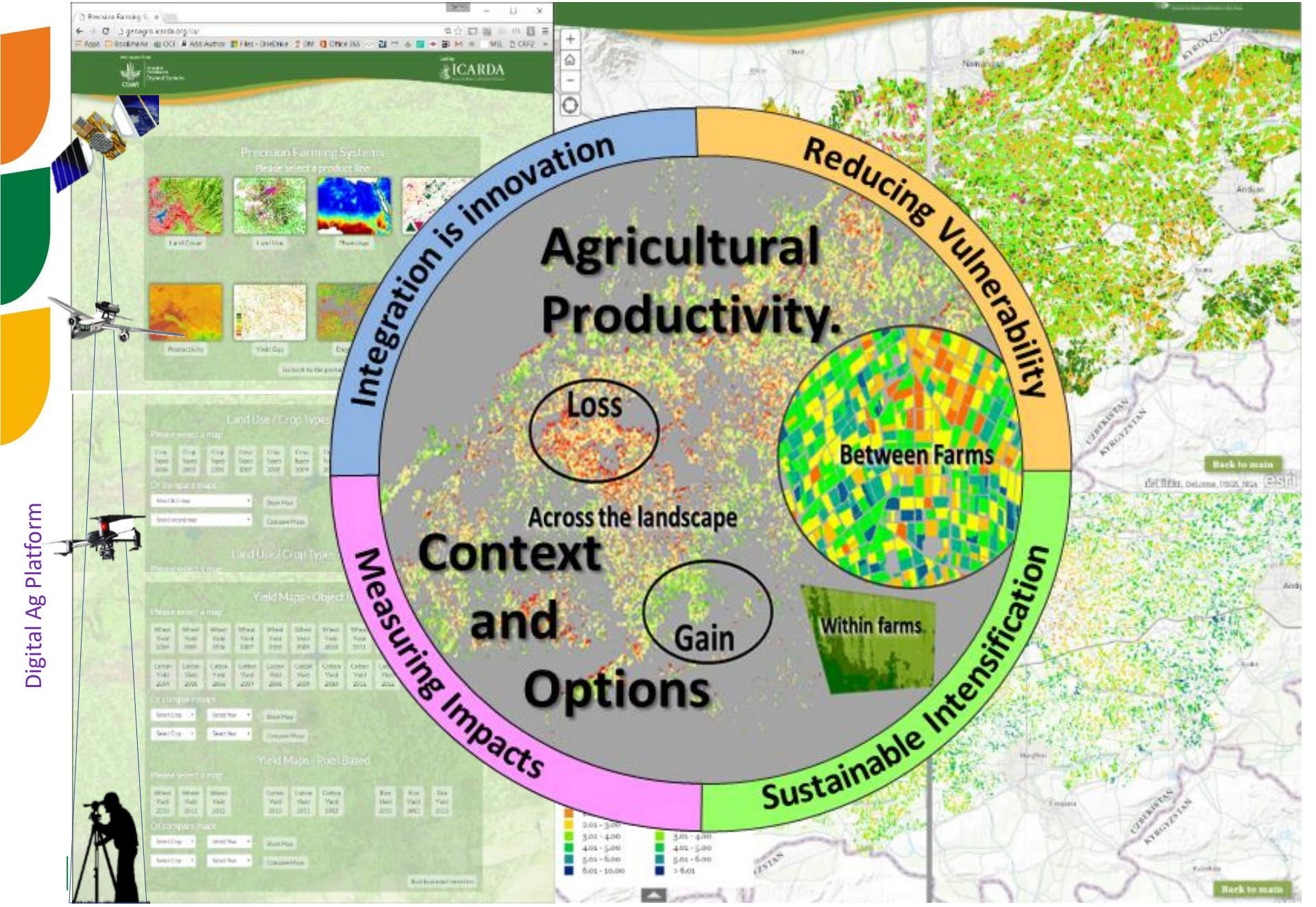
1.0m

0.3m

Agreements

<Biggest drivers

Quantification of Farming Systems @ multiple-scales




Fingerprinting of the farming systems to make spatially informed decisions for timely actions
For example: use case of rice based systems for pulses

