

DryArc Interface

R4D framework for collaboration between
CGIAR and FAO on Dryland Agriculture

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FAO e-Agriculture Webinar, June 15, 2020

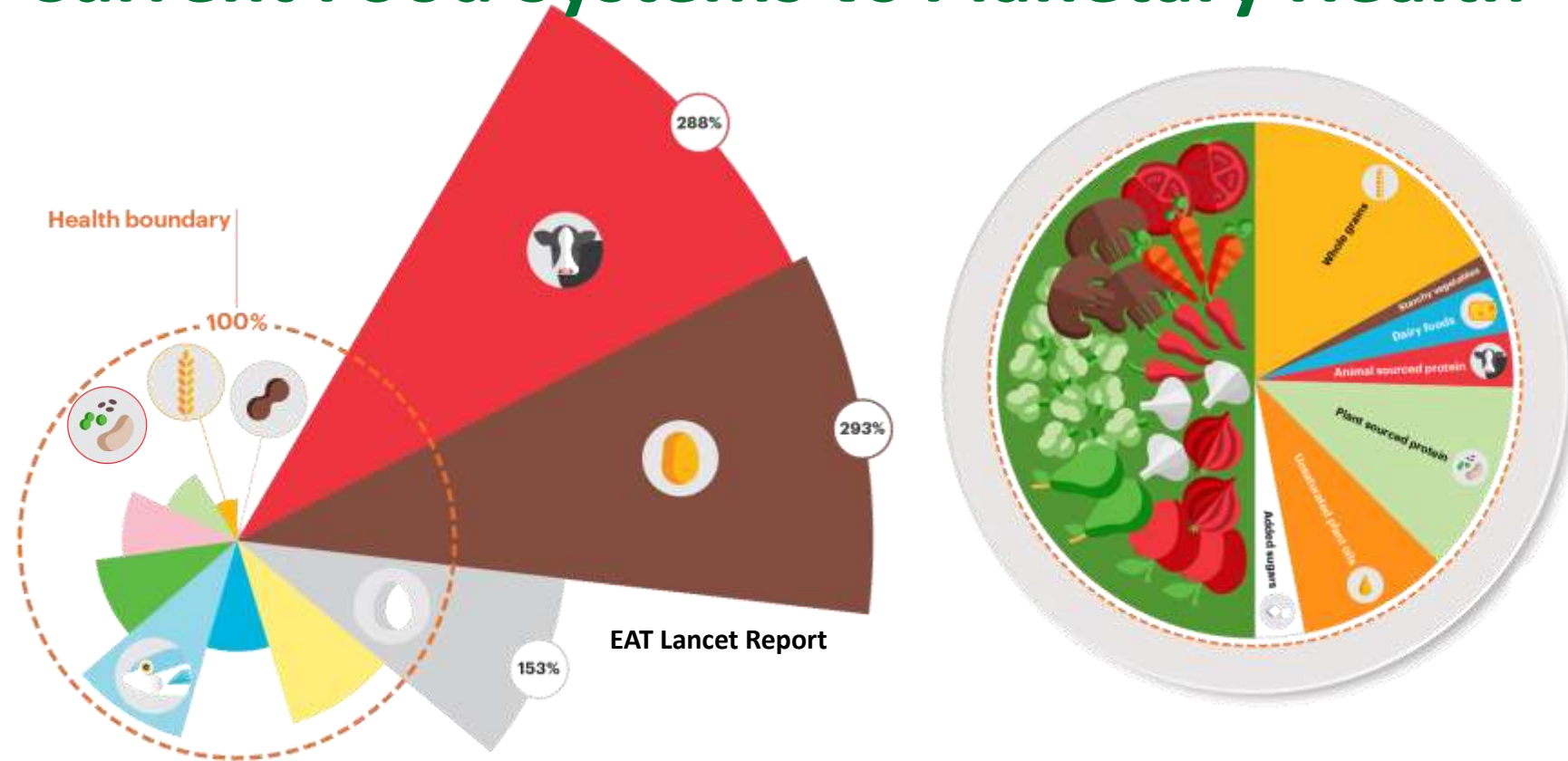
Health is continuum from soil > plant > humans ...
Family farms that connects the continuum



The food is one thing that links to every sustainable developmental goals



Current Food Systems vs Planetary Health



Paradigm shift from **monocropping** to **resources efficient** integrated Agri Foods Systems with more crops, tress, livestock, rotation, nutrition >> **“more wealth per acre”**

Emphasized foods



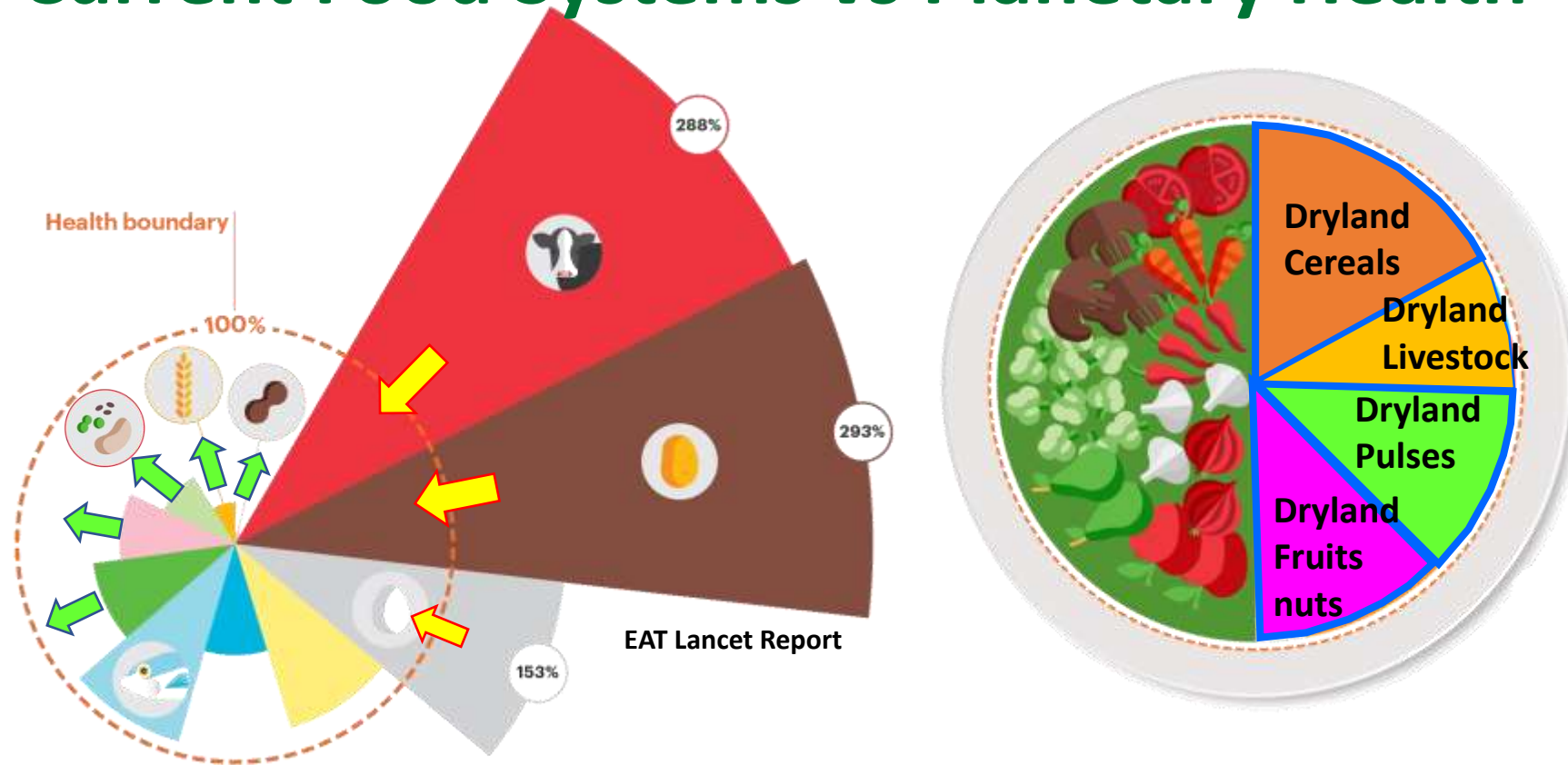
Limited intake



Optional foods



Current Food Systems vs Planetary Health



Balanced Agroecosystems that strengthen the food & ecological security

Rich-crop diversity, recycling of nutrients and healthy soils and landscapes produce an abundance of food in a balanced ecosystem

Emphasized foods



Limited intake



Optional foods



SCIENCE FOR HUMANITY'S GREATEST CHALLENGES

Global challenges

We are at a crossroads in the world's food system. We cannot continue our current trajectory of consuming too little, too much, or the wrong types of food at an unsustainable cost to natural resources, the environment and human health.



**Living within
planetary
boundaries**



**Sustaining
food
availability**



**Promoting
equality of
opportunity**



**Securing
public health**



**Creating
jobs and
growth**

<https://cgiar.org/>

Changing diet pattern >> cropping systems >> Sustainable living

Sustainable alternatives for future food systems

Biodiverse agroecosystems for plant based diets



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





United Nations Decade of
FAMILY FARMING

2019-2028

**“Family farms produces 80%
of the food in the world.”**

- FAO Family farming decade

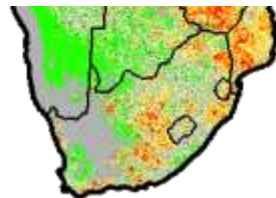


Support towards rebuilding the resilience

>> through sustainable intensification



0 800 1,600
ICARDA-GU©2015



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

Data driven decisions & diversified systems

>> with farm focus (rural welfare)

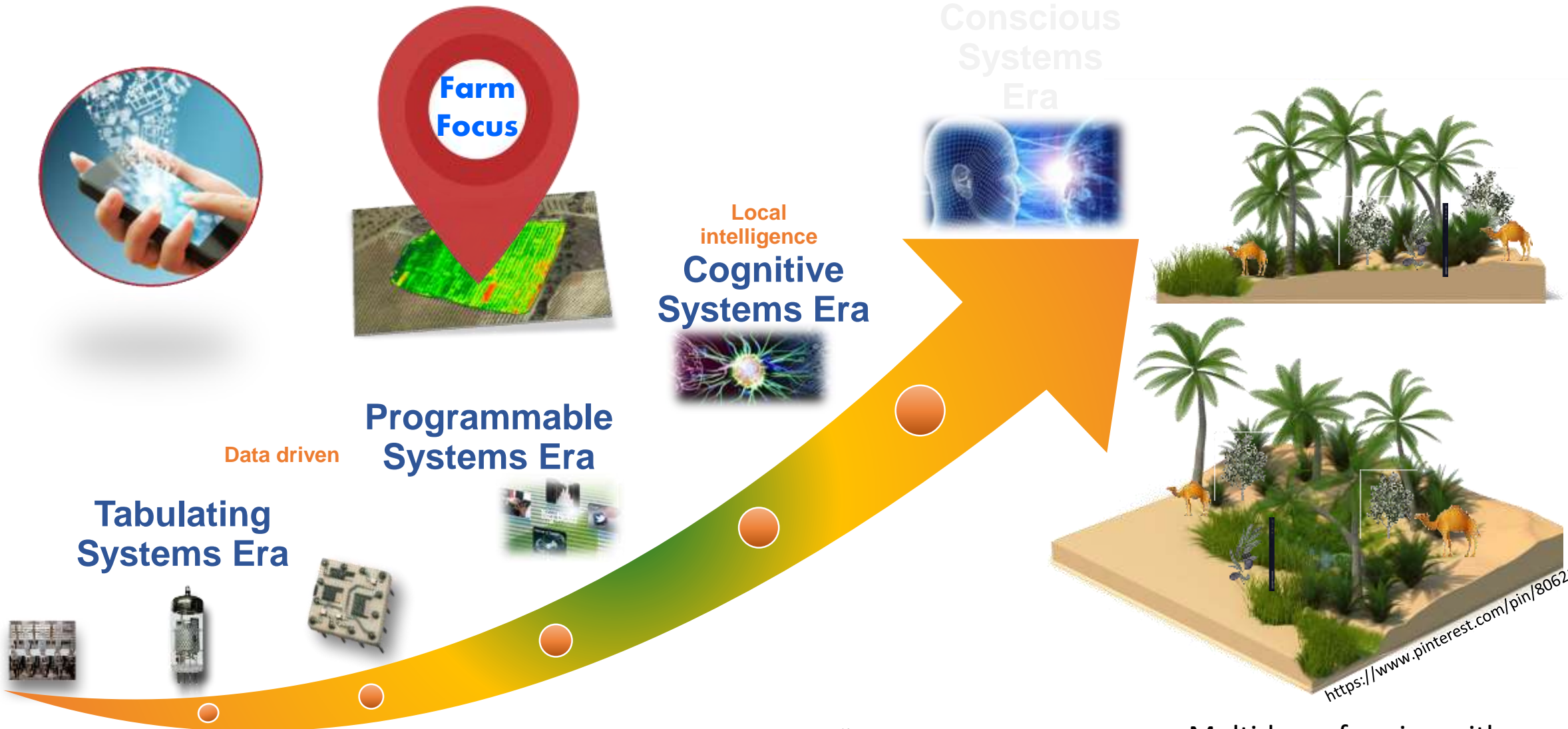
Geo Big Data for building inclusive agroecosystems for **economically viable options** and **ecologically sustainable actions** for more food, nutrition and health

Sustainable intensification
Target specific interventions
Bridging the gaps*
Resource 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

New era of Geo Bigdata analytics in farming systems

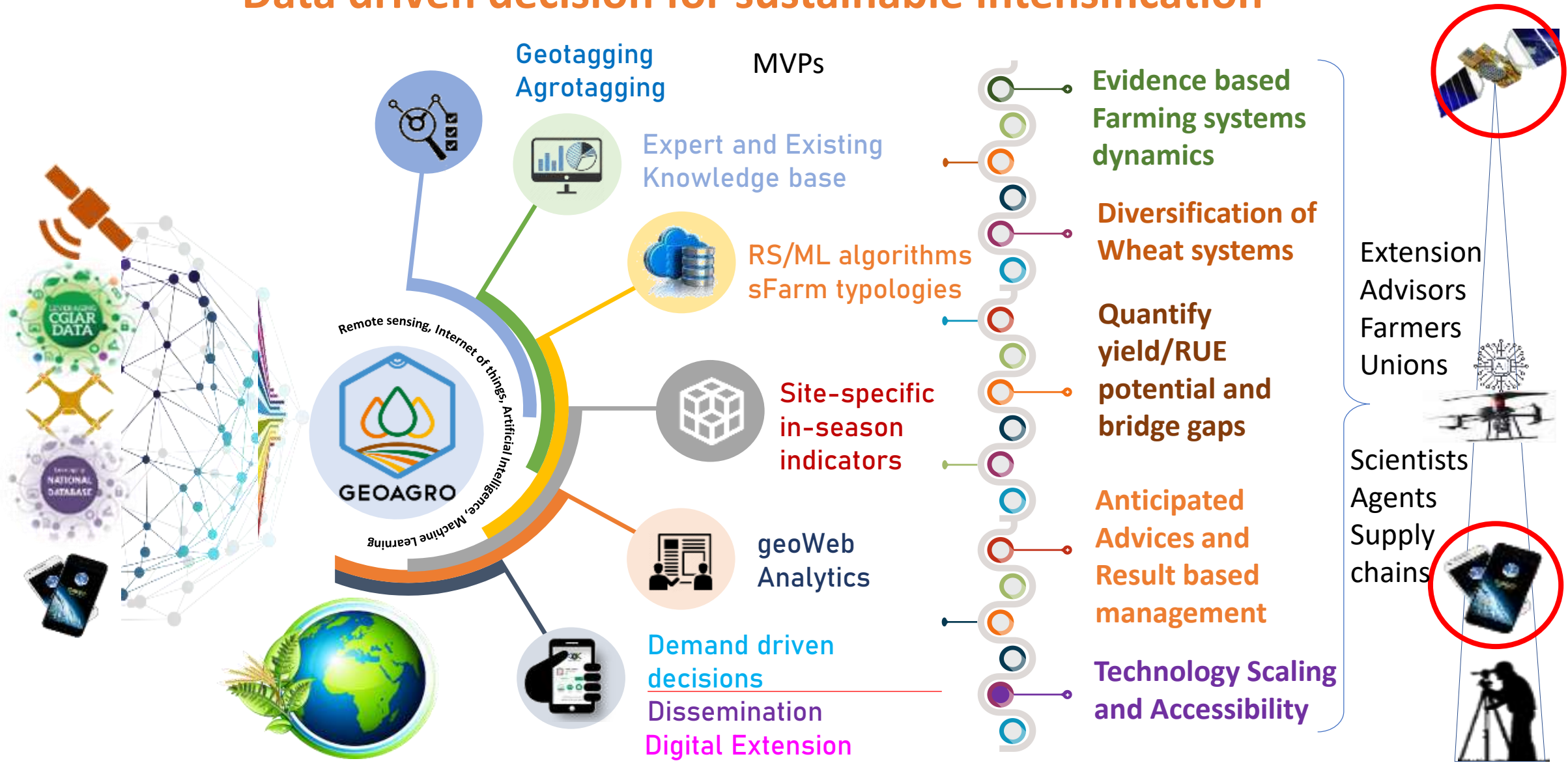


Multi-layer farming with crops, trees, and animals

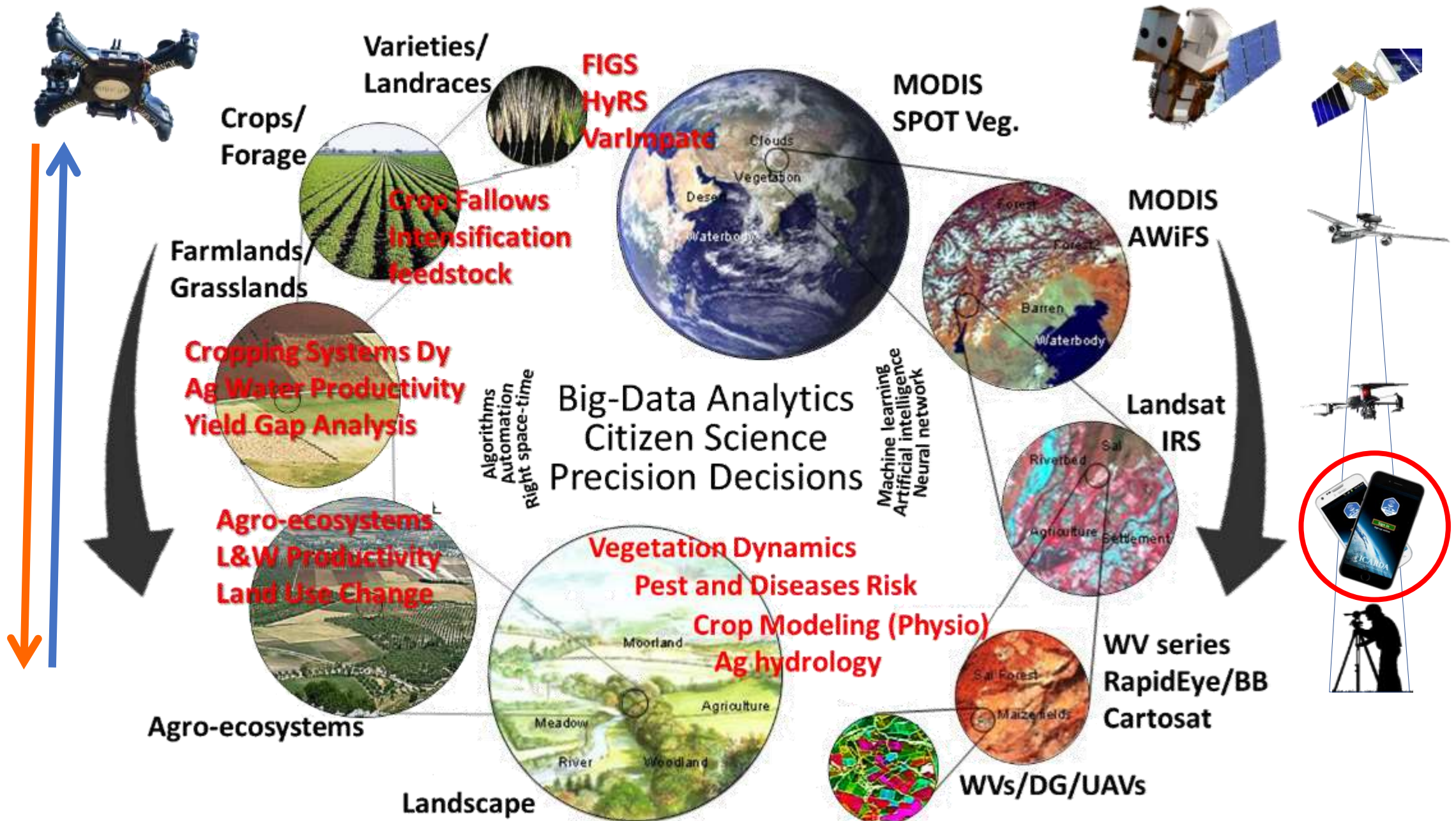
<https://www.pinterest.com/pin/80621>

Digital Augmentation for Revitalizing Agriculture

Data driven decision for sustainable intensification







Scaling trade in/trade offs



Framework of DryArc Mapping Interface Tool

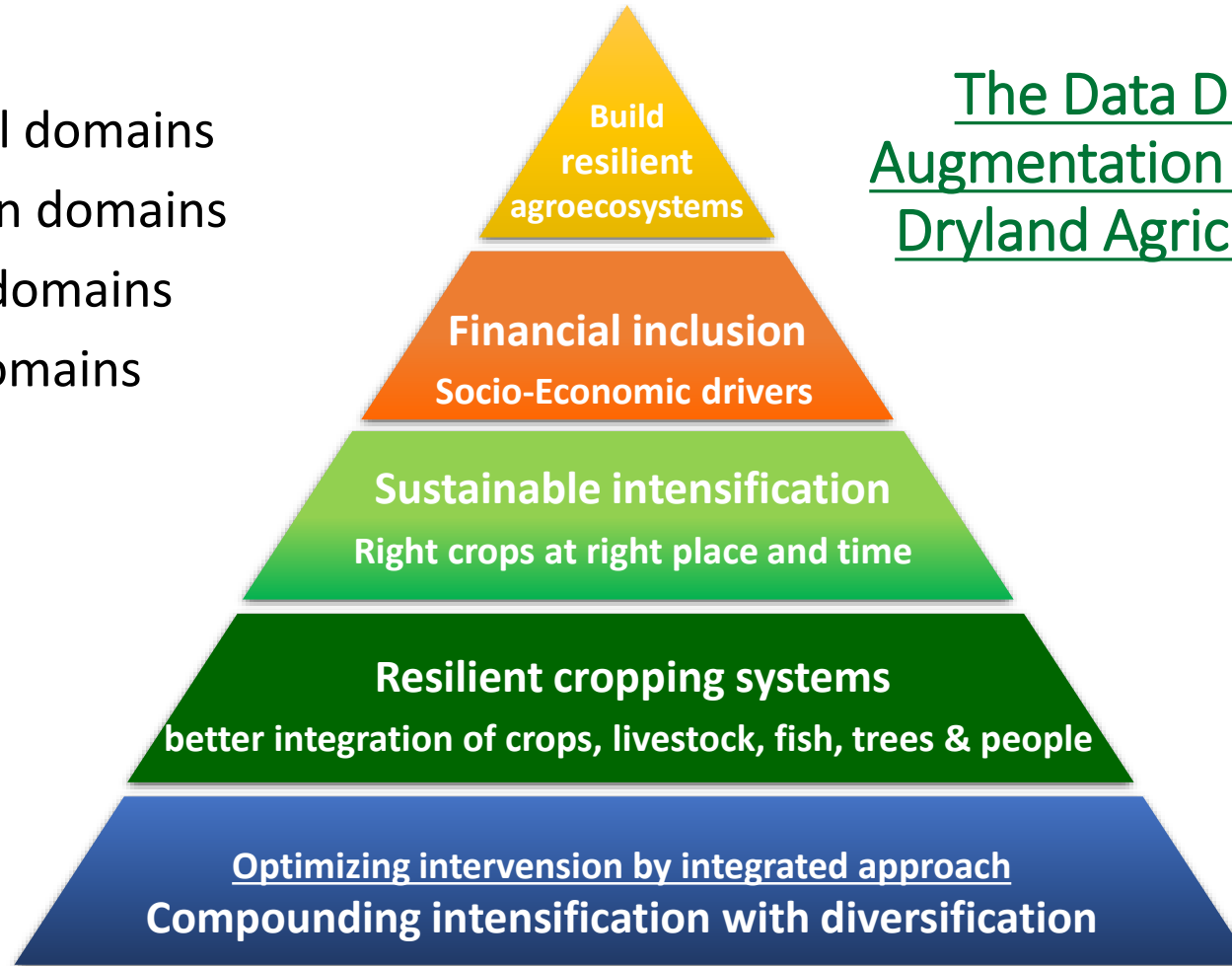
Digital Augmentation for Resilient Agroecosystems

-  1. Functional domains
-  2. Integration domains
-  3. Modular domains
-  4. Service domains

Region to Farm Scale



Pixel/Farm/Parcel
 A single entity for each & every developmental entry point



The Data Driven Digital Augmentation Interface for of Dryland Agriculture at Scale

1000m

500m

30m

10m

Daily

Monthly

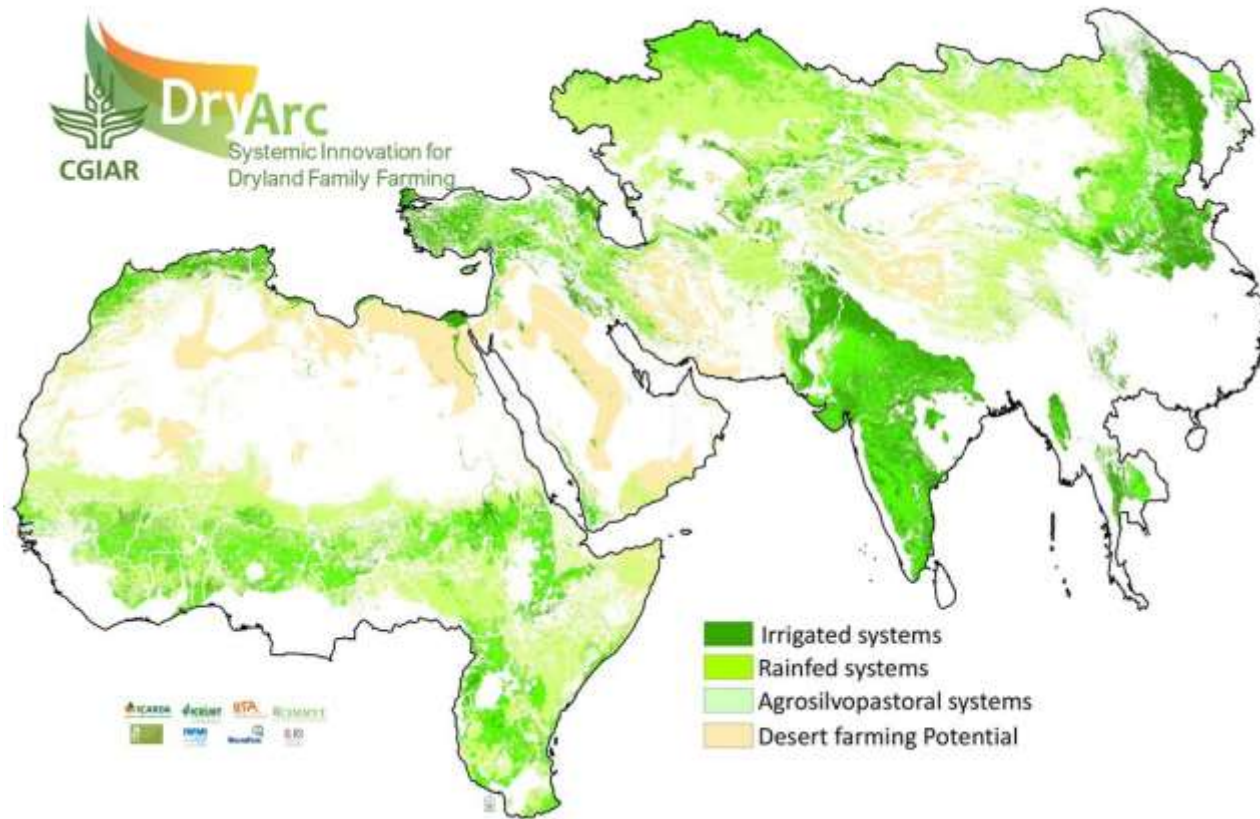
Seasonal

Annual



Framework of DryArc Mapping Interface Tool

Digital Augmentation for Resilient Agroecosystems



SHARE Knowledge, Technologies and Data

COMBINE
Technologies in
Systemic
Innovation

ACCELERATE
co-design
with Farmers
Communities

ENABLE-
Policies and
Institutions
for Systemic
Innovation

INTEGRATE
Innovations
and
Methods

MODULES for interface collaboration

SHARE

- Acts as a **global and open access repository** using the FAIR principles to describe and enable searching into **ready-to-scale technologies** (crops, livestock, fish, soil, water, energy, food processing, ICT etc.) adapted to irrigated, rainfed, agro-pastoral or desert farming systems which have been developed over the past 40 years by the **public and private sector**.
- It also supports **benchmarking** analysis and ex-ante impact assessment of technologies that are under development for the drylands by public and private sectors.

COMBINE

- Builds on the knowledge base of the SHARE module to **design systemic innovations** adapted to a specific scale (from farm to country) and in specific enabling environments (community, policy, market).
- By integrated modelling, trade-off analyses and ex-ante impact assessments, these technologies - normally initially developed for application one by one - are integrated, co-designed and transformed into a set of systemic innovation options adapted to specific contexts targeting a set of SDGs.
- Involves on-farm experiments and prototyping approaches with stakeholders for the most complex combinations when there is a lack of data and models on key interactions.

ACCELERATE

- Supports **community-based projects** to accelerate scaling of the systemic innovation options in regions and farming systems where the socio-economic (including gender) and policy contexts are conducive and can rapidly transform the agri-food systems to achieve a targeted set of SDGs.

INTEGRATE

- Allows **component-based research** (e.g. plant breeding, development of innovative soil, water and energy technologies) to be integrated at an early stage (from product profile definition) in the missing components of the SHARE module for systemic innovation in the drylands.

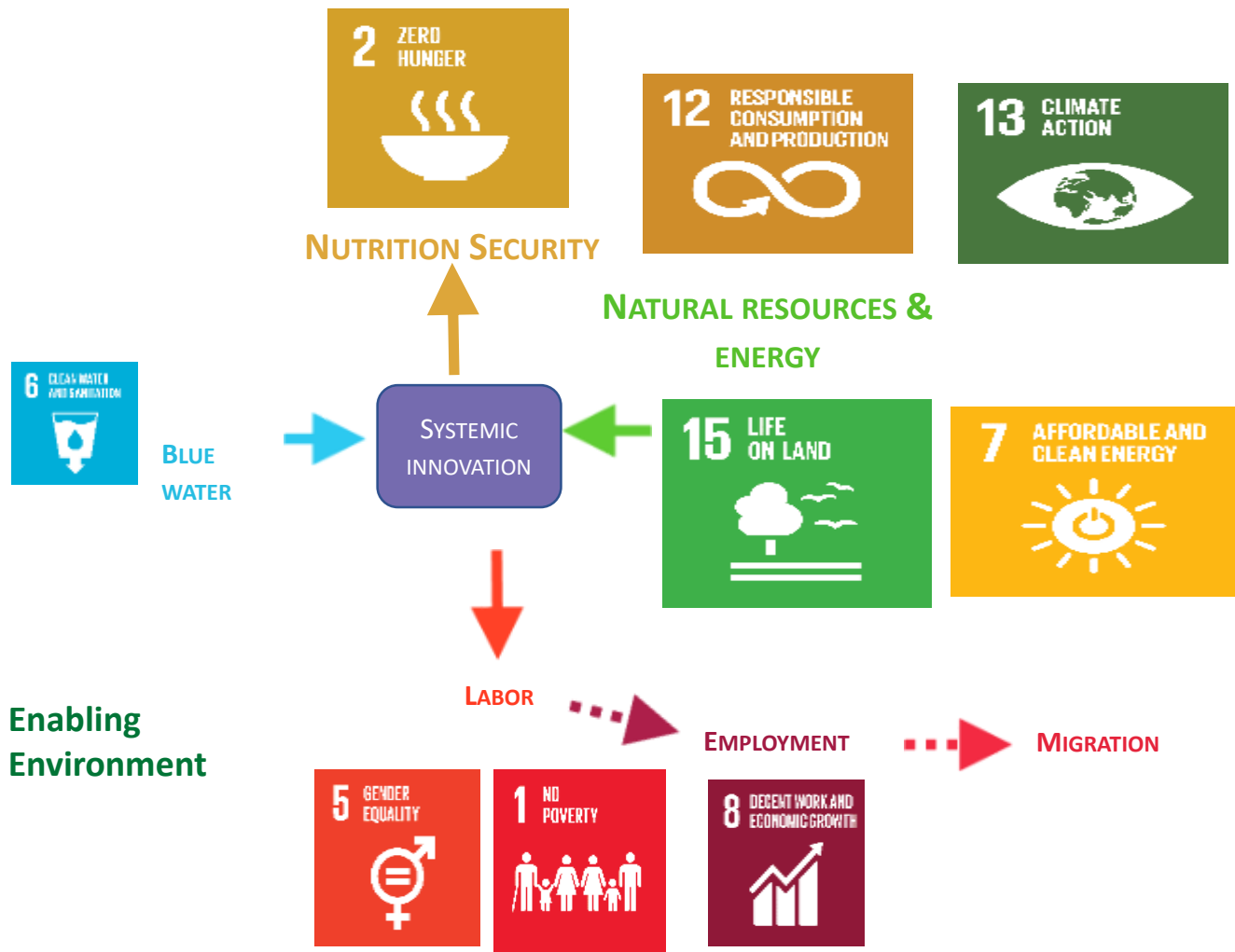
ENABLE

- Support **capacity development, policy design and cost-benefit analysis** in order to create the enabling environment for agri-food systems transformation by the ACCELERATE module.
- Foster **knowledge exchange** across scales, sectors and stakeholder groups to develop capacities to put in place the policies, institutions and services to bring systemic innovation to scale for impact and sustainable intensification of the key agri-food systems across the DryArc region.
- Encourages increased and improved **(evidence-based) investments** by the public and private sectors including governments, development and financial institutions, companies (local, national and international) and farming communities.
- Supports foresight analysis of the **DryArc Hotspots** where conditions of the “Perfect Storm” are met as well as ex-ante impact assessments in these regions.
- Supports a **DryArc Academy** to develop capacities on systems analysis and innovation process in research, extension, public and private services.

Systemic Innovation for synergies among SDGs in Drylands

Components

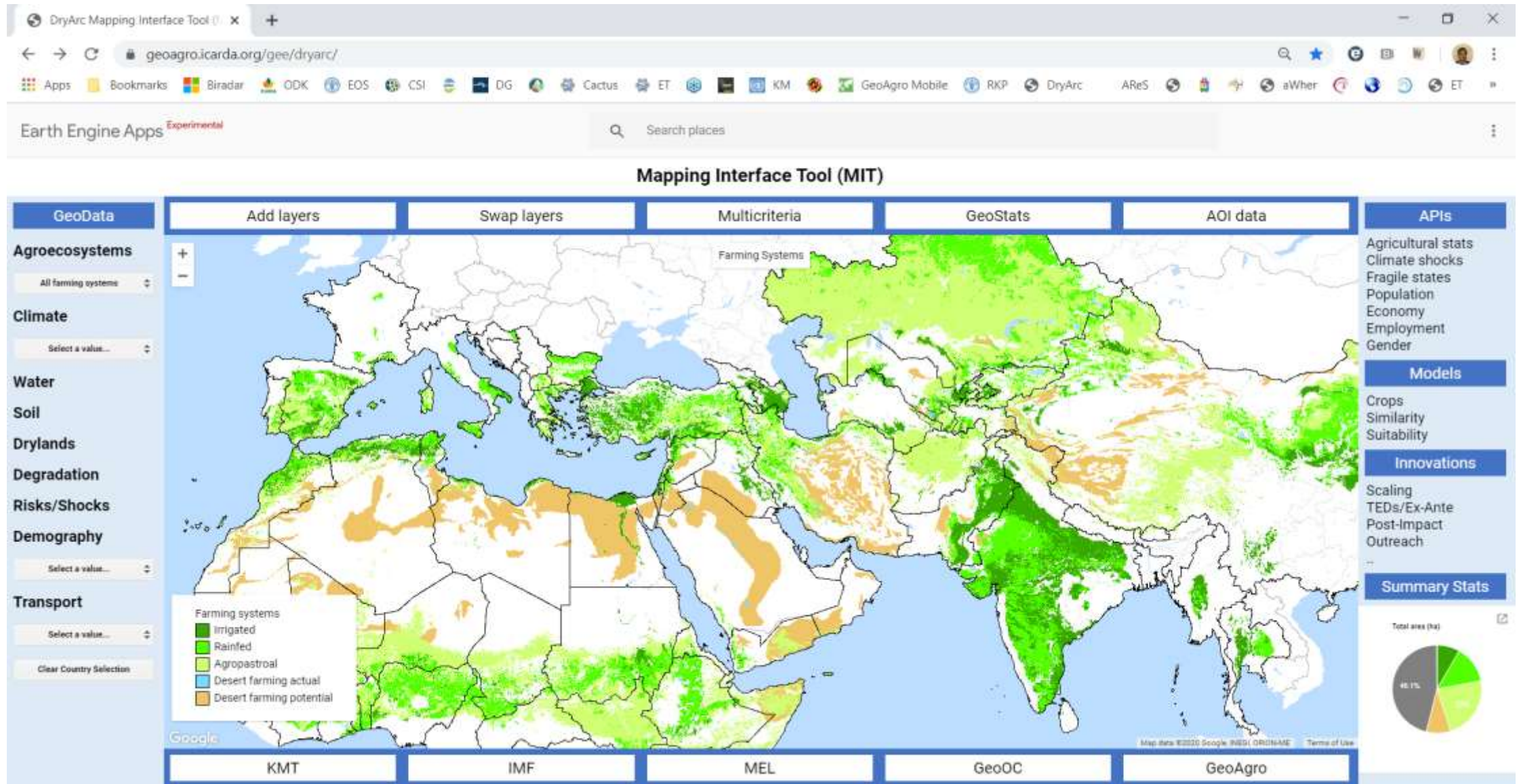
Enabling Environment



The DryArc’s application of systemic innovation is underpinned by **five core principles**:

1. Harnessing key **interactions** rather than focusing on individual components
2. Promoting **synergies** and minimizing trade-offs for resource use efficiency
3. Effectively **scaling** innovations by considering multiple spatial and temporal scales and sectors
4. Designing plausible and comprehensive **trajectories**
5. The enabling potential for uptake of innovations and impact lies in the **socio-economic** domain

The DryArc Interface designed to provide services to stakeholders, countries and researchers to implement projects with the DryArc modules



AOI-Area of Interest; APIs- Application Program interface; KMT-Knowledge Management Tools; IMF- Integrated Modelling Framework; MEL- Monitoring and Evaluation Platforms; GeoOC-Geoinformatics Option and Context; GeoAgro- Geoinformatics for Sustainable Agroecosystems; TEDs- Technology Extrapolation Domains;

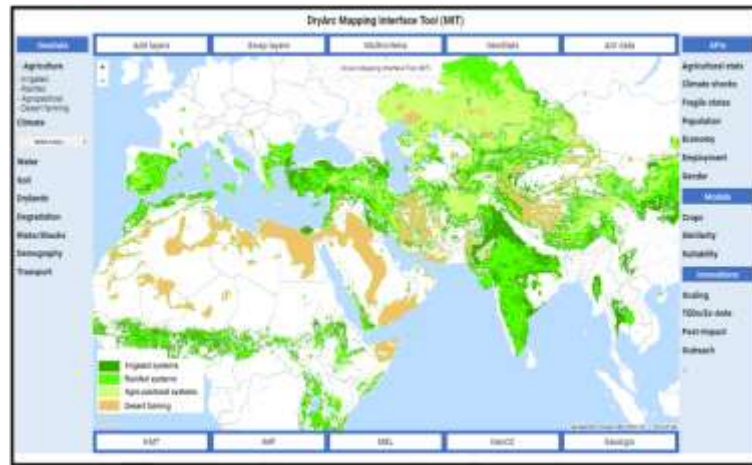
Examples of Potential collaboration between DryArc and FAO on Dryland Agri-food systems