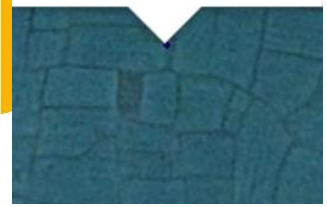
Quantifying the Dynamics of rice crops

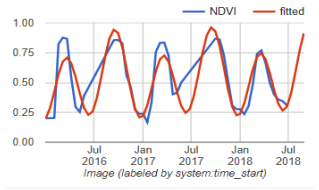
>> figure printing of the farms and typologies

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

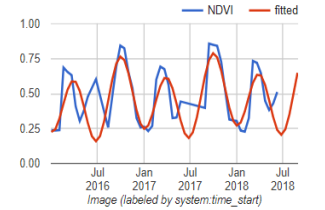




Pakurseni LDTW

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

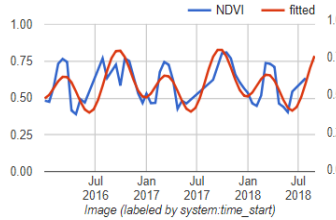
Directions: To here - From here



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

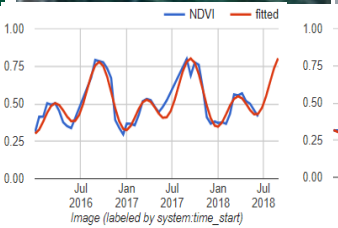
Directions: To here - From here



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

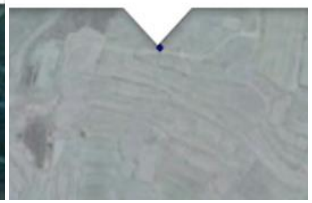
Directions: To here - From here

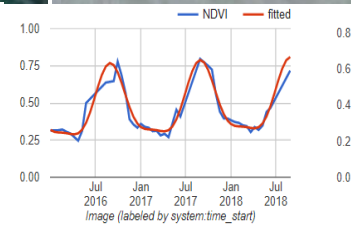


Kundra - IV PDW

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

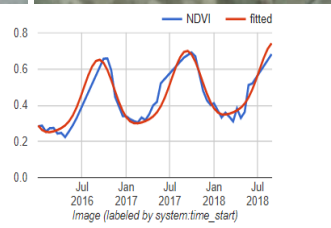




Gosain Bundh SFMIS-moved

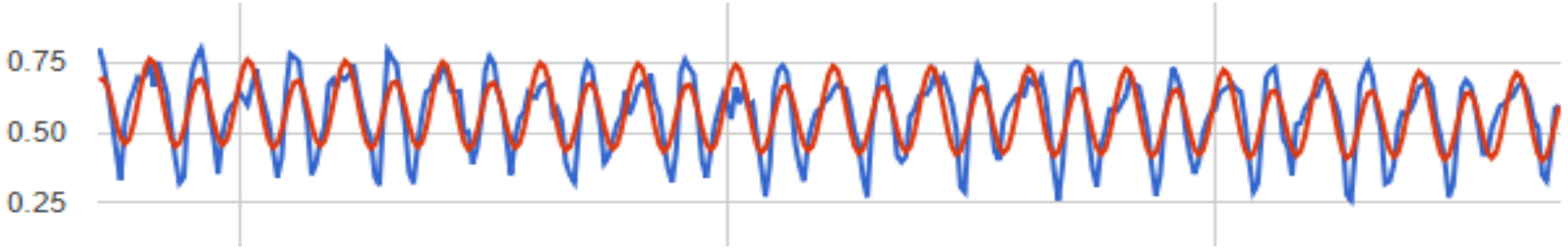
Gosain Bundh SFMIS	
FID	71
BATCH	2
SchemeName	Gosain Bundh SFMIS
District	PURULIA
Block	KASHIPUR
Scheme_Typ	SFMIS(40ha)
Village_Mo	Uluberia
Lat	23.477367
Long	86.790317
PhysicalPr	100
HODate	September 10, 2015