1. Functional domains
2. Integration domains
3. Modular domains
4. Service domains

(2) R4D and D Projects

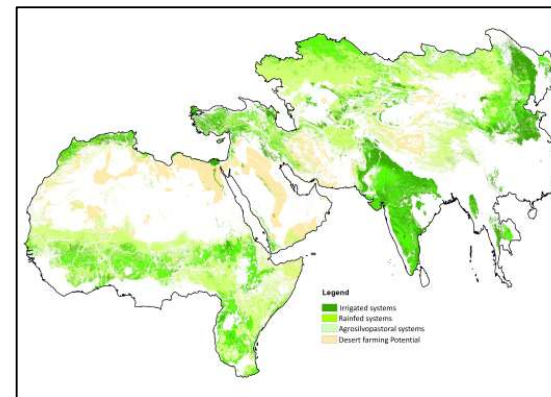
(1) Tools, Databases, Services

DryArc Interface

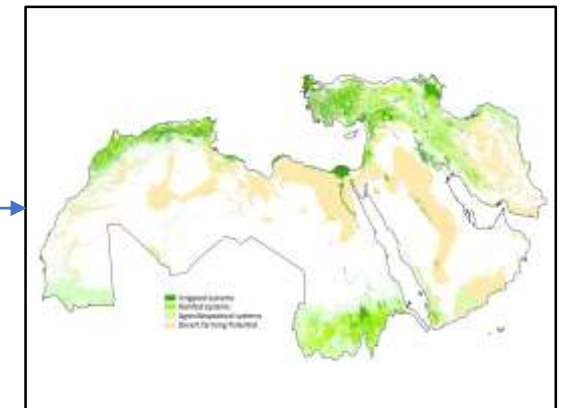


WOCAT WAPOR FAOStat

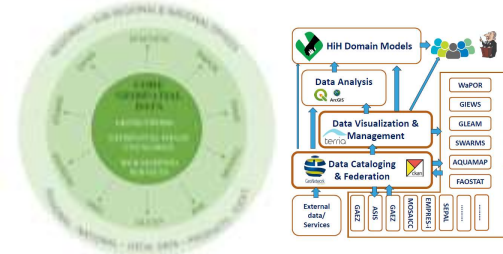
Global Drylands/DryArc region



MENA/NENA Region



Hand-in-Hand Initiative



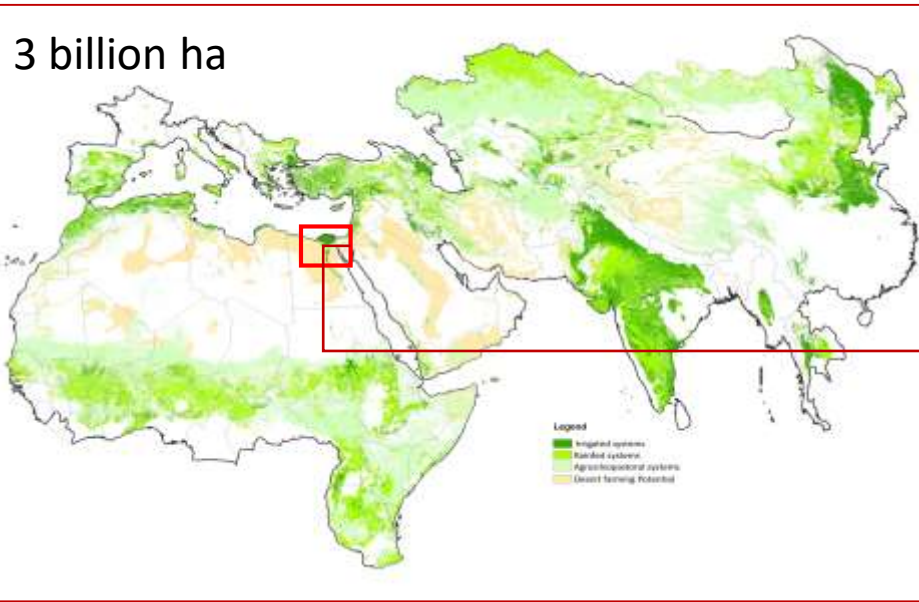
Water Scarcity Initiative



MENA ET-
Network

GIEWS: Global Information and Early Warning System of Food and Agriculture; SFM/NFM: Sustainable Forest Management and National Forest Monitoring System; WAPOR: Water Productivity Open Access Portal; GIAHS: Global Important Agriculture Heritage Systems; MOSAICC: Modelling System for Agricultural Impacts of Climate Change; ASIS: Agricultural Stress Index System;

A fractal approach of water-soil limited agro-ecosystems



Irrigated systems



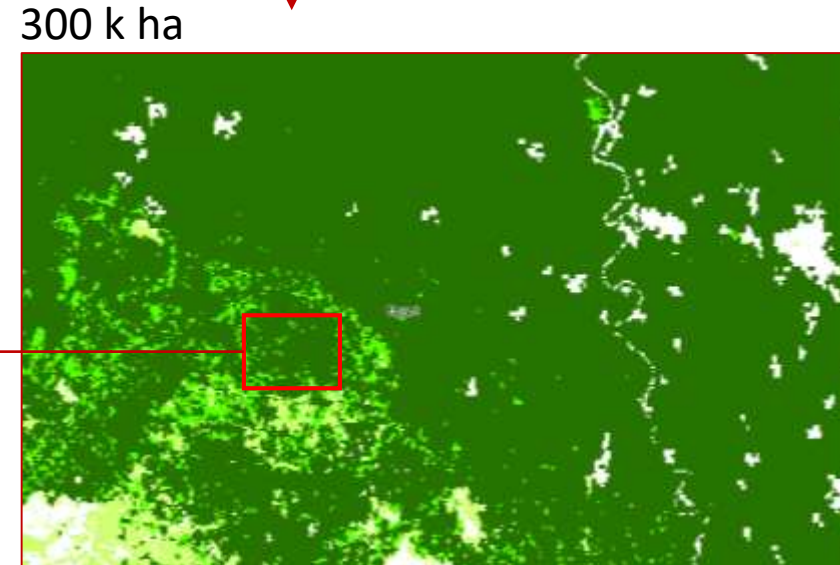
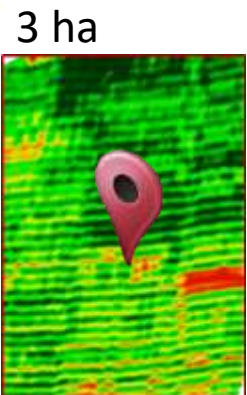
Rainfed systems



Agrosilvopastoral systems



Desert farming Potential

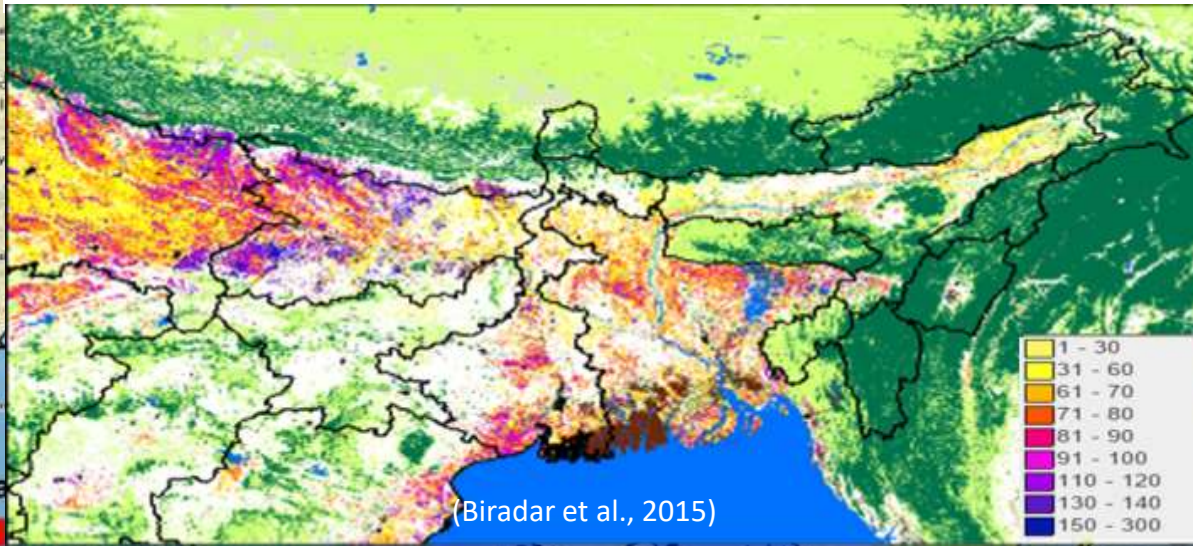


Dynamics of Cropping Systems

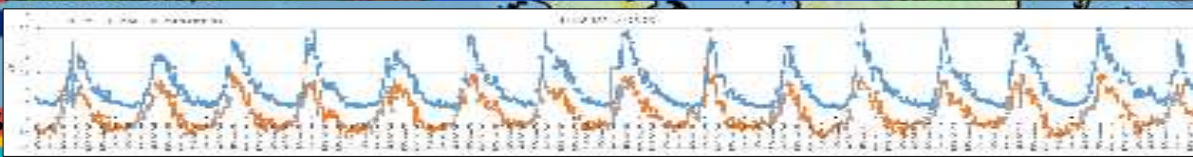
- Integrated Agro-Eco
- Sustainable Intensif
- Pulses as a crops of
- Building diet and W



Length of the crop fallows with start-date and end-date



(Biradar et al., 2015)

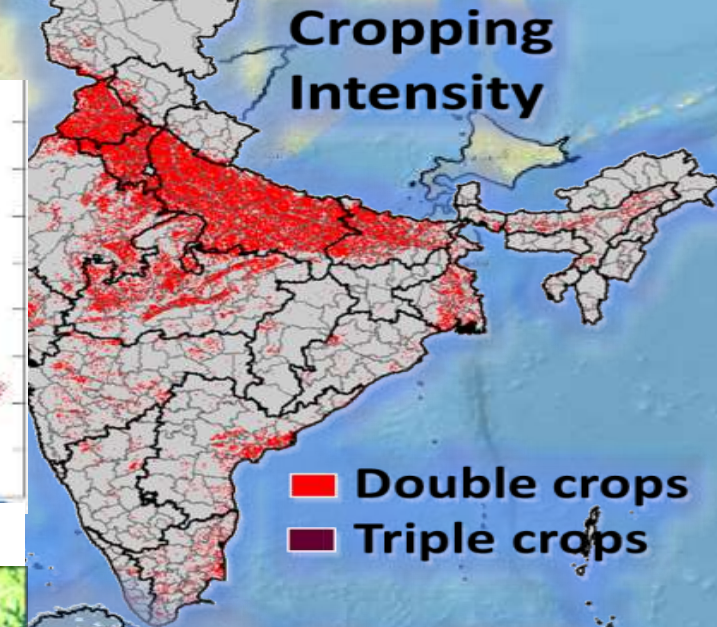


Agricultural Intensification

72%

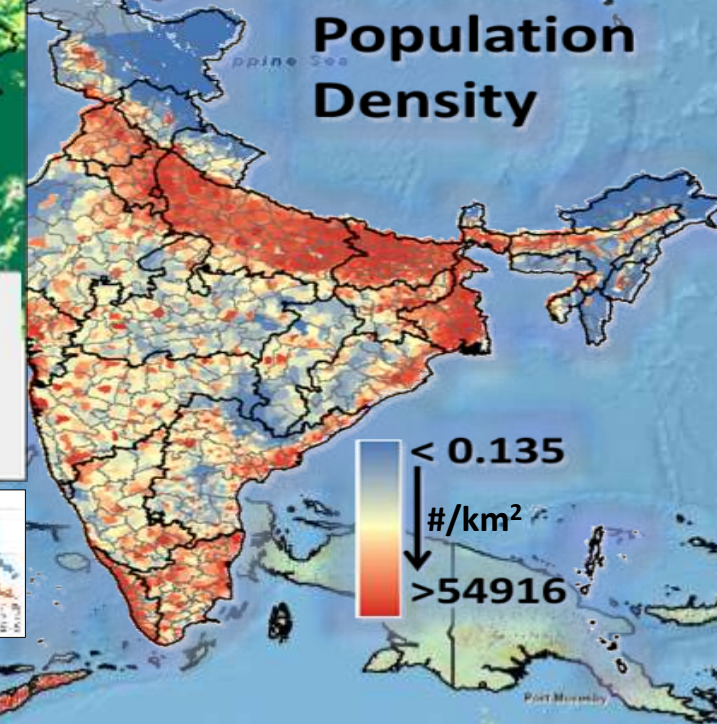
21%

Increase in Arable Land



Cropping Intensity

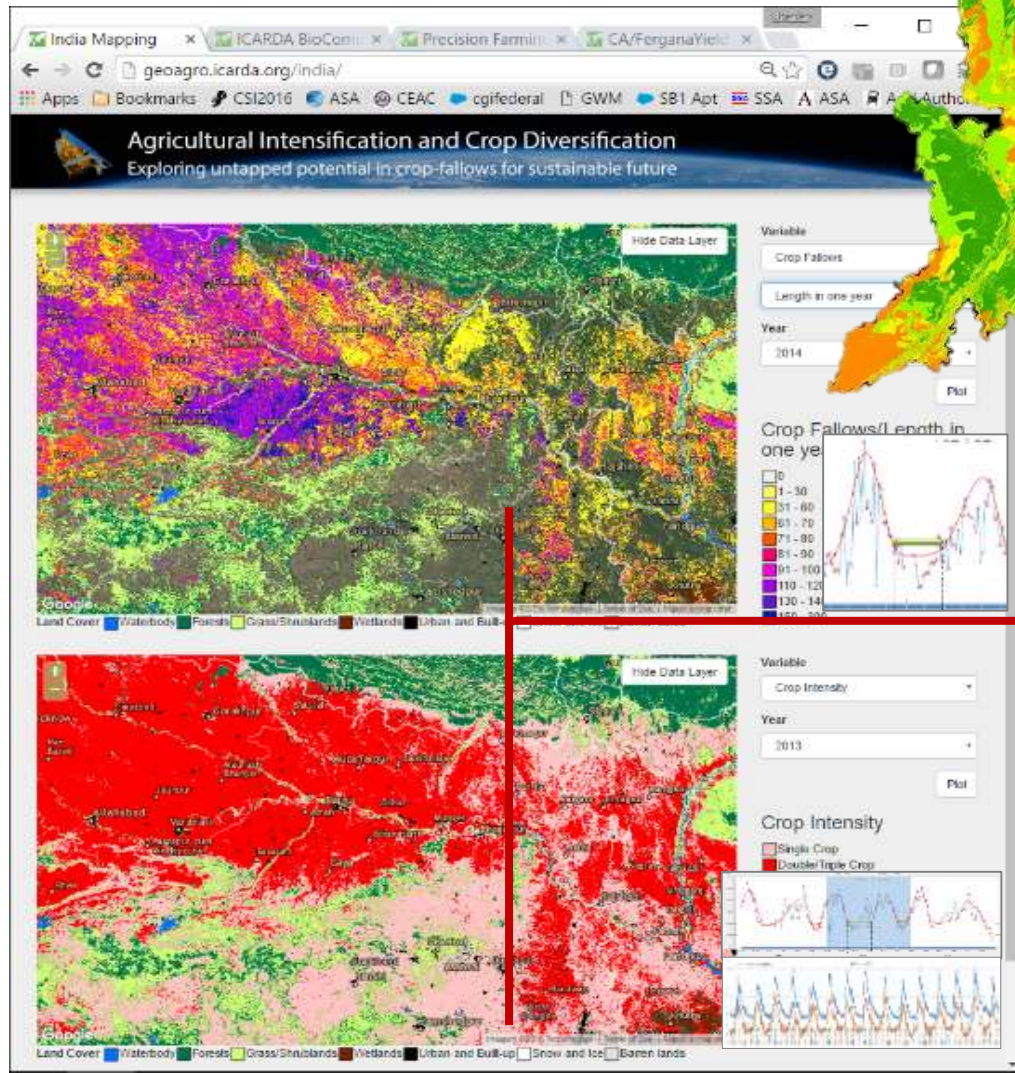
Double crops
Triple crops



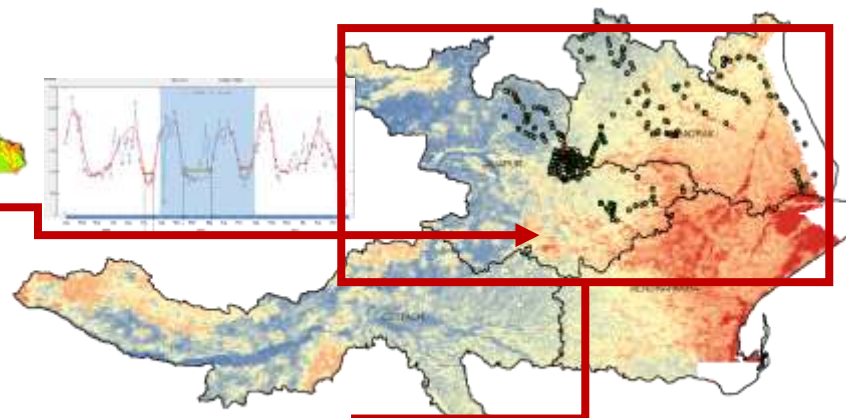
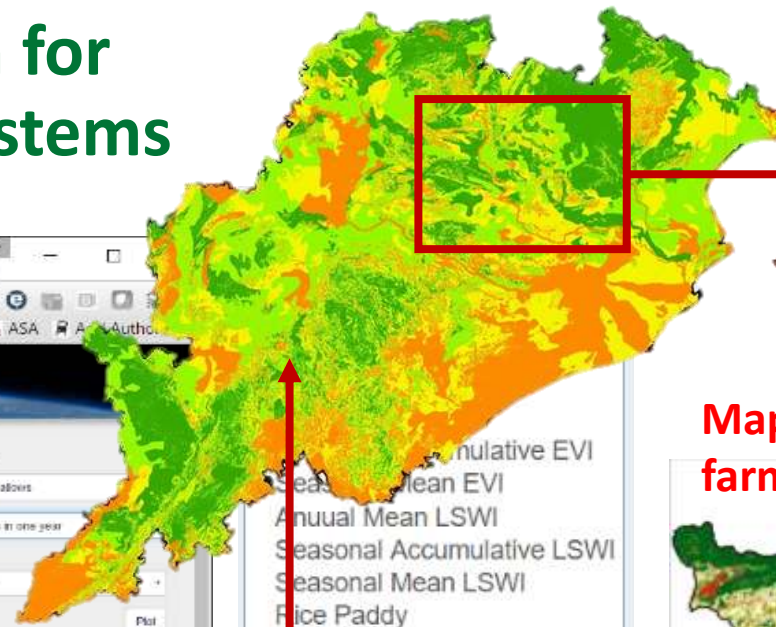
Population Density

< 0.135
#/km²
> 54916

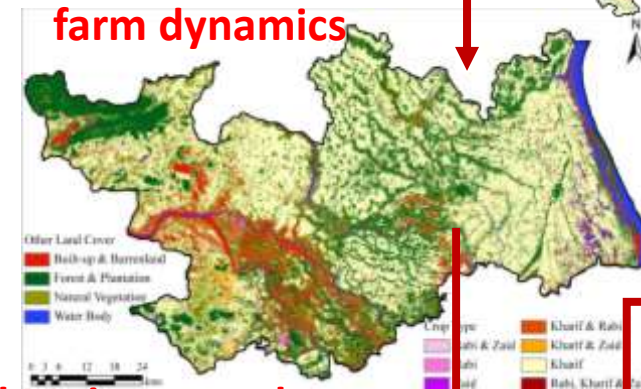
Systemic Innovation for Diversified farming systems



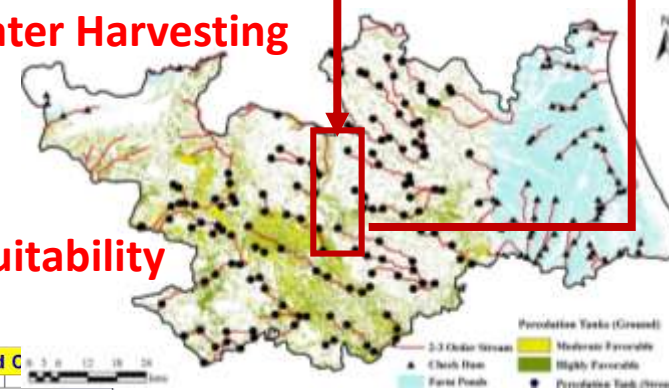
From 2000 to current (real-time mapping)