Directions: To here - From here



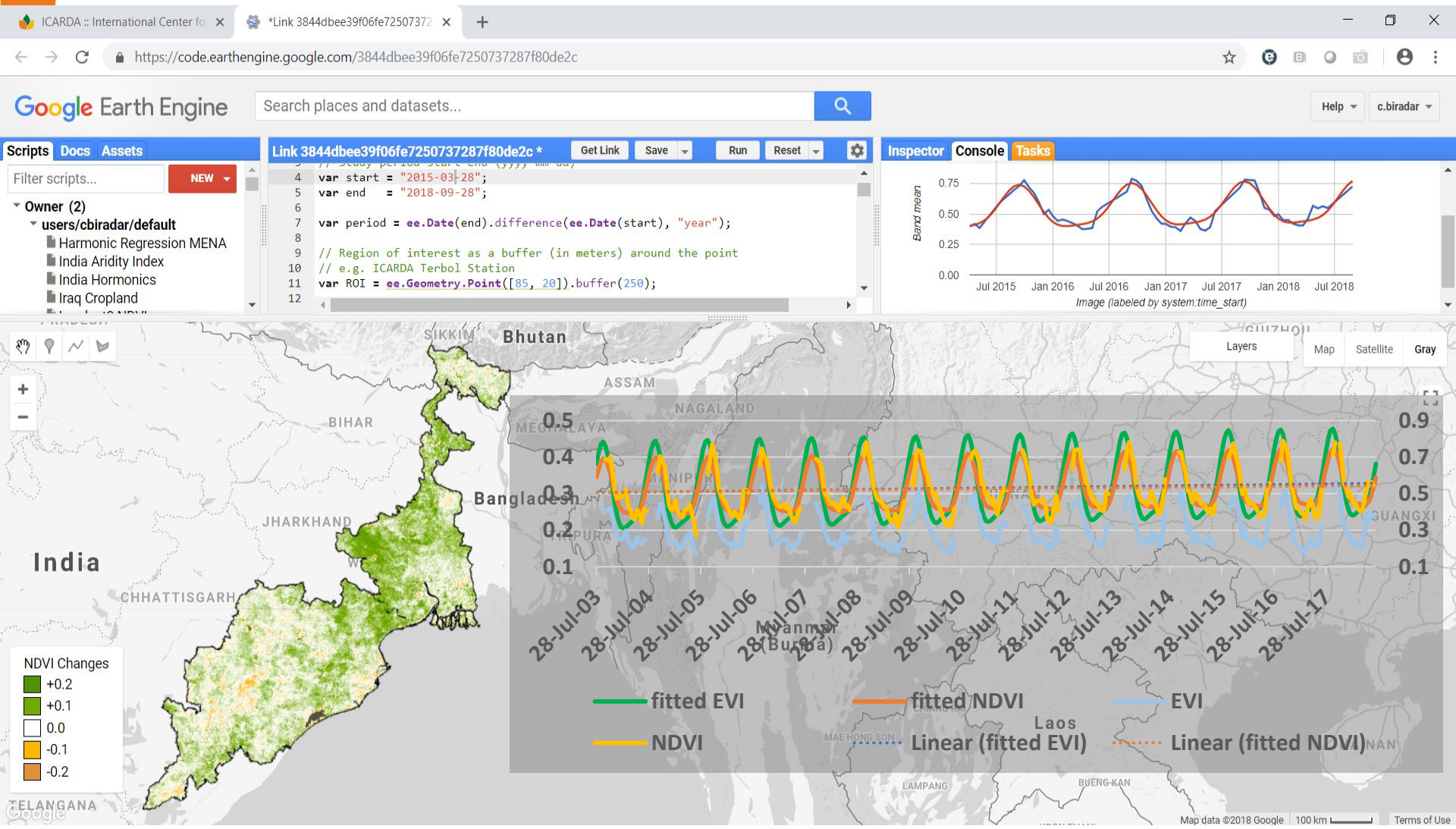
Fallows in Double cropped area