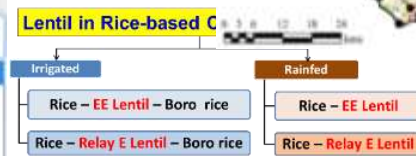
Mapping Realtime farm dynamics



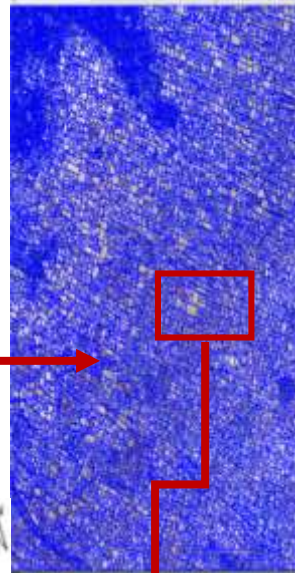
Soil Moisture and Water Harvesting



Variety Suitability



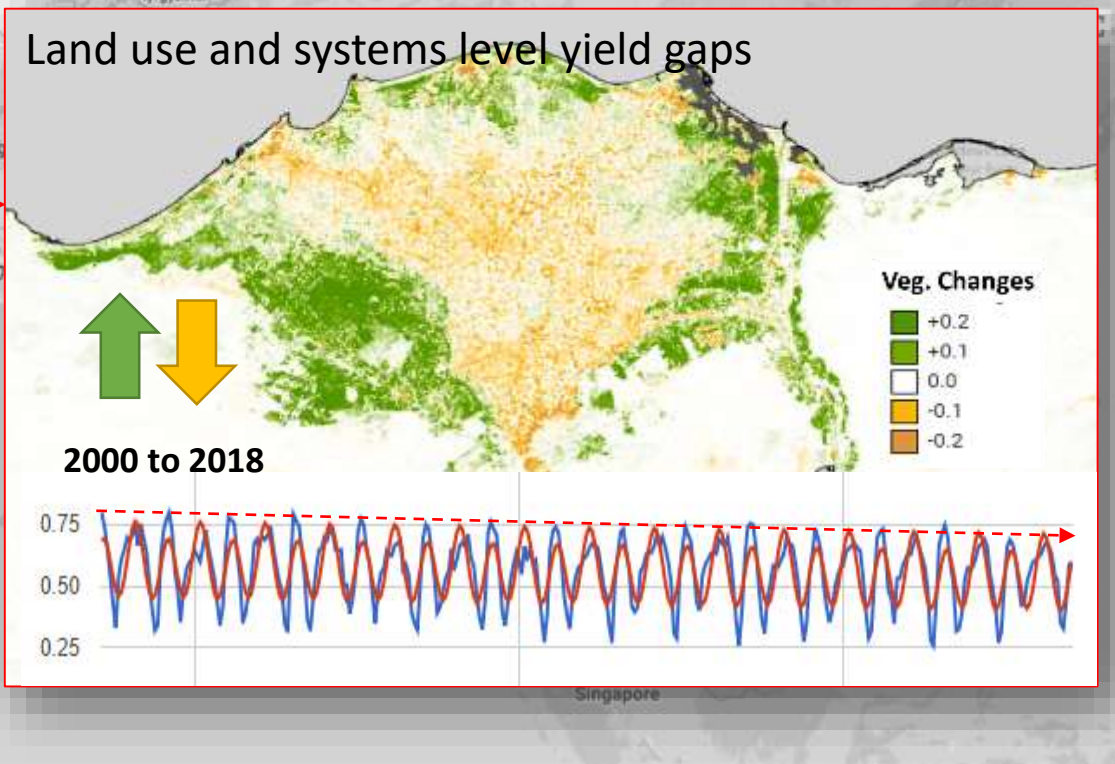
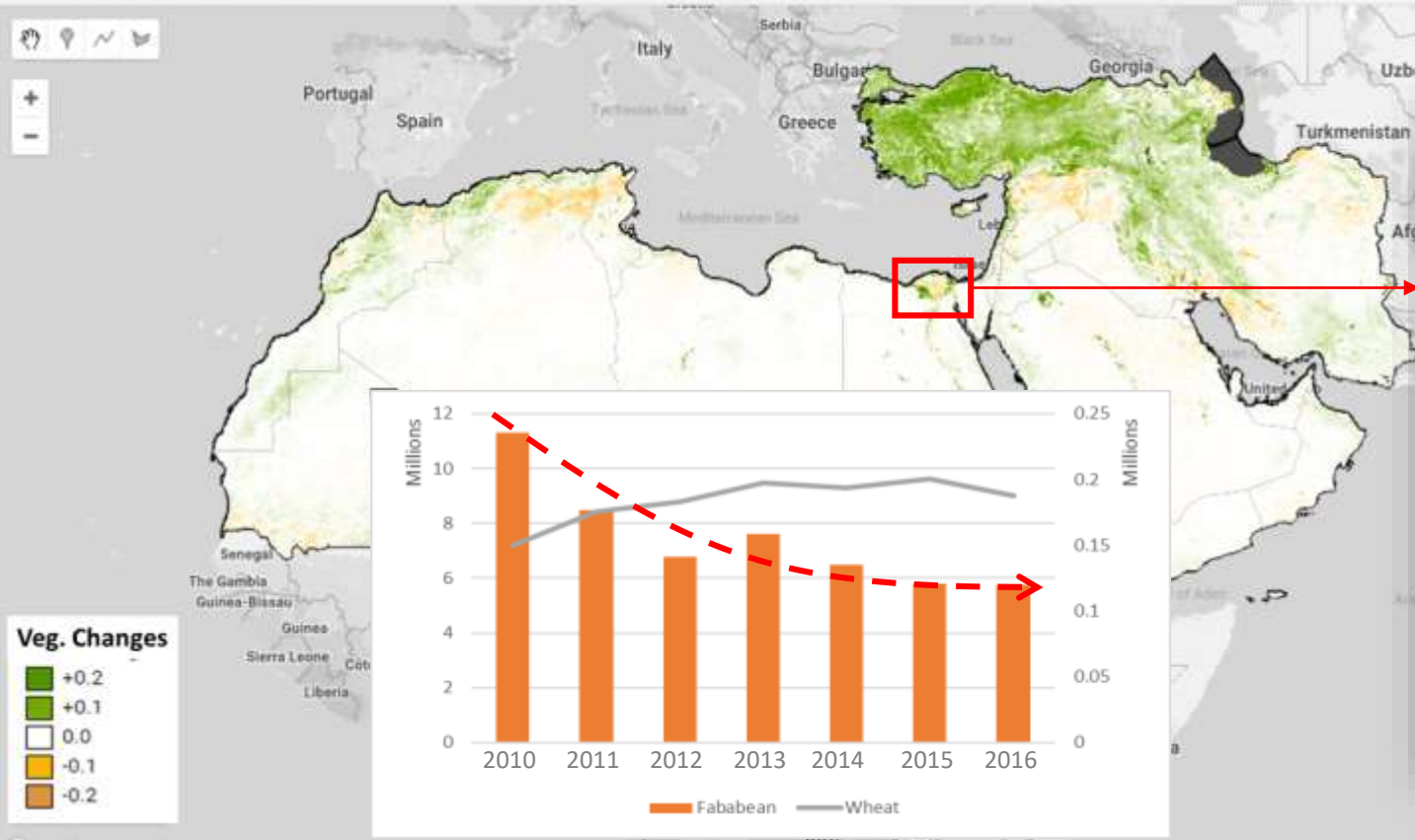
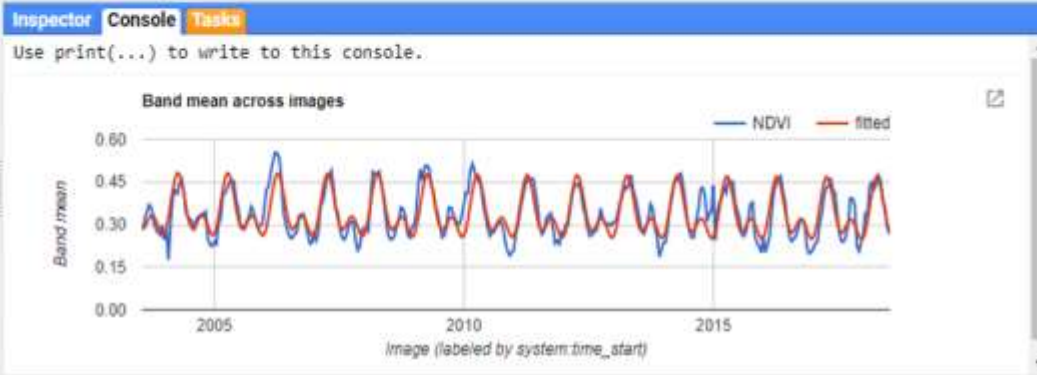
Agro-Tagging



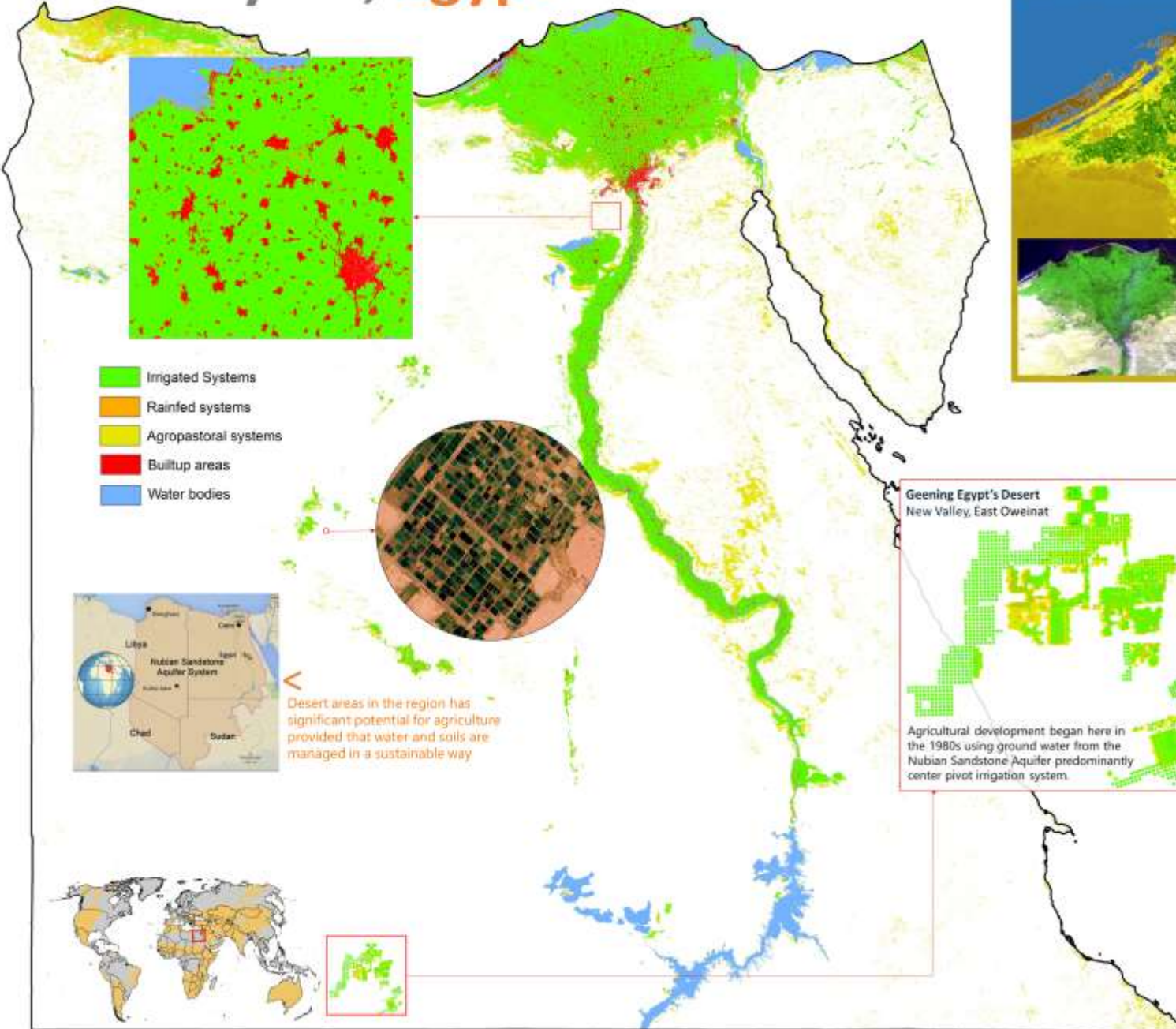
Tracing changes to target interventions

- Scripts
- Docs
- Assets
- NDVI Time Series
- NDVI Time Series (Iraq 2)
- NDVI Time Series (Iraq)
- NDVI Time Series (Jordan 250m)
- NDVI Time Series (Jordan)
- NDVI Time Series (Syria)
- NDVI_WBOD
- NDVI_WBOD (copy)
- Sentinel NDVI
- Sentinel NDVI (Jordan)
- VegChange MENA
- WB-OD NDVI
- users/cbiradar/Telangana

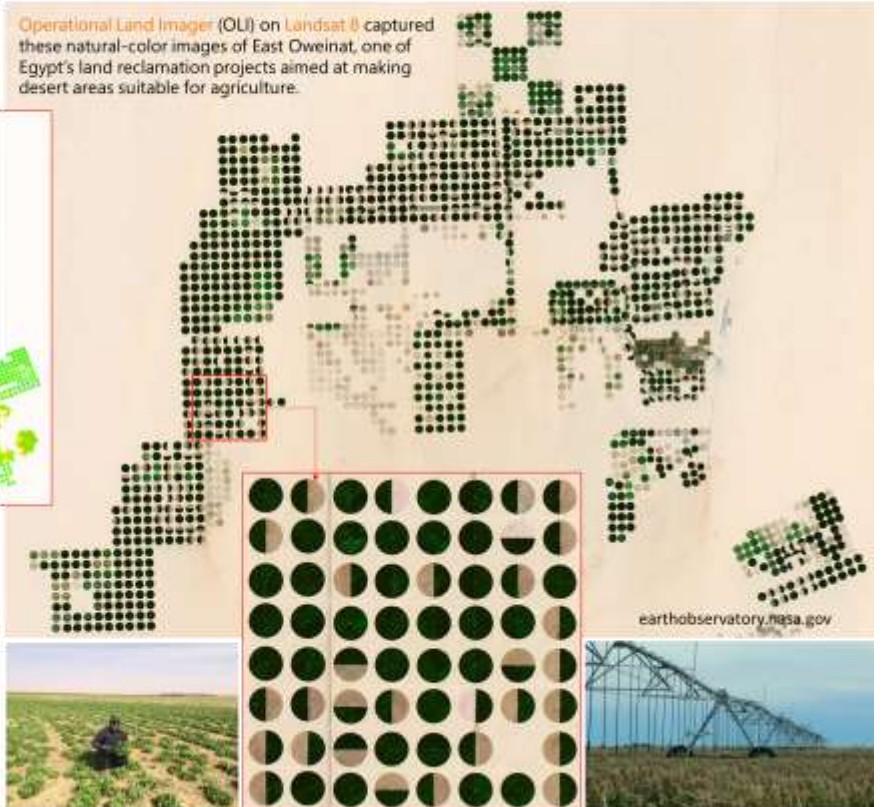
```
17 /*
18 */
19 // Load the vector/shapefile data, "geometry" is the column name of KML data
20 var fusionID = "ft:148w0BhwEj2P2225vacSaxPwF8bCV558yisPBhuox";
21 var MENA = ee.FeatureCollection(fusionID, "geometry");
22
23 // Add ROI shapefile as a layer to the Map
24 Map.addLayer(MENA, {}, "MENA Countries");
25
26 Map.centerObject(MENA, 4);
27
28 var GRAYMAP = [{stylers: [{saturation: -100 }]},
29 {elementType: "labels", stylers: [{lightness: 20 } ]}],
30 {featureType: "road", elementType: "geometry", stylers: [{visibility: "simplified"}]},
31 {featureType: "road", elementType: "labels", stylers: [{visibility: "off"}]}],
32 4
```



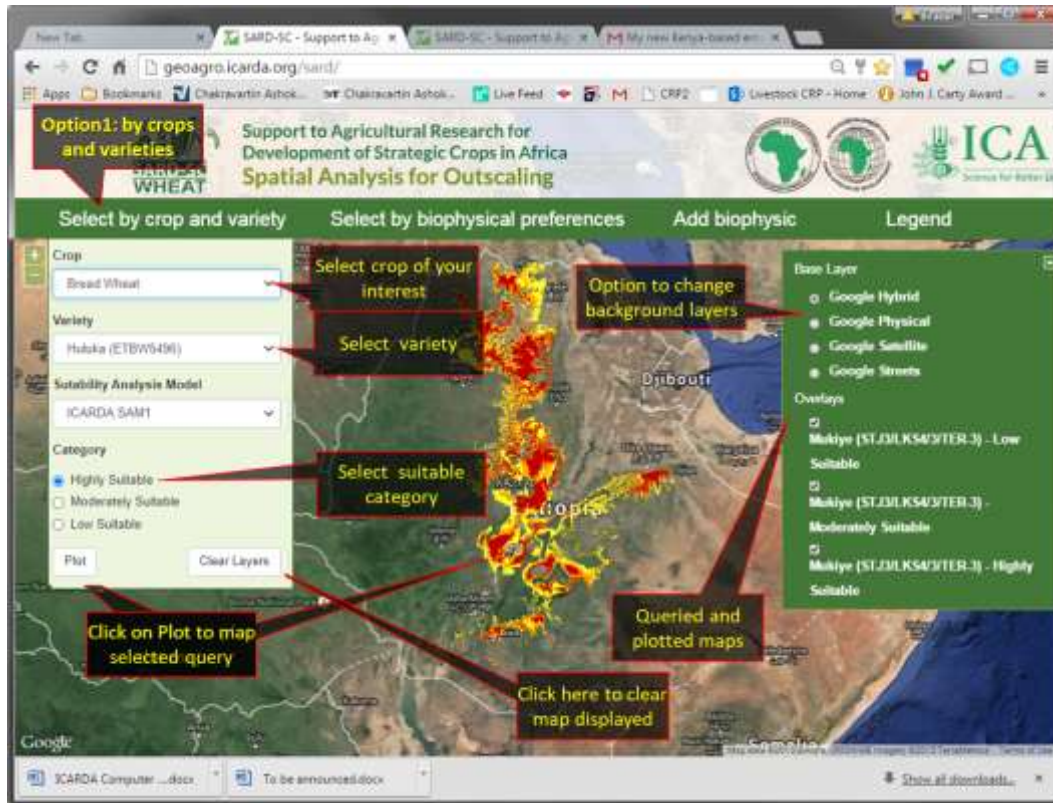
The DryArc, Egypt National level



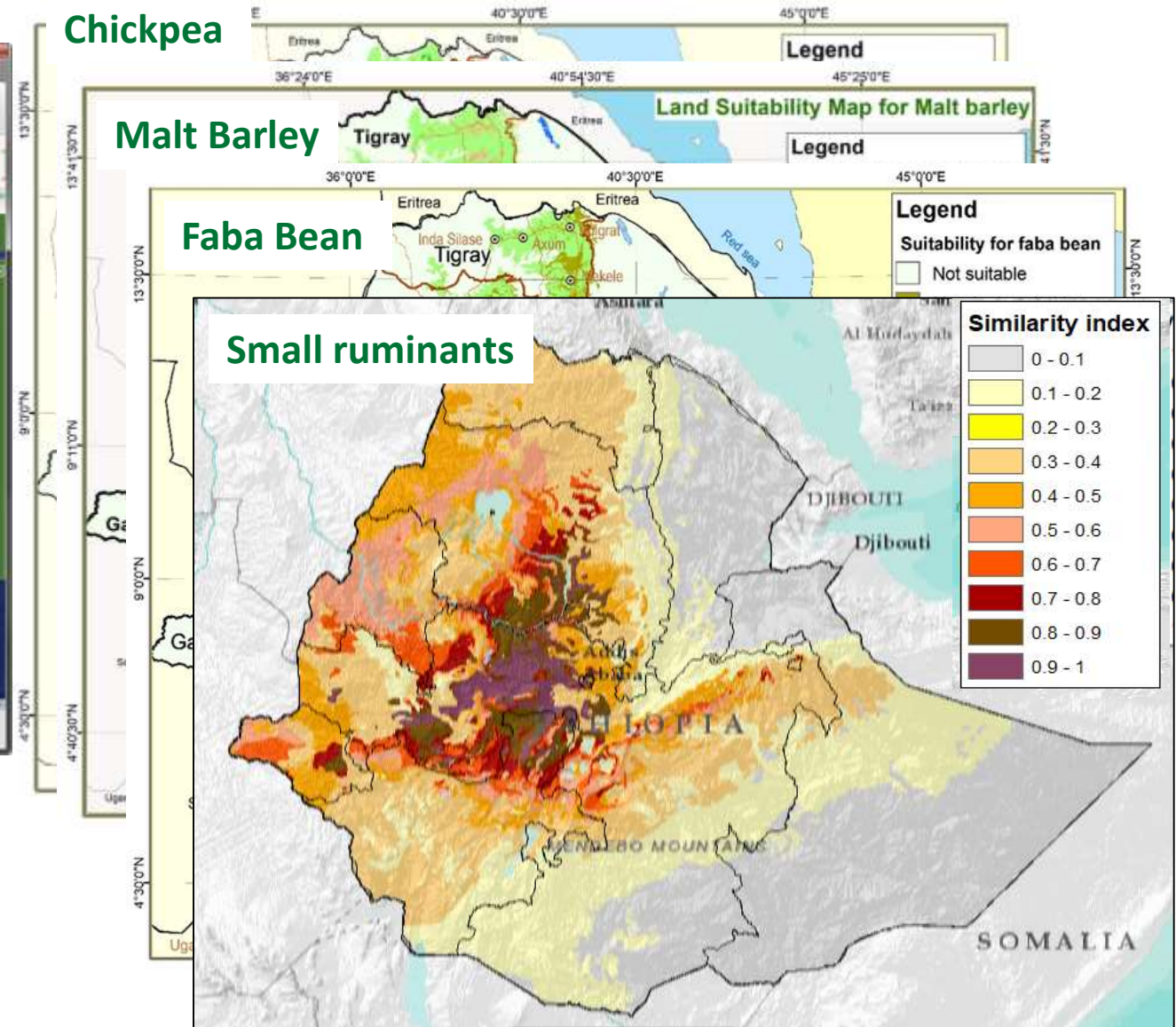
Desert areas in the region has significant potential for agriculture provided that water and soils are managed in a sustainable way



Scaling domains for specific varieties and breeds



Chickpea



Biradar et al., 2015. Mapping scaling domain for wheat varieties, SARC SC hub countries. ICARDA.

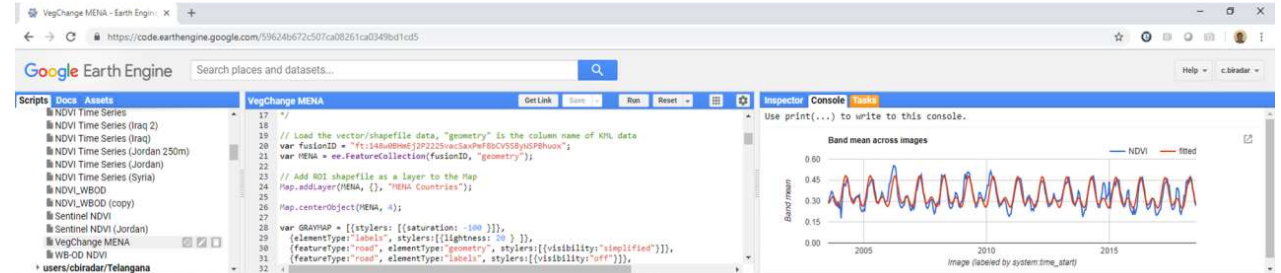
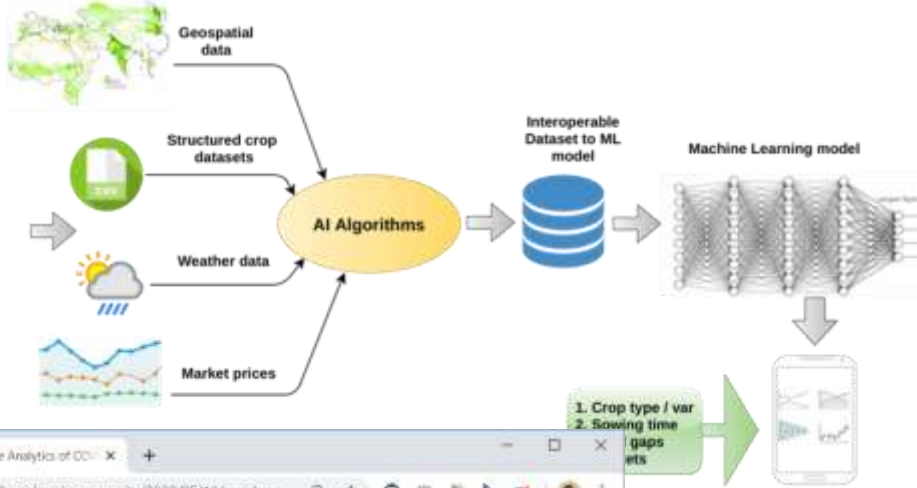
Nigusie, D., Mulugeta, W., Molla, A., Bishaw, Z., and Biradar, C., 2019. GIS-based multi-criteria land suitability mapping for scaling Faba bean varieties in Ethiopia. *African Crop Science Journal*, Vol. 27, No. 4, pp. 687 – 708

Demeke Nigusie, Wondafrash Mulugeta, Adamu Molla Tiruneh, Zewdie Bishaw, Chandrashekhar Biradar. (30/3/2019). Land Suitability Mapping for Production of Chickpea, Faba Bean and Malt Barley Varieties in Ethiopia. Technical report. ICARDA.

Atassi, L., Biradar C., Haile A, Rischkowsky, B., Mwacharo JM. 2018. Mapping breeds to appropriate production environments: a case study of Ethiopian indigenous sheep and goats. ICARDA.

Machine Learning Intelligence & Applications (MILA)

e.g. assess cropping system dynamics

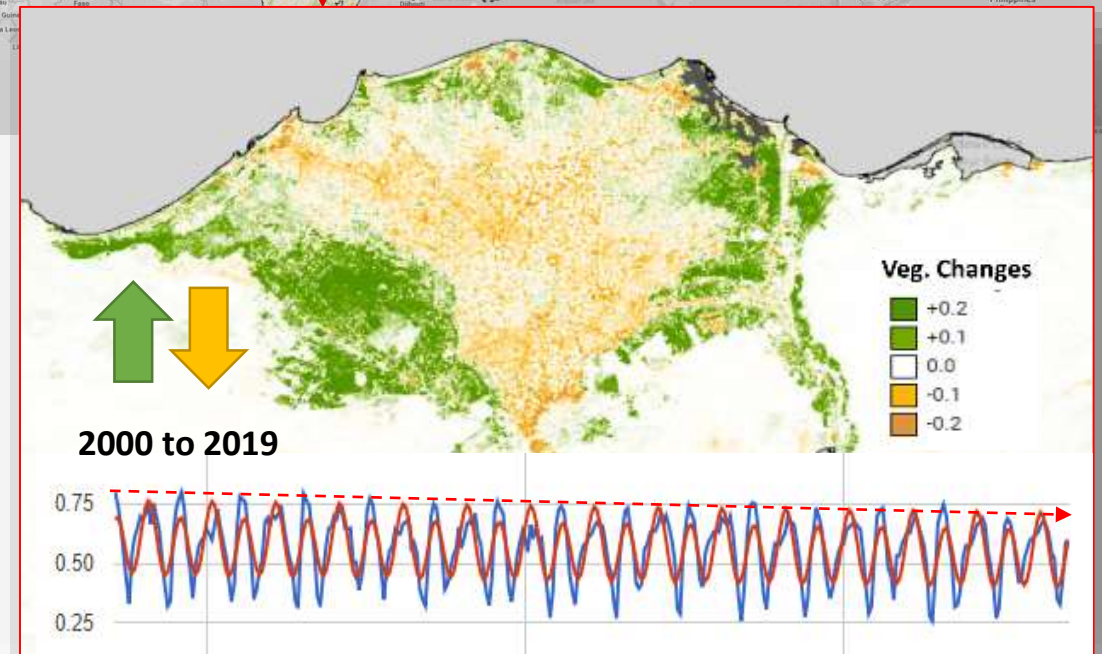


The screenshot shows a web page with the following content:

- Title:** Rapid Response Analytics of COVID-19 Impact on Agriculture and Environment
- Organization:** CGIAR CSU (Center for Global Information Science and User Innovation)
- Author:** Ghazal Khatibi (CGIAR CSU)
- Text:** The COVID-19 global pandemic resulted in precautionary measures in several countries that inevitably affected agri-food systems, its allied industries, and the livelihoods of users and communities alike. Initially, there were no available data to accurately assess COVID-19 impact on the agricultural sector, its livelihoods, and environment. With countries-wide lockdowns and necessary measures, they brought the agricultural sector to an abrupt standstill at a time when crops were at their peak maturity stage and in some cases ready for harvesting. This could have serious repercussions on the food supply chains, and impact the next planting season. A monitoring solution needed to be found to monitor delays in harvesting that could result in production loss and impact on price stability, and gather other important factors to help decision-making during these unprecedented circumstances.

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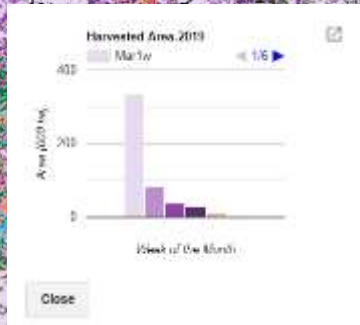
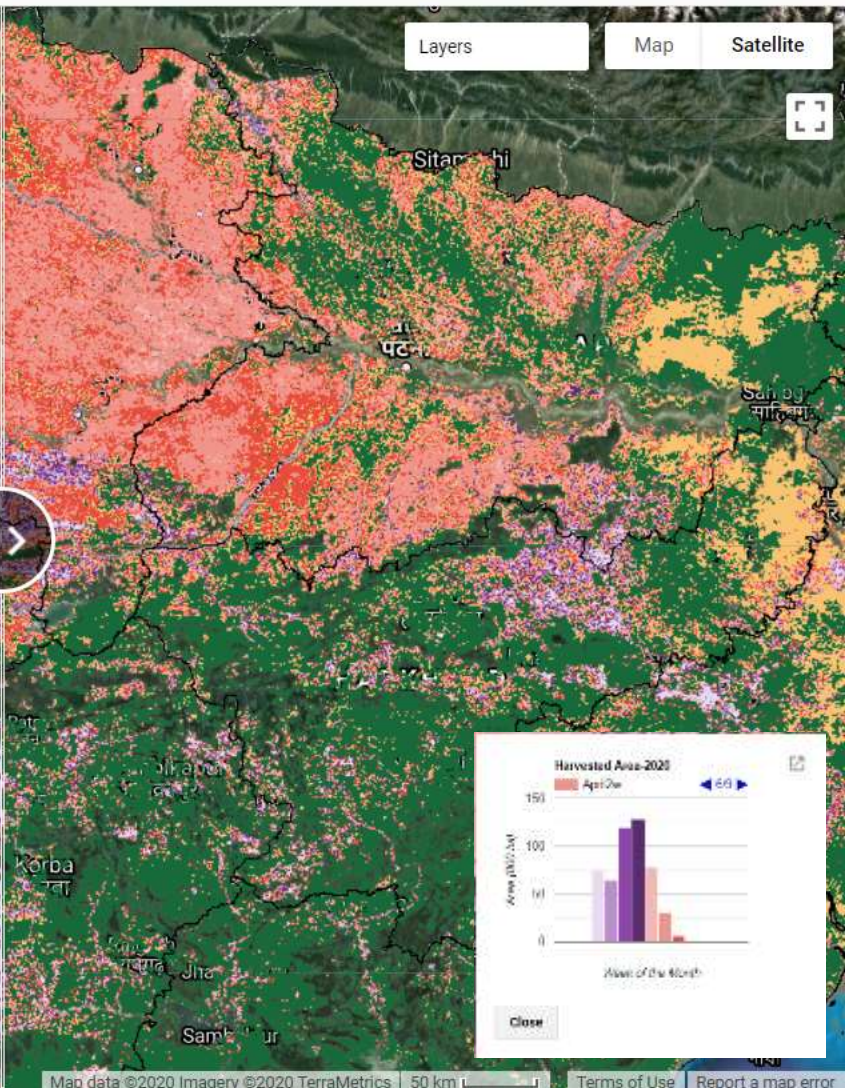
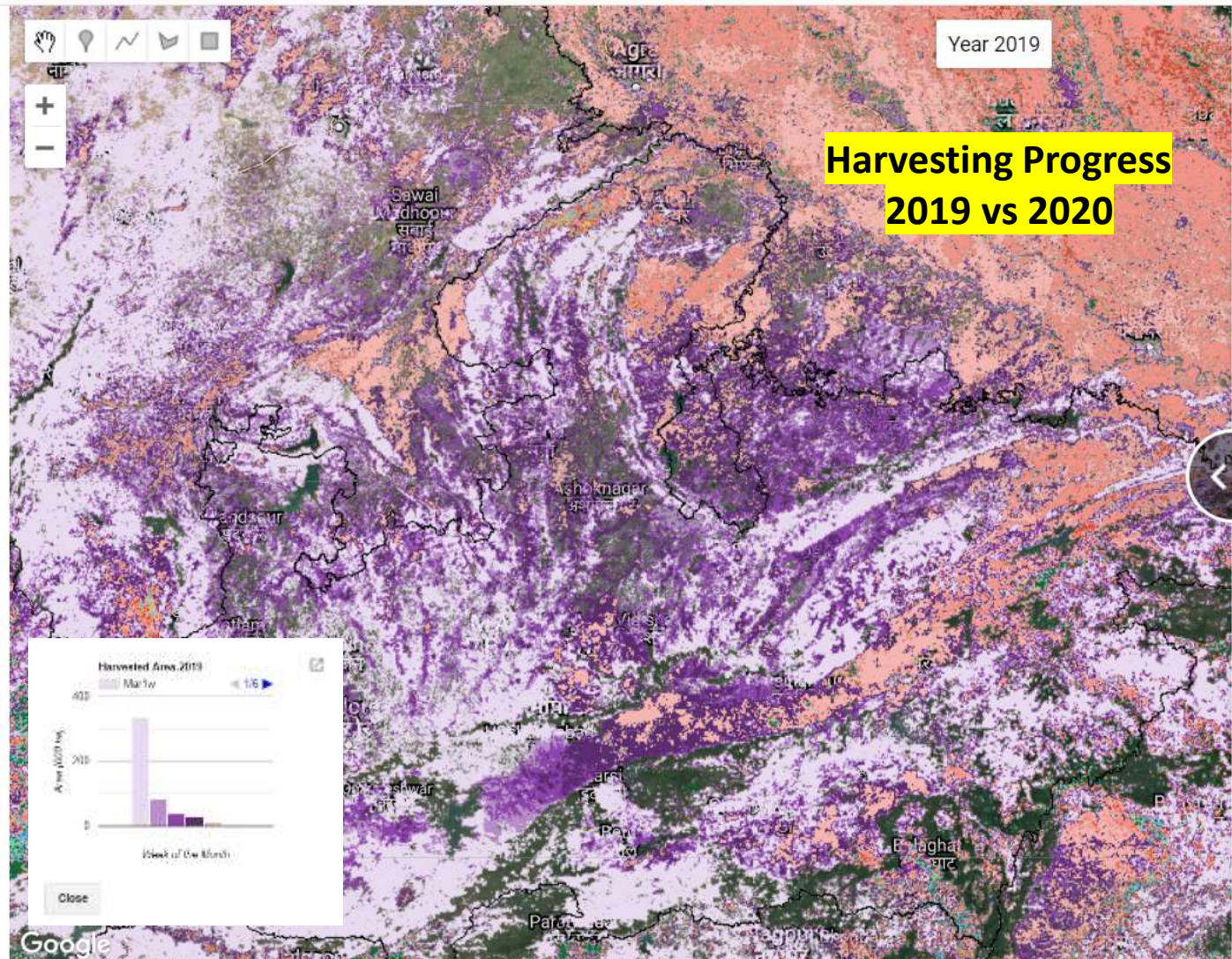
Earth Engine Apps Experimental

Select State and District

Select a State

Go To District

- Legend
- Crop Harvesting Progression
- March 01-07
 - March 08-15
 - March 16-23
 - March 24-30
 - April 01-07
 - April 08-15
 - April 16-23
 - April 24-30
 - May 01-07
 - May 08-15
 - May 16-23
 - May 24-30
 - Crop Not Harvested

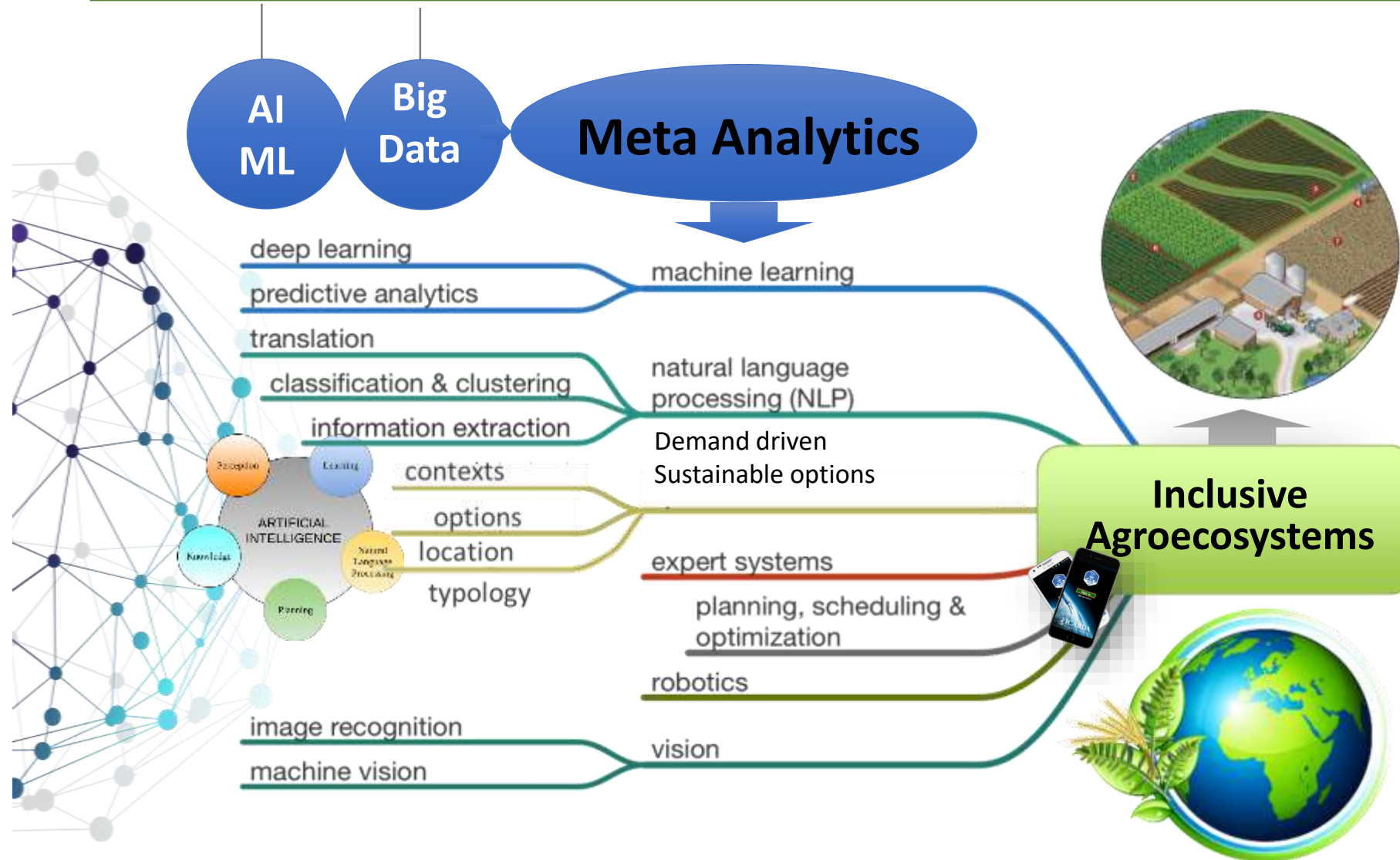


[Crop Fallows Mapping](#)

[Air Pollution Monitoring](#)

Data and Info Integration and Interoperability

@ Crops, animals, soils, weather, agronomy, trade...