Fallows in Single cropped area



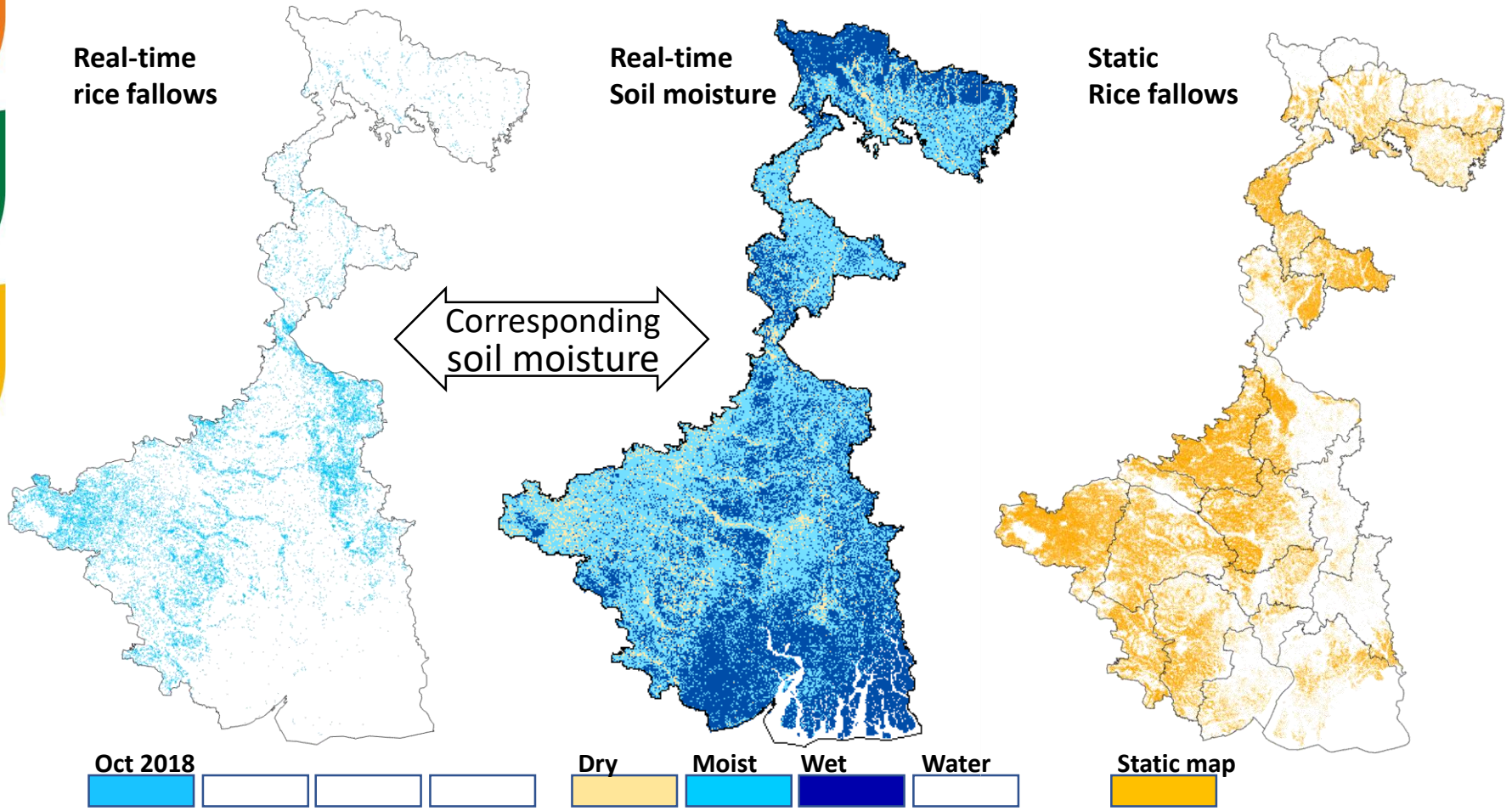
Timely Tracking for precision decisions

>> **near real-time** mapping and monitoring



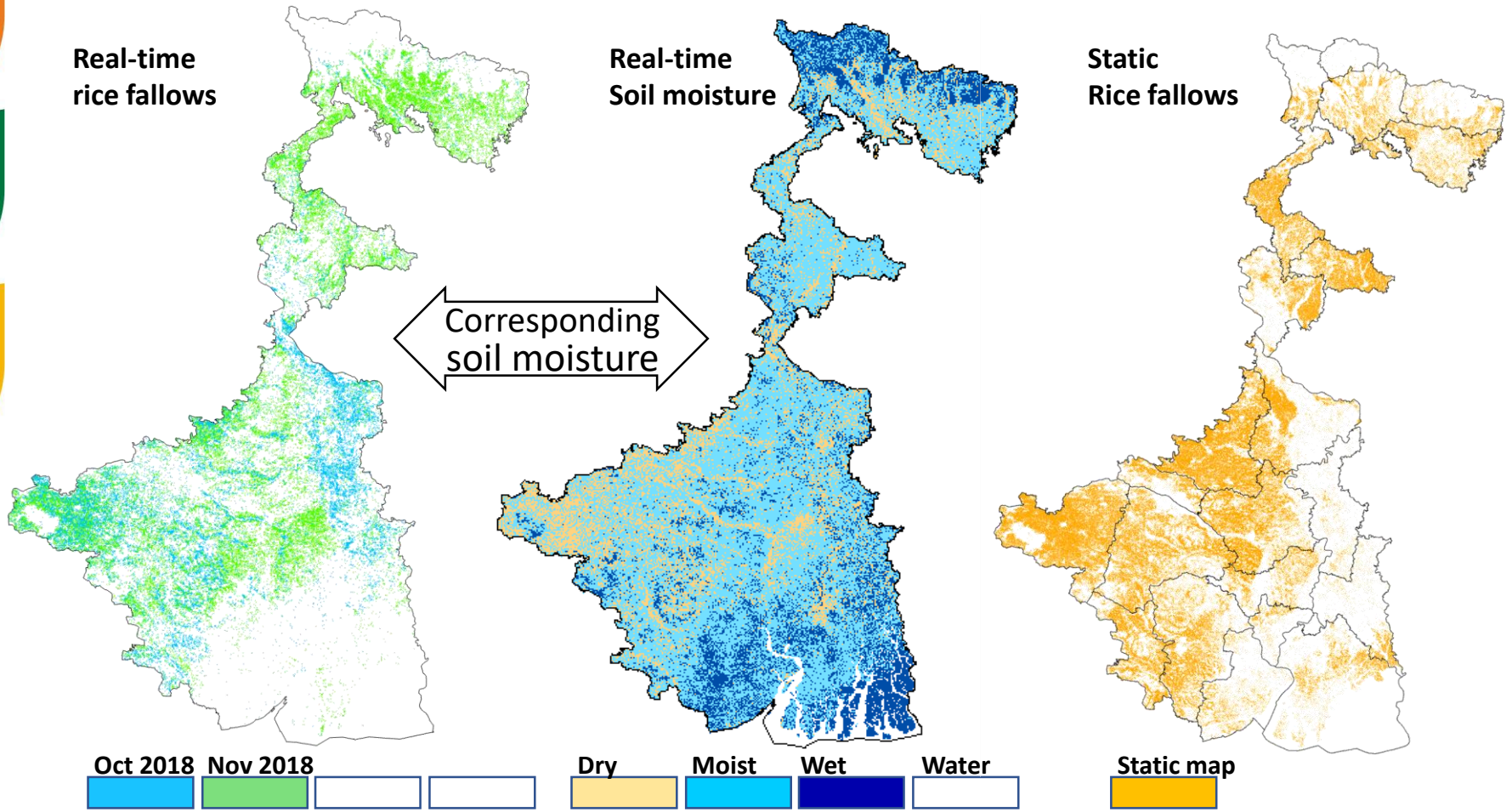
Sustainable intensification of the cereal-based systems