Multi-domain integrations

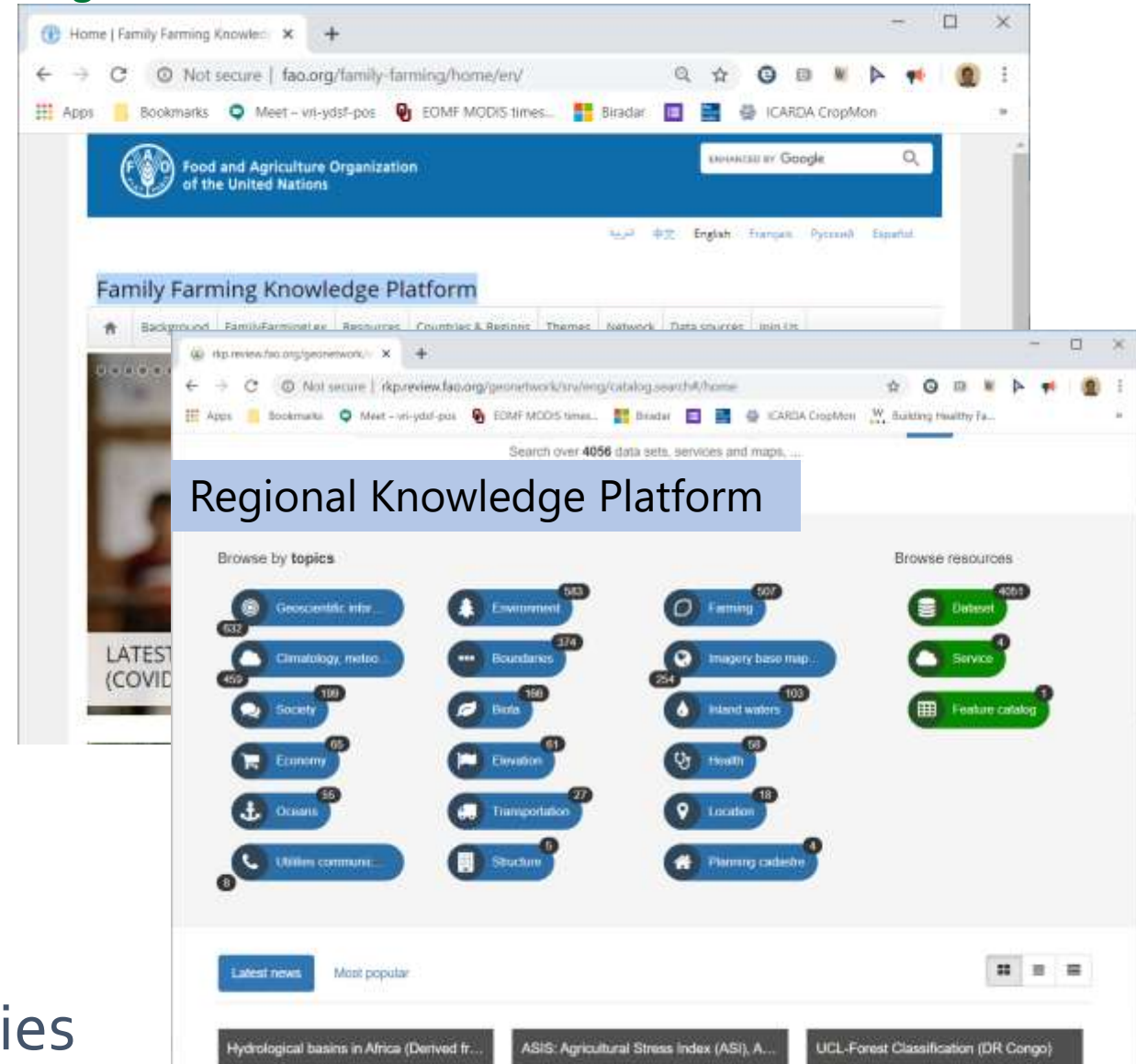
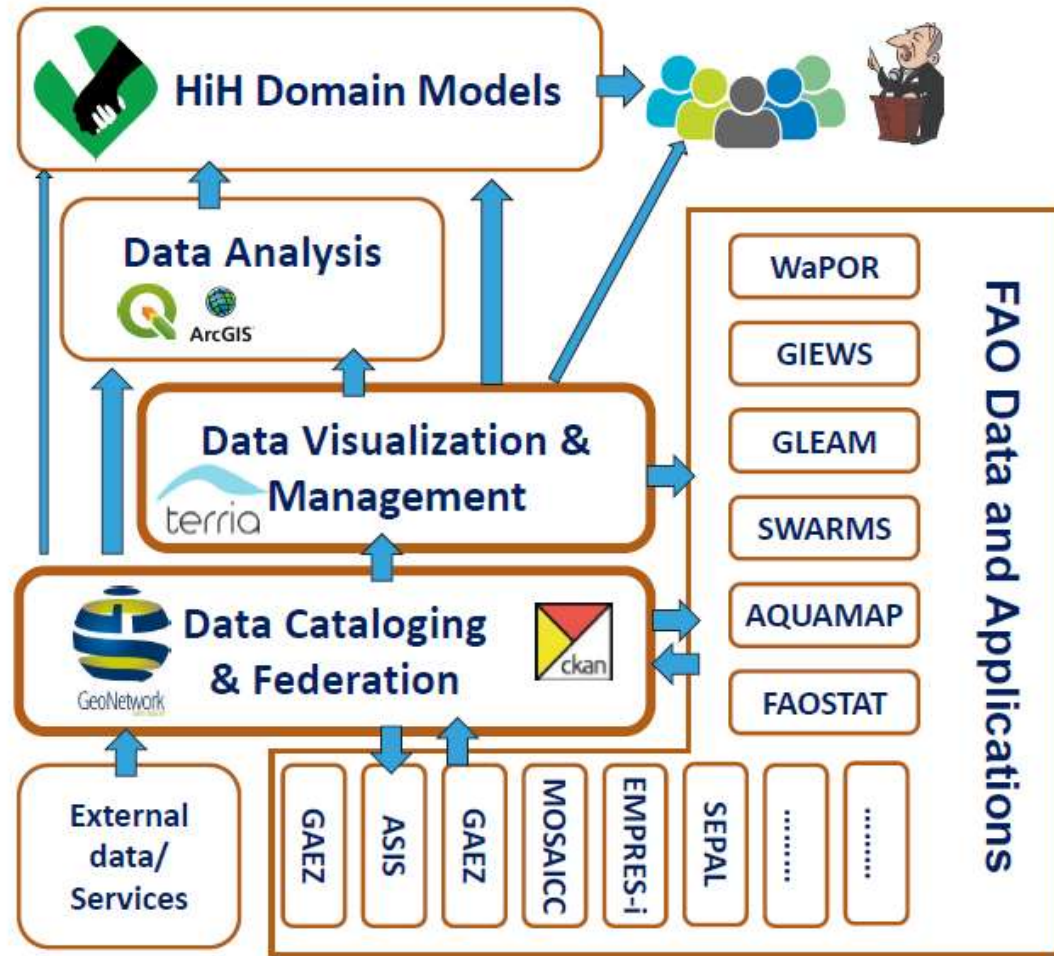
Project specific outputs and integration into interface

The image displays several screenshots of web-based geospatial and agricultural data integration tools:

- Top Left:** A screenshot of the ICARDA Geoinformatics Spatial Solutions portal. The header includes the ICARDA logo and navigation links: Home, About, Datasets, Visualization, Research, Services, Outreach, FAQ, My Account. The main content area features the text "Geoinformatics Spatial Solutions for Integrated Agro-ecosystems" and "Geospatial based Technology and Application (Ge-STA) for Integrated Agro-ecosystems research towards ensuring food and environmental security (especially in the Dry Areas)".
- Top Right:** A screenshot of a "Carbon Sustainability (Crisis v 1.0)" web application. It shows a map of South Asia with a color-coded overlay representing carbon sustainability. A legend indicates a scale from 0 to 100. On the right, there are control panels for "Overall Sustainability Layer" and "Carbon Sustainability (Crisis v 1.0)", including a pie chart showing a distribution of 100% across different categories.
- Bottom Left:** A screenshot of the "Agricultural Monitoring in Yemen" interface. It displays a grid of satellite imagery maps for different regions, with a legend and a data visualization component.
- Bottom Center:** A screenshot of the "ET Basin Agriculture Water Productivity" interface. It prompts the user to "Please select a product line" and offers four options: Evapotranspiration, Yield, Water Productivity, and Water Productivity Hotspots. Each option is accompanied by a small thumbnail map.
- Bottom Right:** A screenshot of a "date palm" monitoring tool. It features a map with a grid overlay and a legend. Below the map, there is a line graph showing data over time. A text box on the right states: "Hotspots in date palm growing areas using Sentinel series (S2) and GEE".

Multi-domain integrations

Project specific outputs and integration into interface



4,000+ metadata and 1,300+ data series
1,000,000+ geodata layers and thousands of statistics series

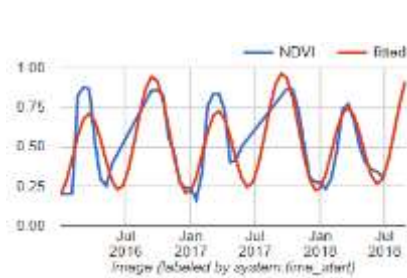


Dynamics of cropping systems and rotations

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](#)

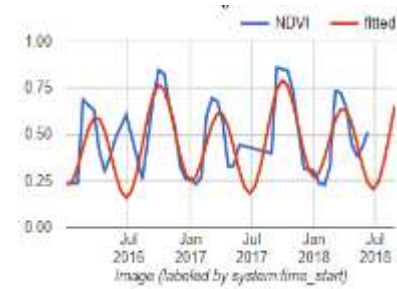


Fallows in Double cropped area

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

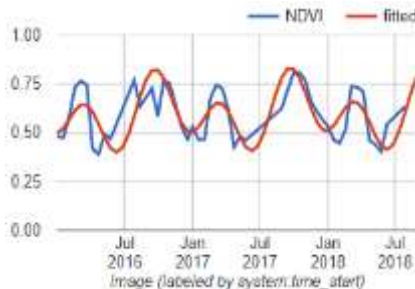
Directions: [To here](#) - [From here](#)



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

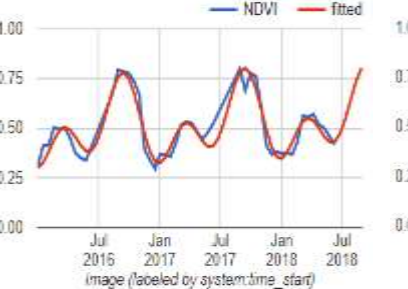
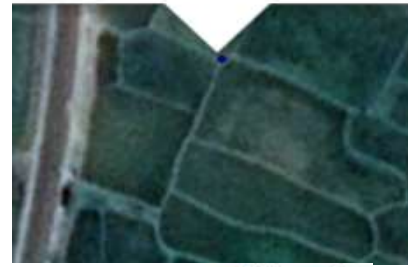
Directions: [To here](#) - [From here](#)



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

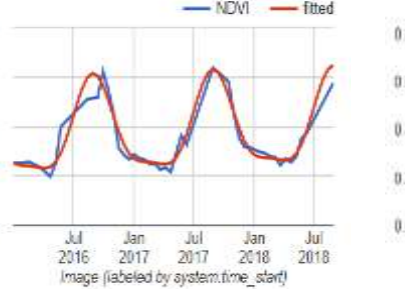
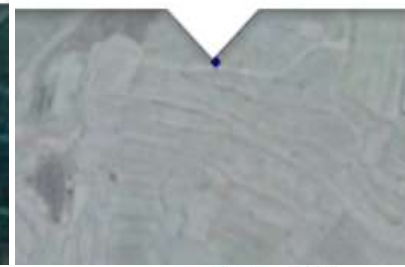
Directions: [To here](#) - [From here](#)



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](#)

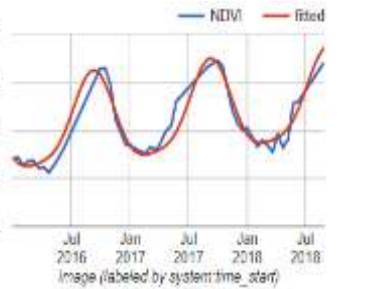


Fallows in Single cropped area

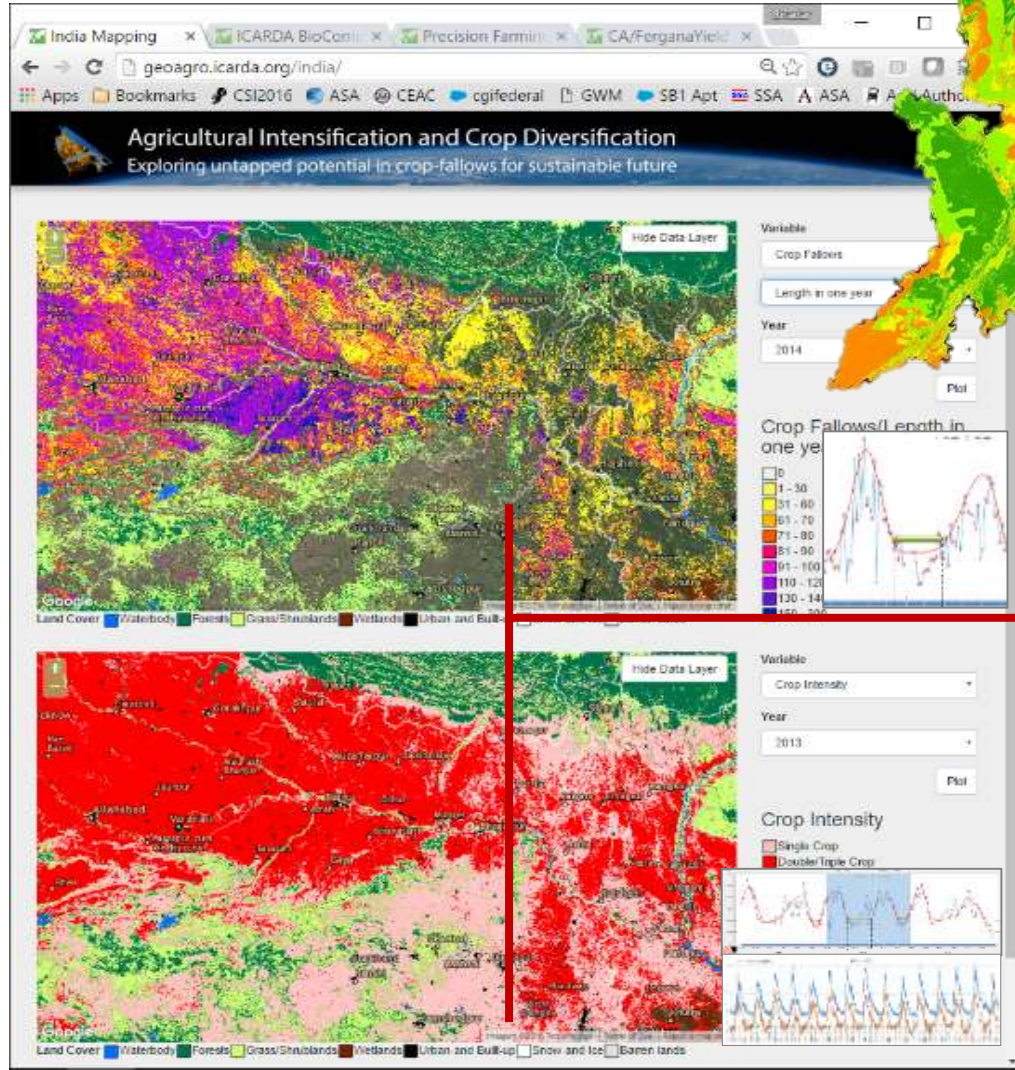
Gosain Bundh SFMIS-moved

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

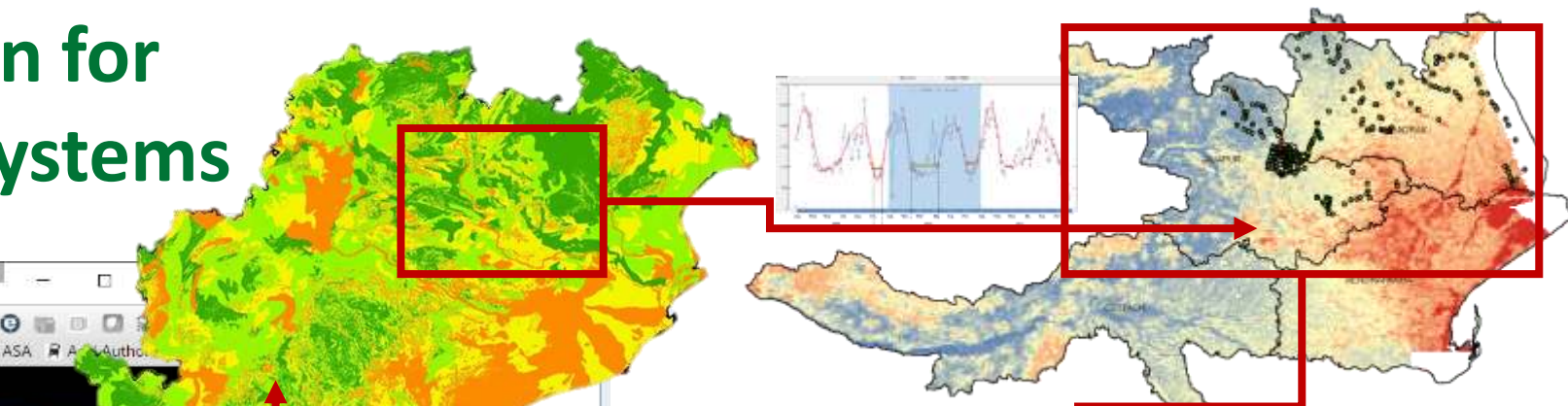
Directions: [To here](#) - [From here](#)



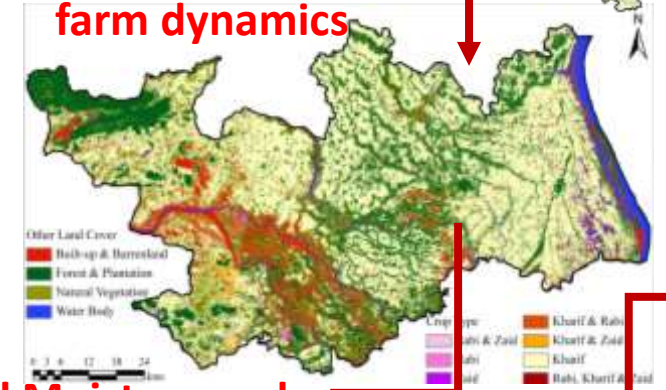
Systemic Innovation for Diversified farming Systems



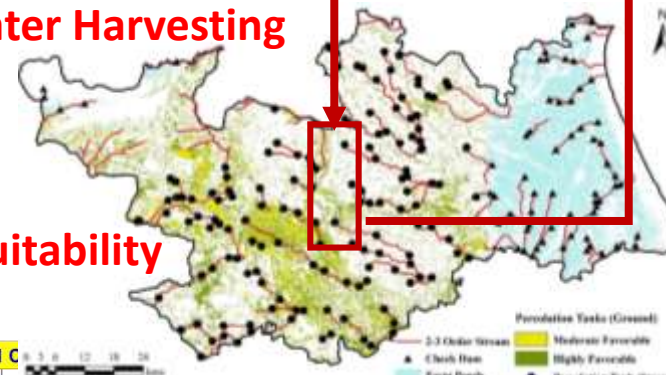
From 2000 to current (real-time mapping)