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



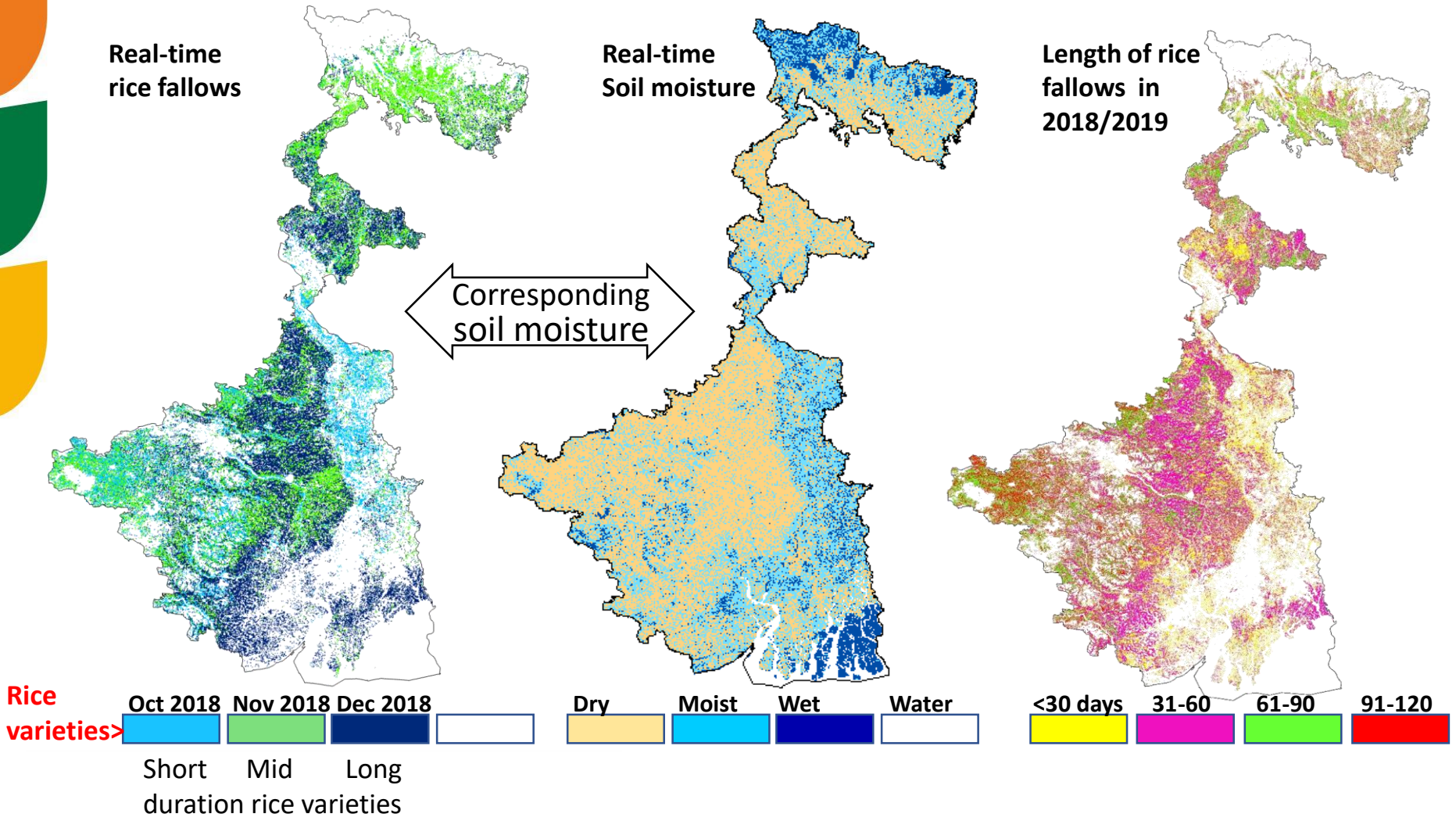
Sustainable intensification of the cereal-based systems

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



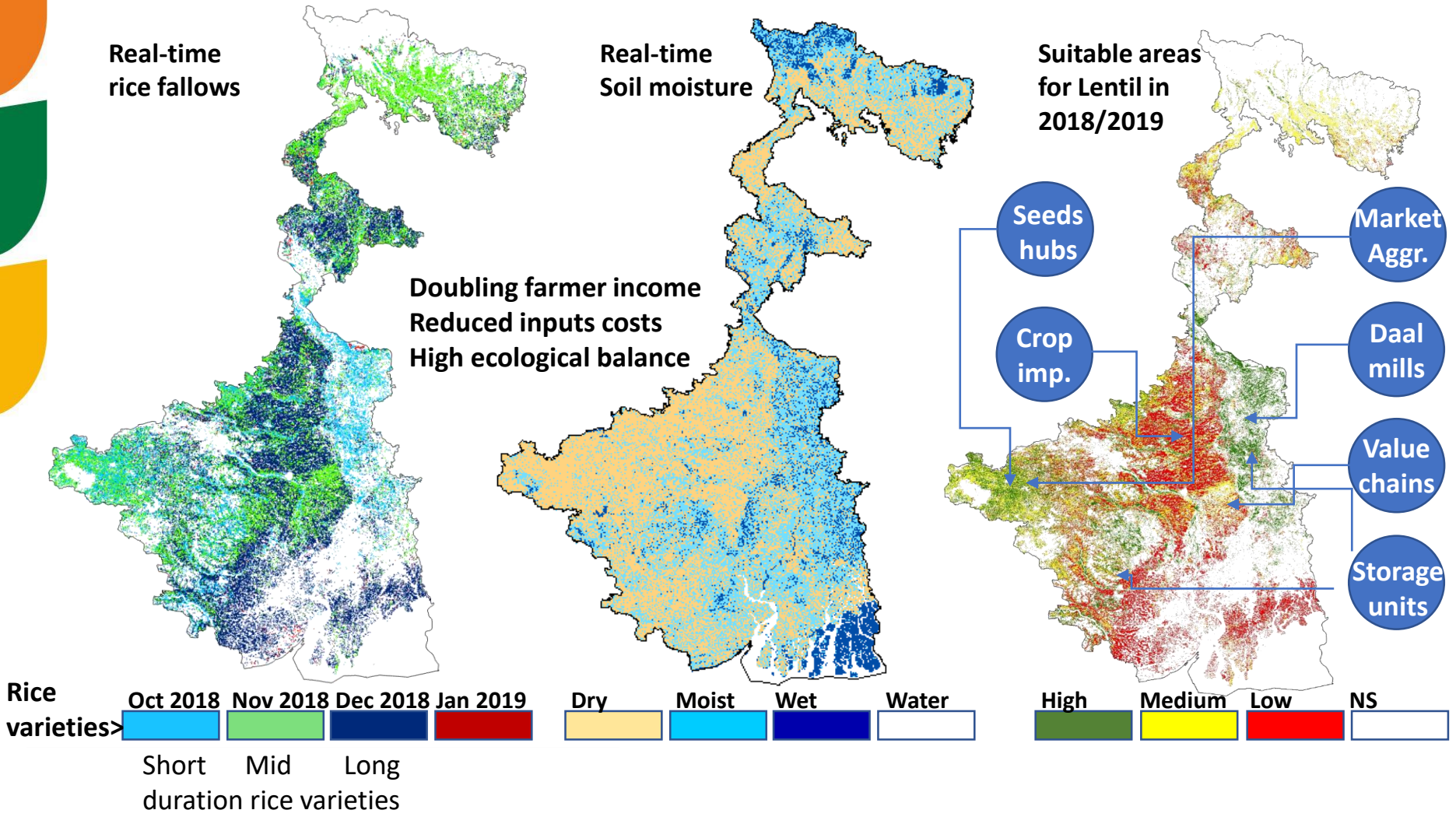
Sustainable intensification of the cereal-based systems