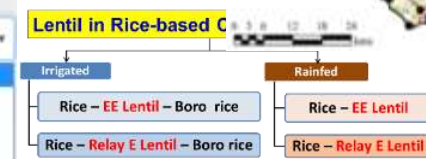
Mapping Realtime farm dynamics



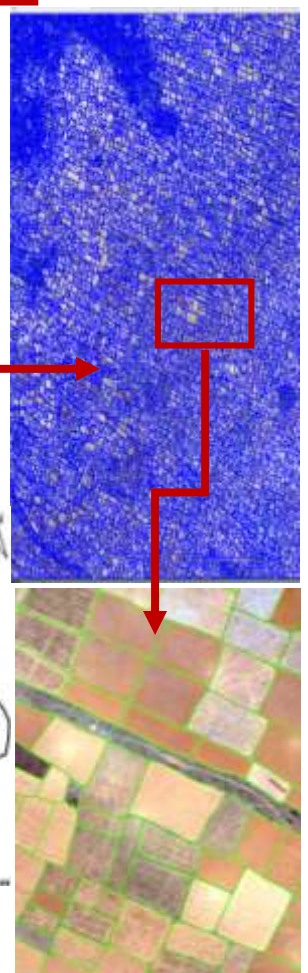
Soil Moisture and Water Harvesting



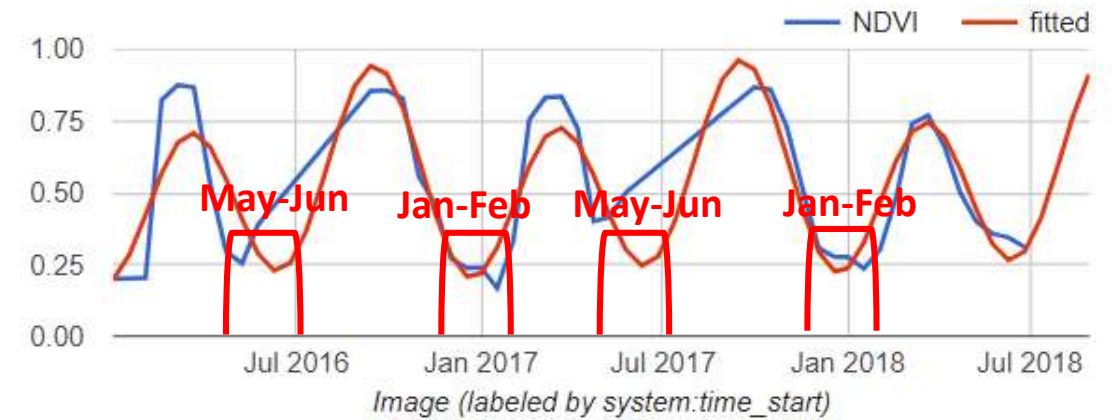
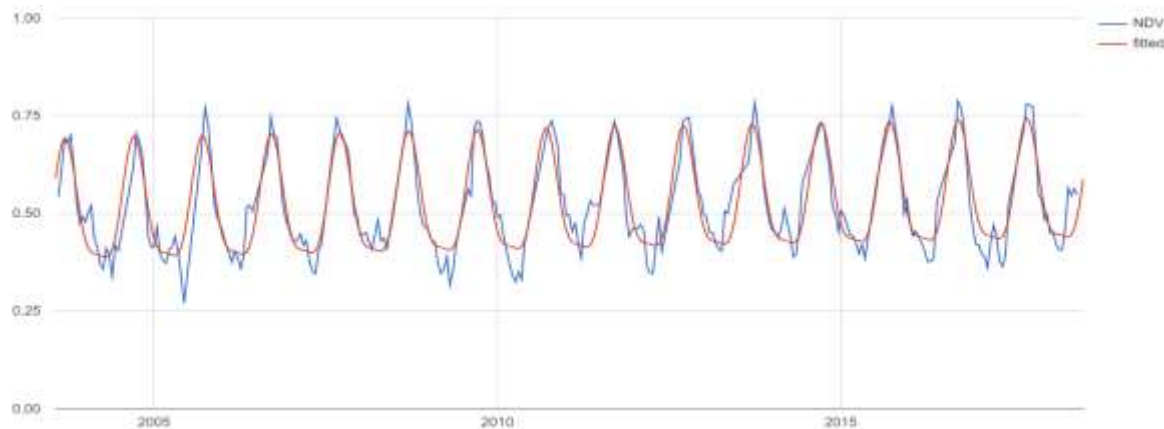
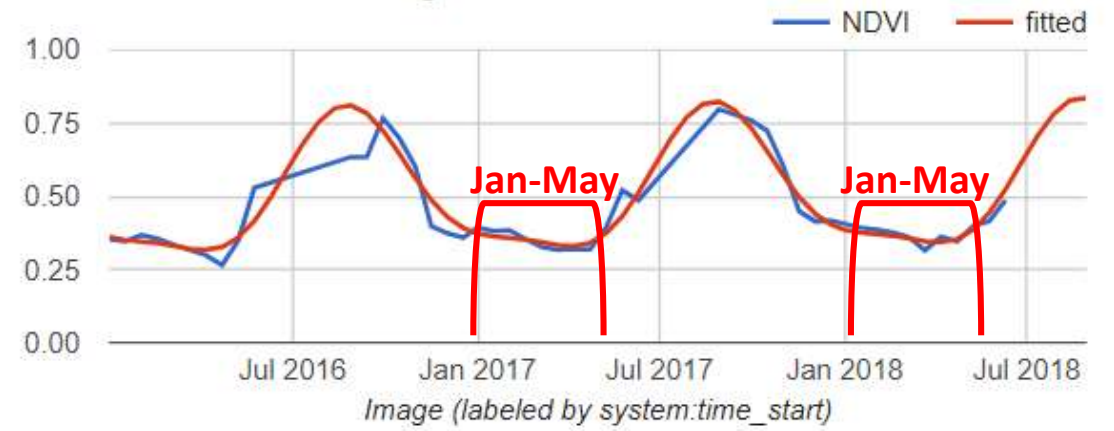
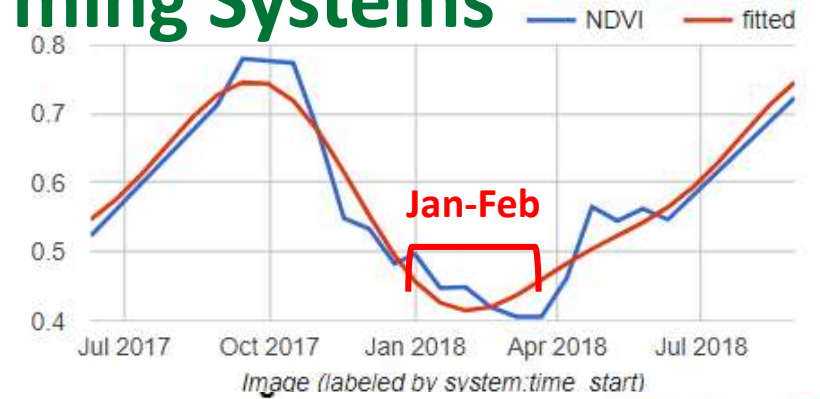
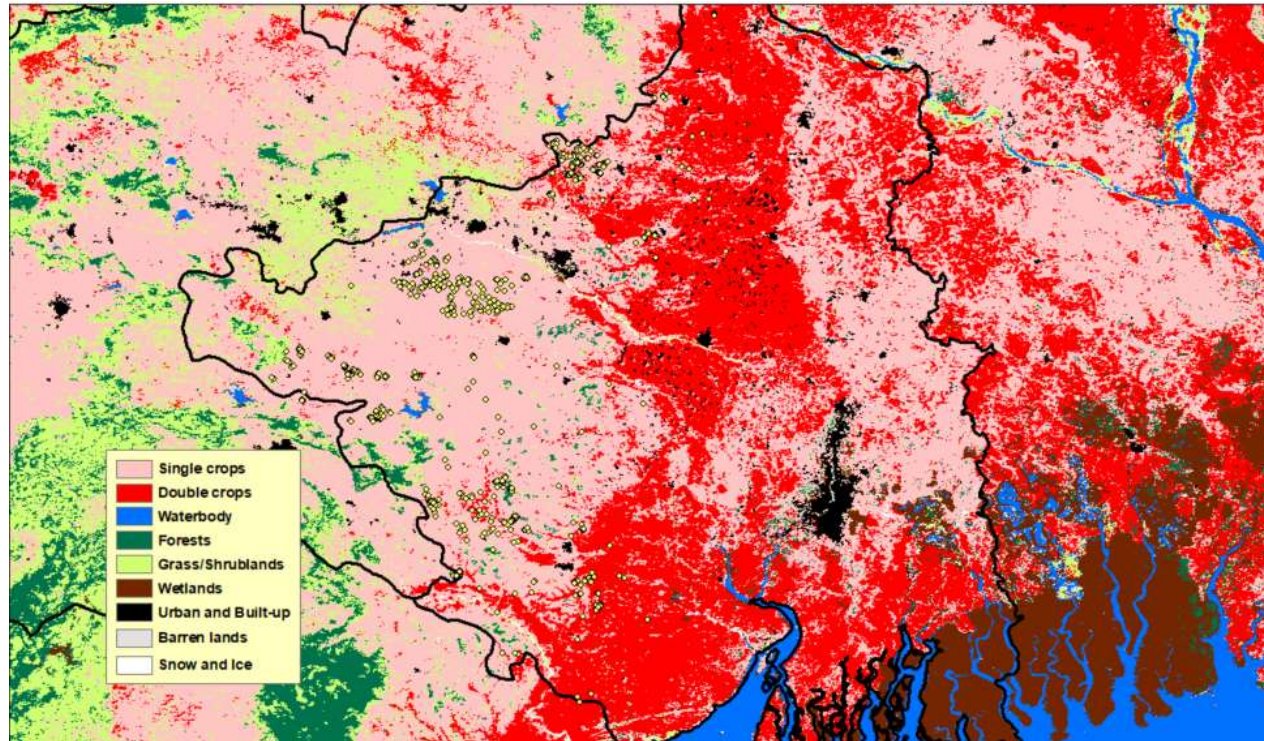
Variety Suitability



Agro-Tagging

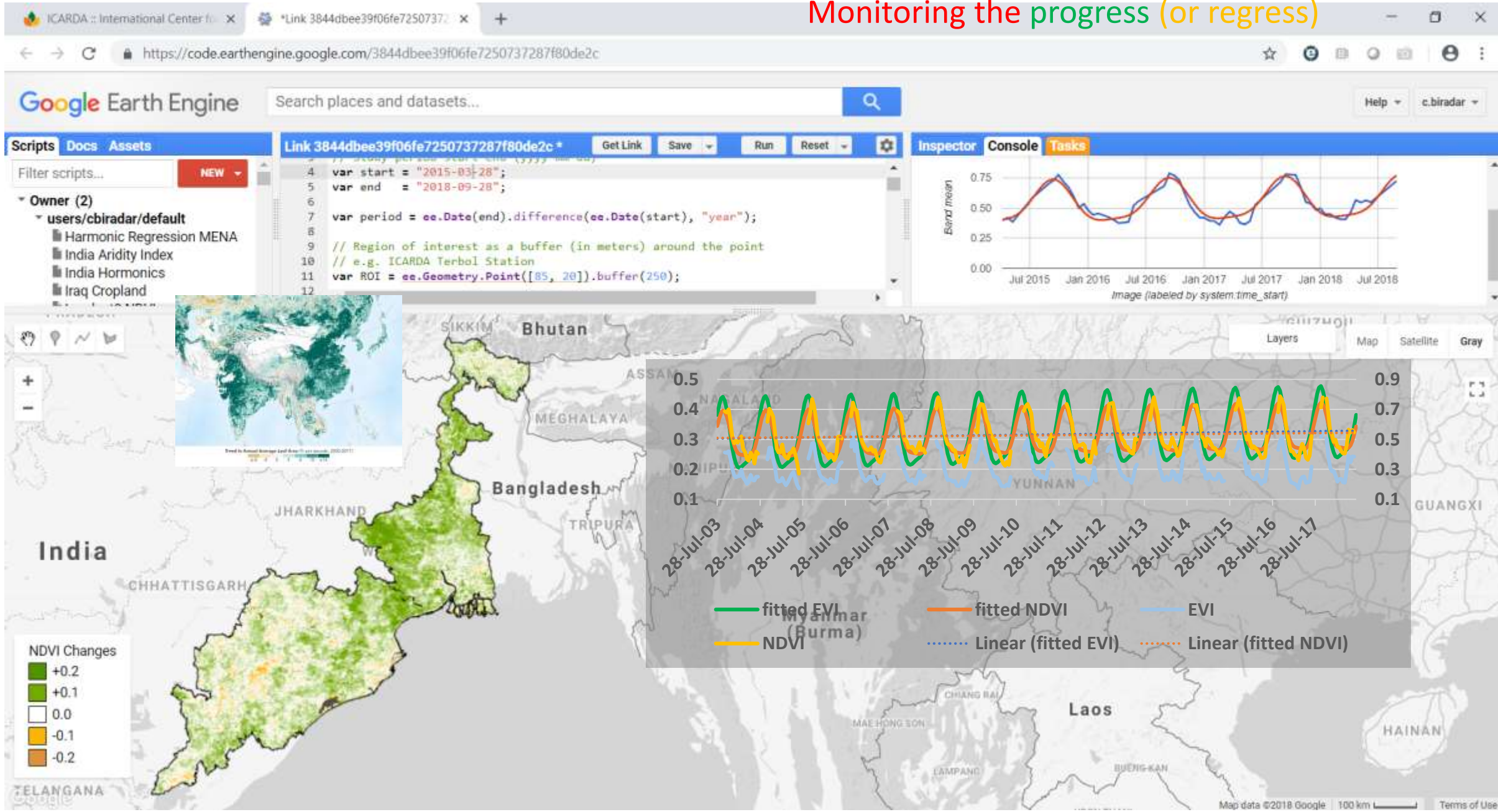


Systemic Innovation for Diversified farming Systems



Tracking farming systems dynamics for better decisions

Monitoring the progress (or regress)

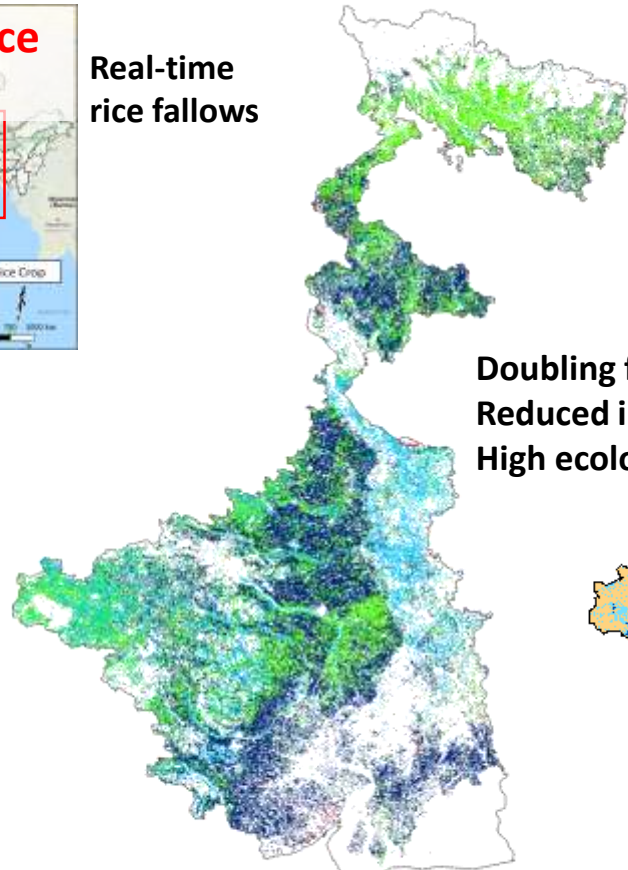


Sustainable intensification of the cereal-based systems with legumes

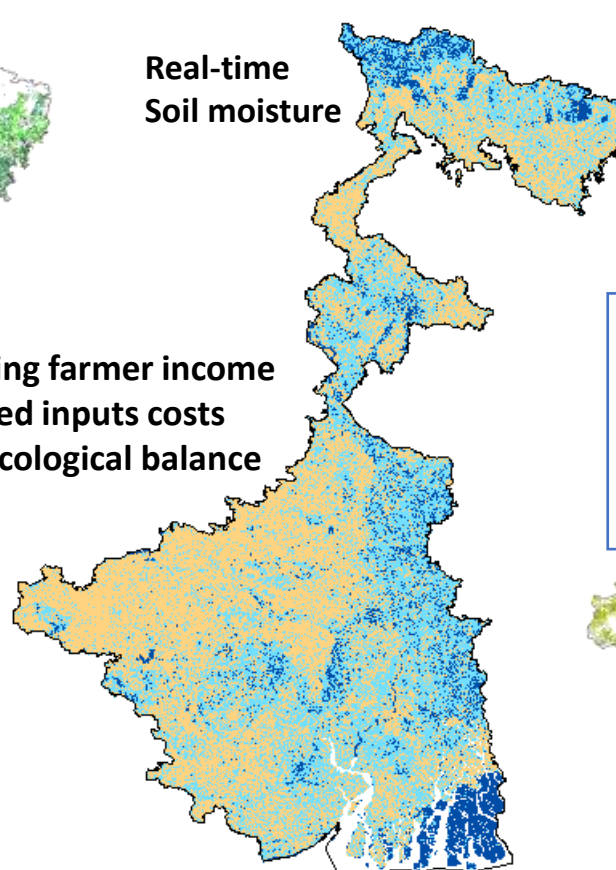
Near Real-time monitoring to target site specific interventions (package of practices)



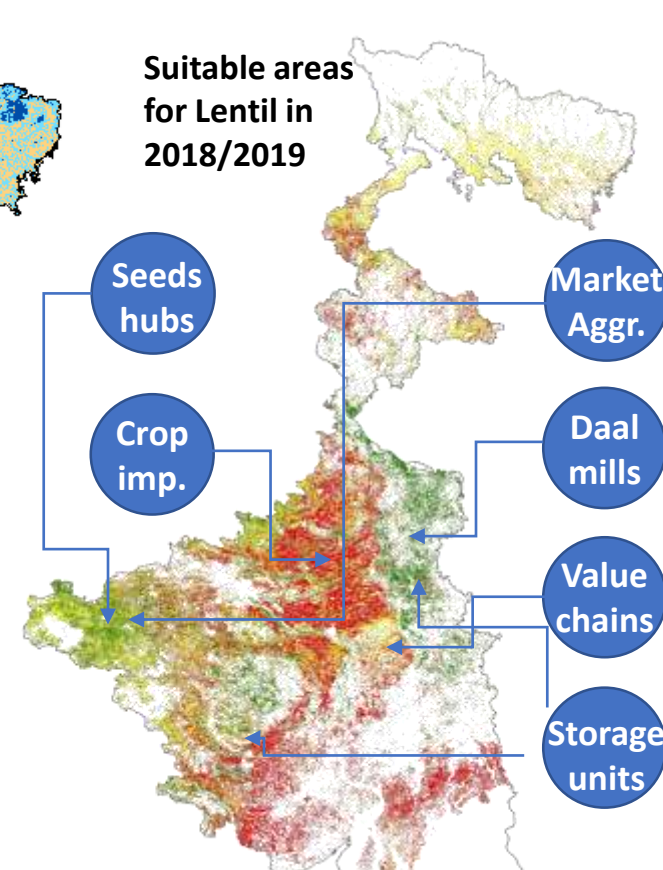
Real-time rice fallows



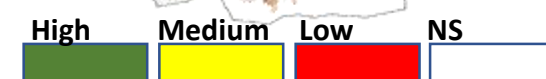
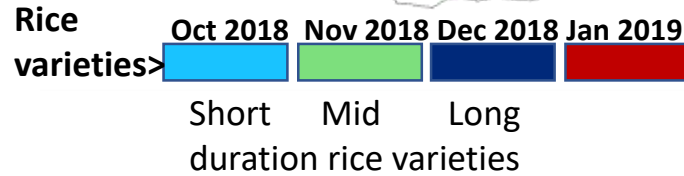
Real-time Soil moisture



Suitable areas for Lentil in 2018/2019



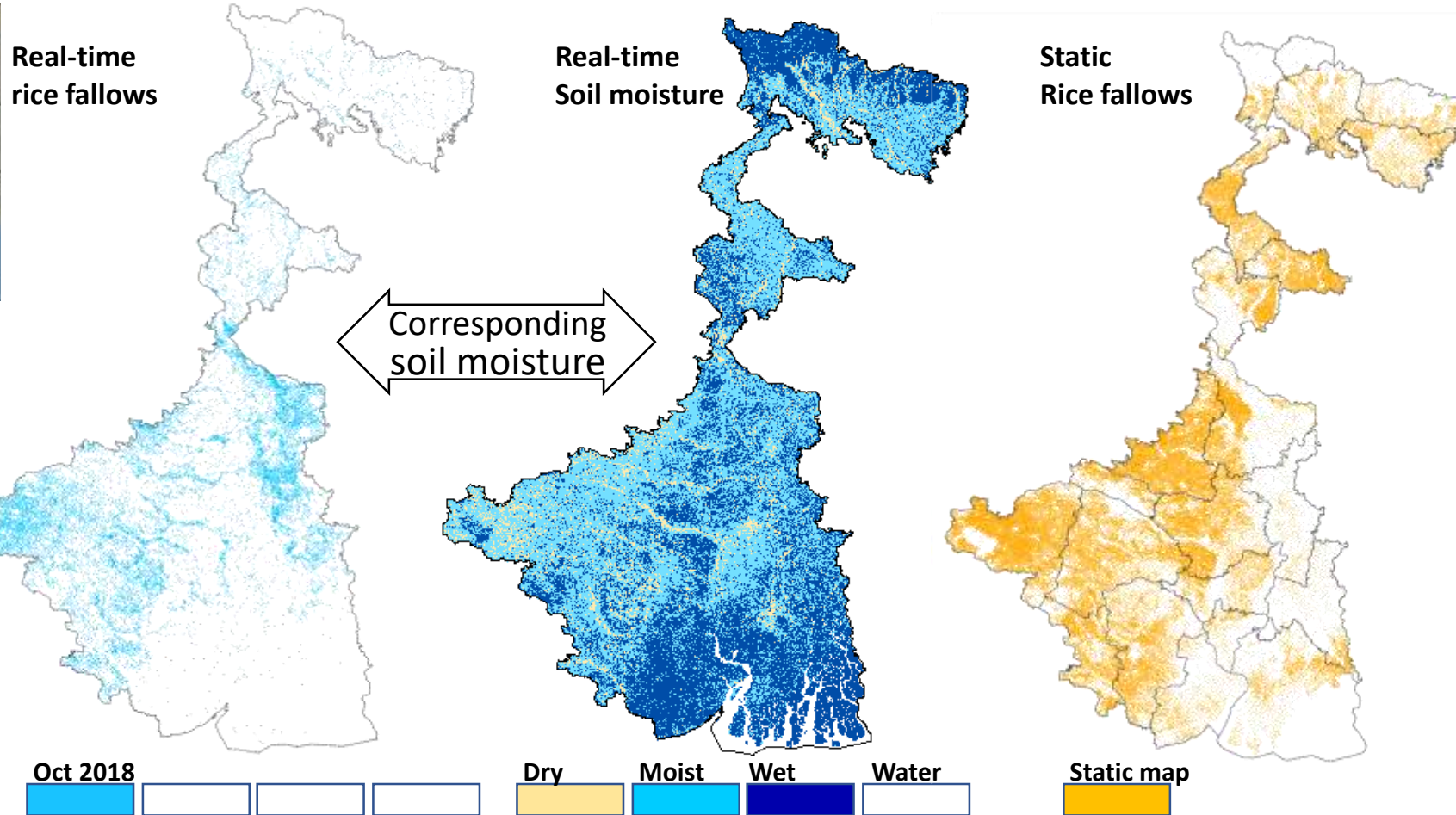
Doubling farmer income
Reduced inputs costs
High ecological balance