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



Sustainable intensification of the cereal-based systems

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

Dry to Green

Rice fallows

Rice fallows

Rice fallows

Rice fallows

Rice fallows

Rice fallows

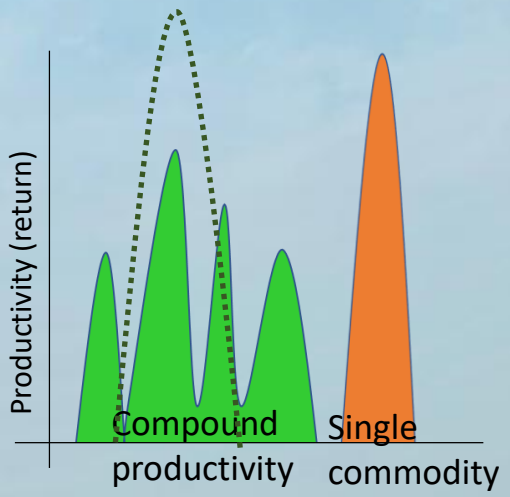
Rice fallows

Lentil in Rice-based Cropping Systems

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

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

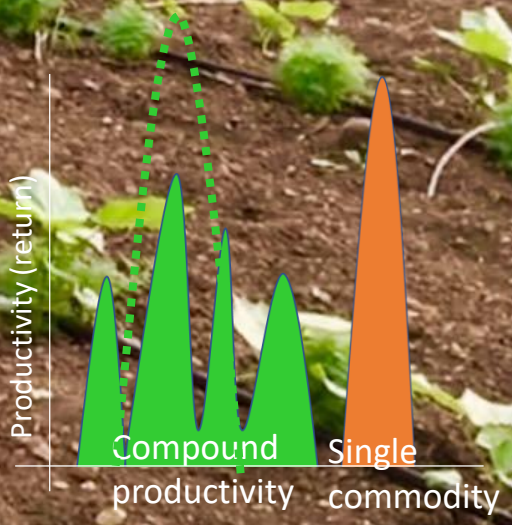


Way forward

- Agri-food systems is **single largest user of land and water resources** and is also **single strangest lever to achieves SDGs** (everything is linked to 'healthy food')
- Location specific analytics required to close the GAPS* to achieve **"more health per acre"-** which **need collective and coordinated efforts**;
- Recent advances in **Earth Observation**, Open-Access, Machine Learning, Cloud Computing, Smartphone, and Citizen Science making Big-Data analytics much **smarter, interoperable and useful** ever before for making spatially informed precision decisions.
- Data driven multiscale informatics are required to build "**inclusive agroecosystems**" for growing food sustainable way for **better world**

*gaps of productivity, data, nutrition, health

Planting multiple crops for monthly income while main crop continue to grow
(Salad greens, radish, leafy amaranth, cilantro, dill, spinach in Cotton crop)



Production follows functions

Lets leverage technology to rebuild functional agri-food systems to achieve UN SDGs for All

Vasudhaiva Kutumbakam
"the world is one family".

Thank You

c.biradar@cgiar.org

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Principal Scientist (Agro-Ecosystems)
ICARDA Head-Geoinformatics Units

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geoagro.icarda.org