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

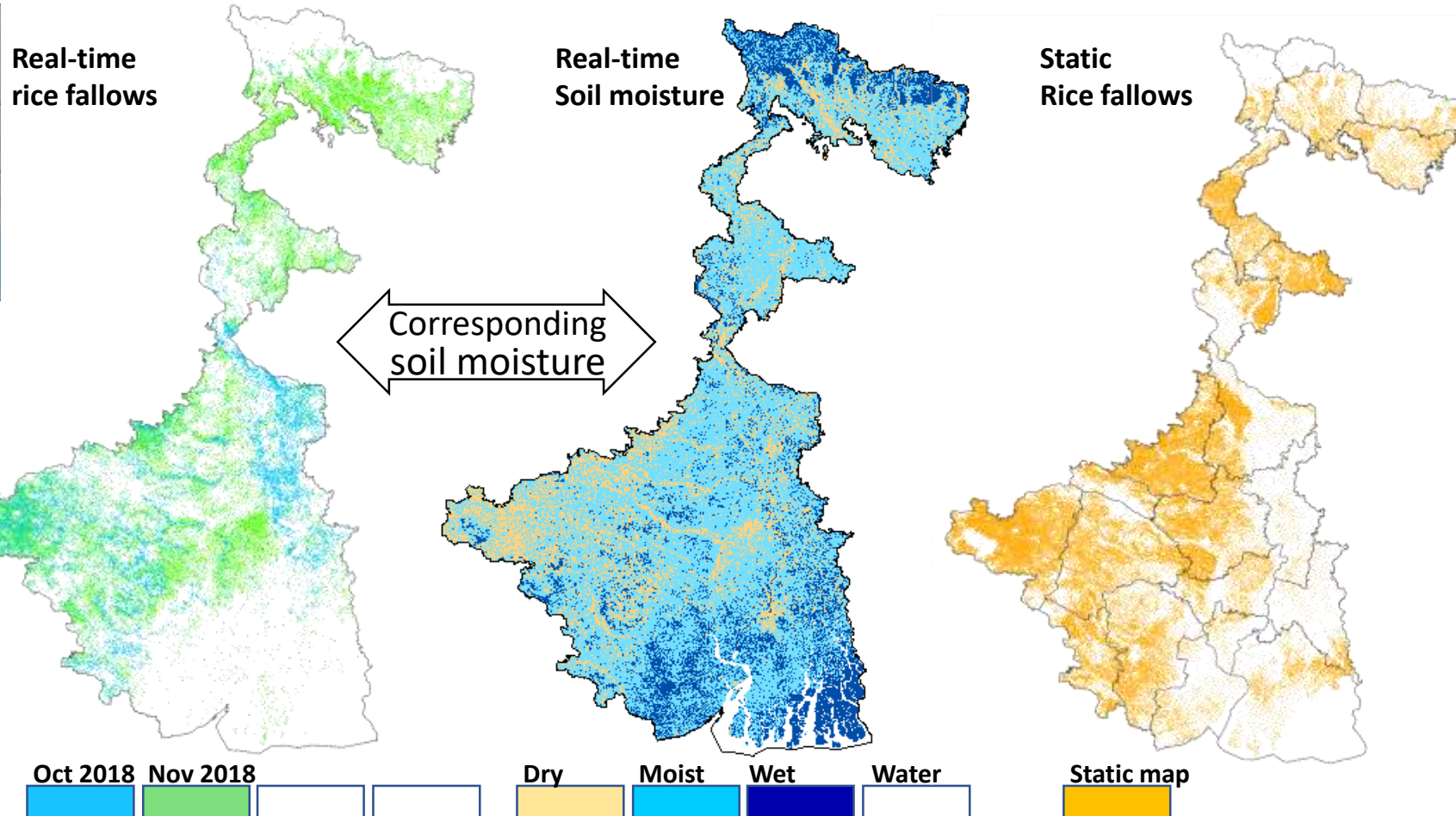
Sustainable intensification of the cereal-based systems with legumes

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



Sustainable intensification of the cereal-based systems with legumes

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

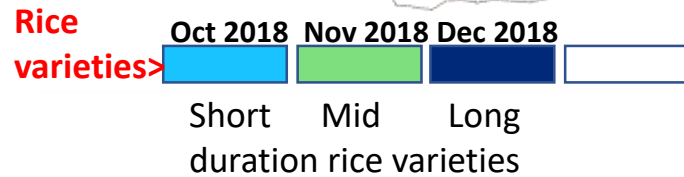
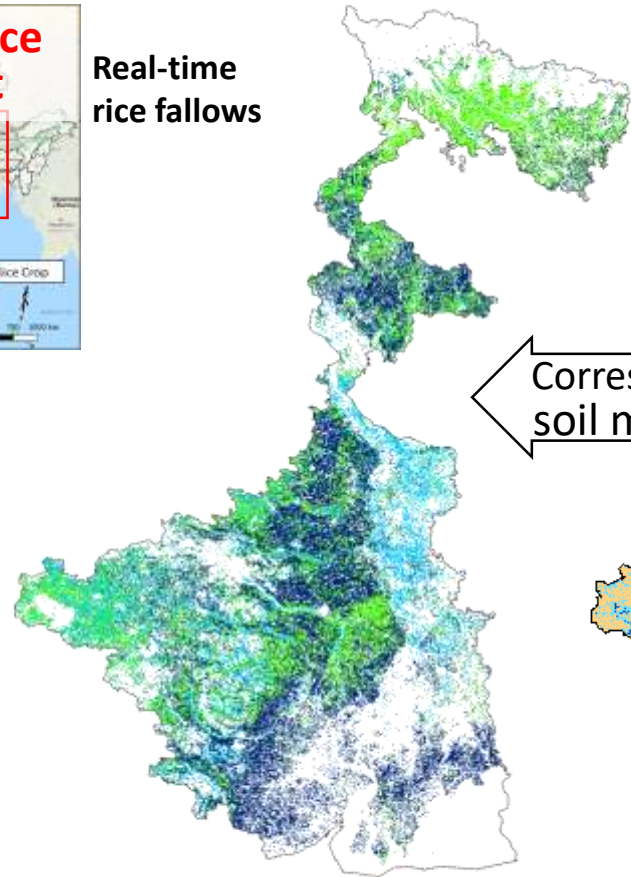


Sustainable intensification of the cereal-based systems with legumes

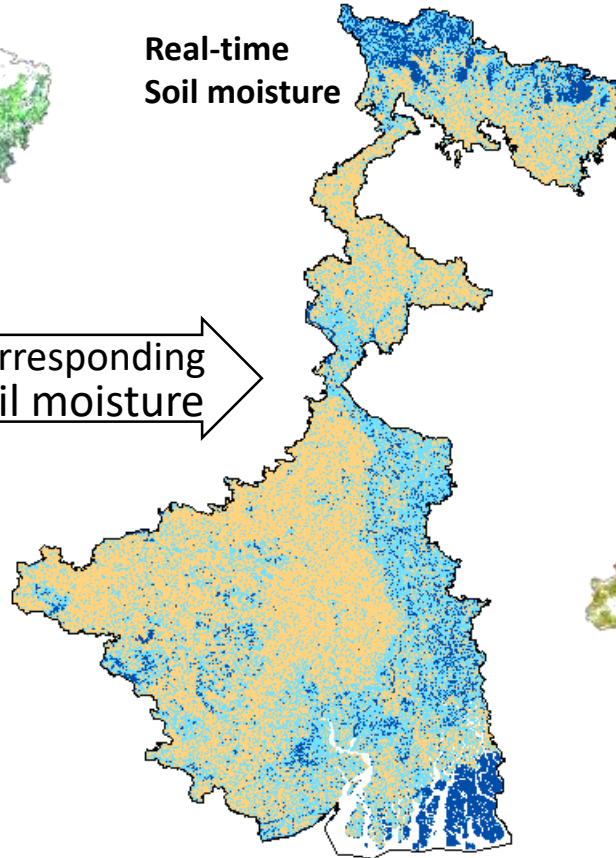
Real-time monitoring to target site specific interventions (package of practices)



Real-time rice fallows



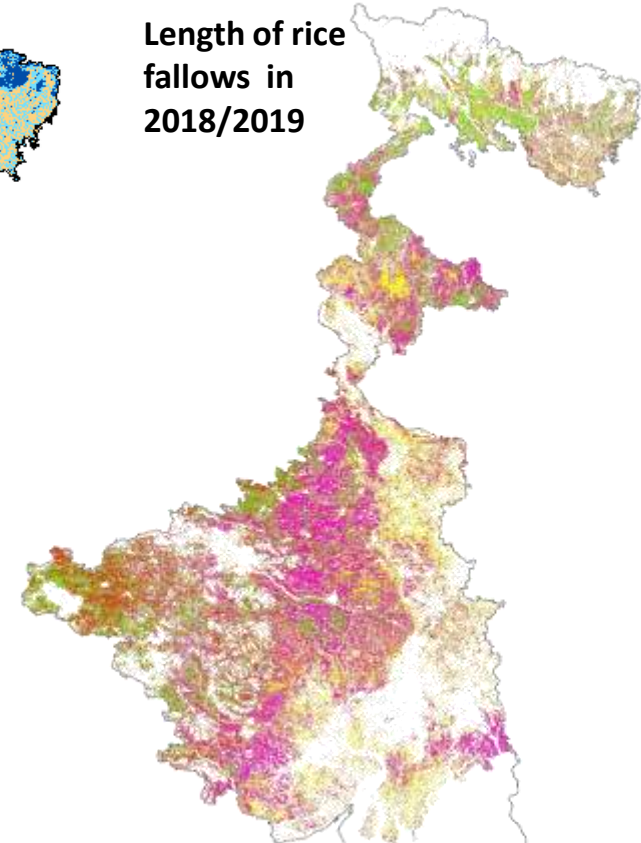
Real-time Soil moisture



Corresponding soil moisture



Length of rice fallows in 2018/2019

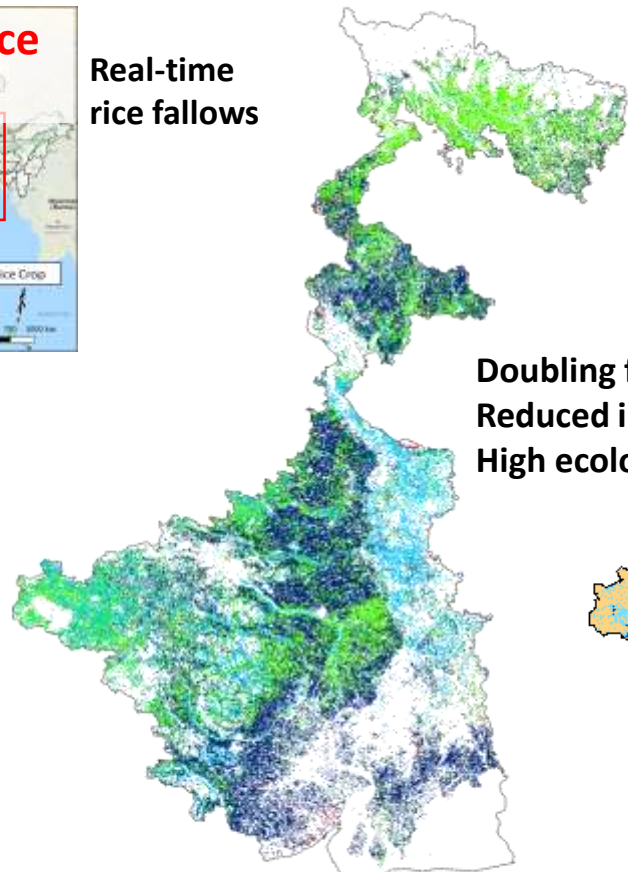


Sustainable intensification of the cereal-based systems with legumes

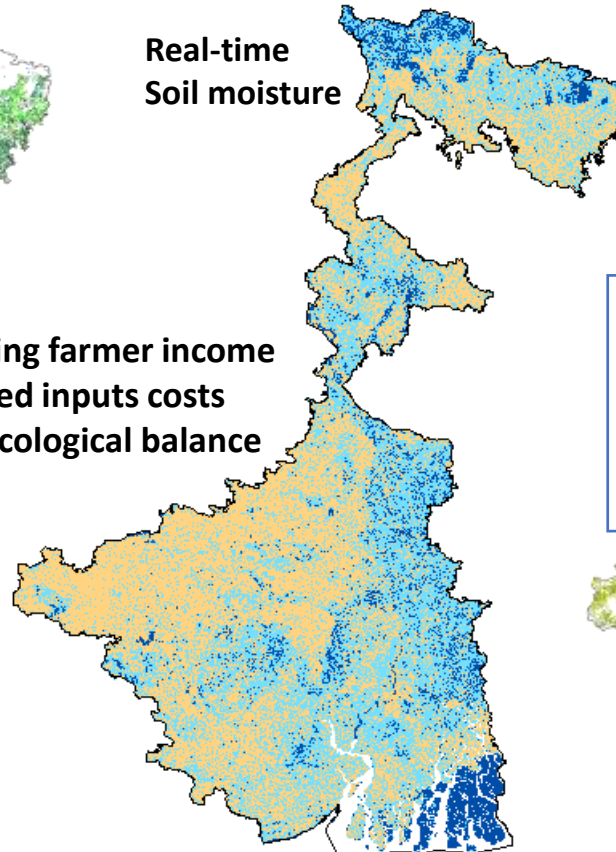
Real-time monitoring to target site specific interventions (package of practices)



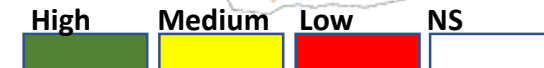
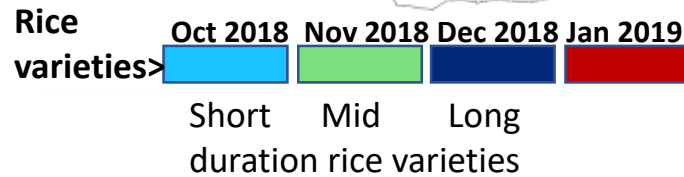
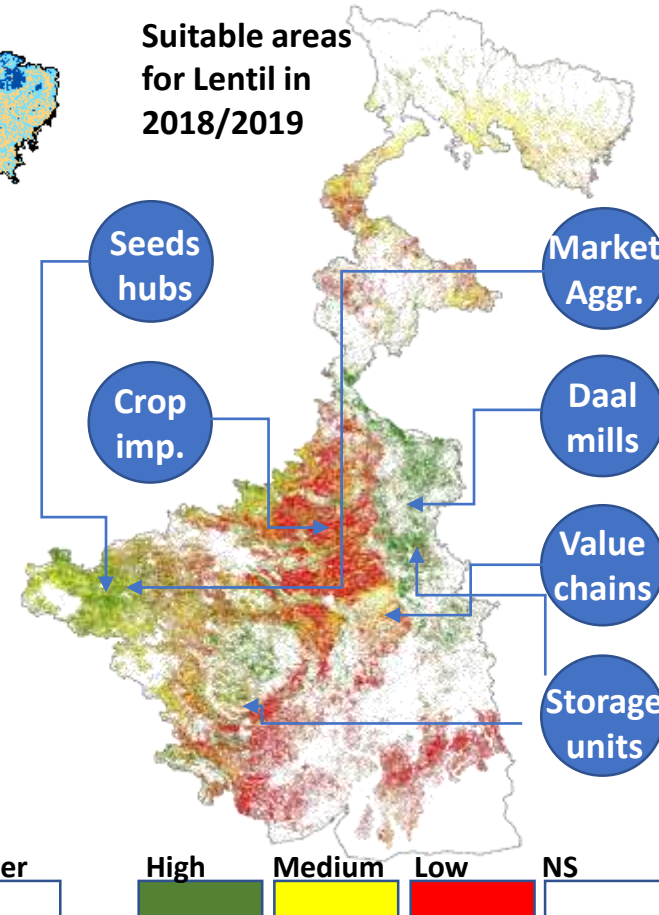
Real-time rice fallows



Real-time Soil moisture



Suitable areas for Lentil in 2018/2019

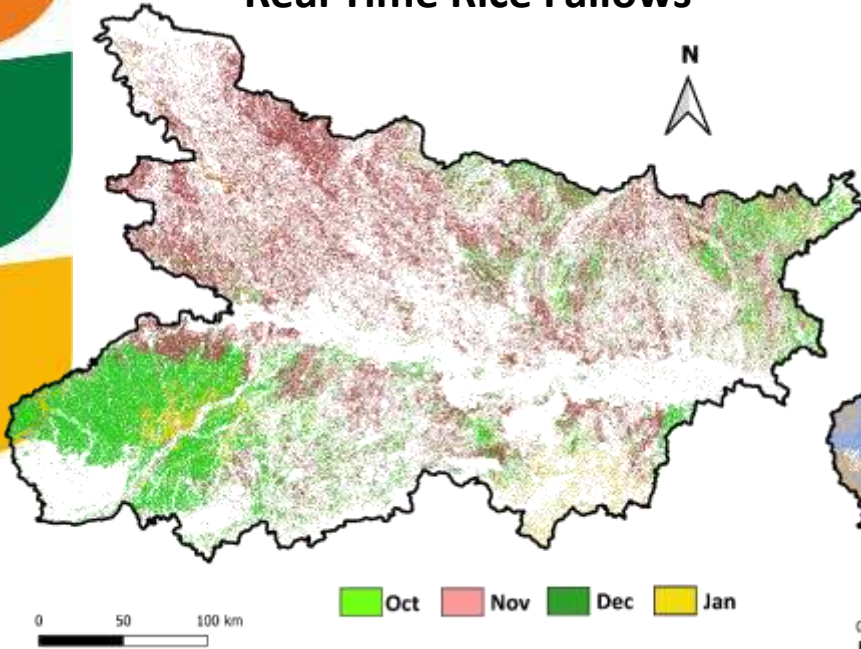


Shift in short duration varieties for both rice and legumes

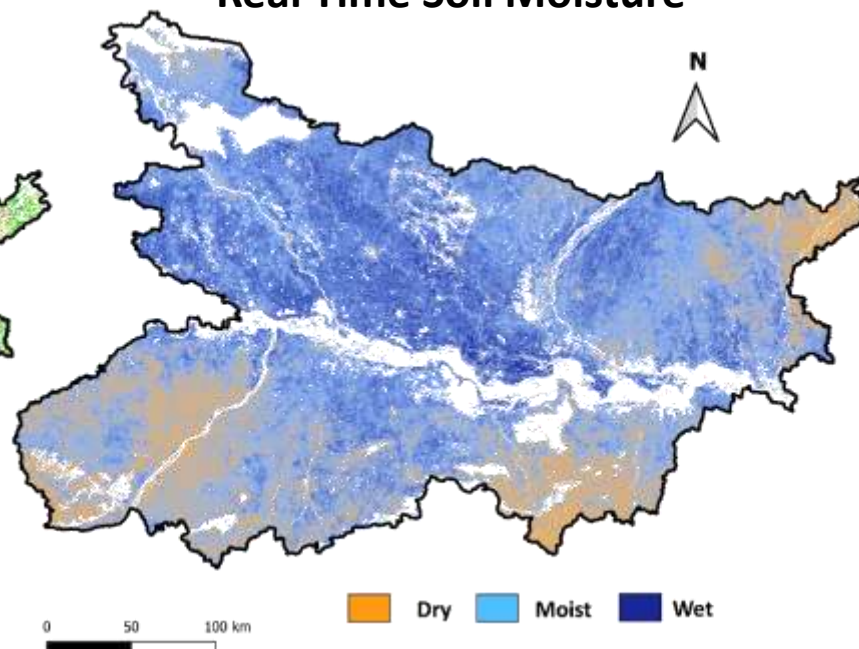
Sustainable intensification of the cereal-based systems with legumes

Scaling options to other regions

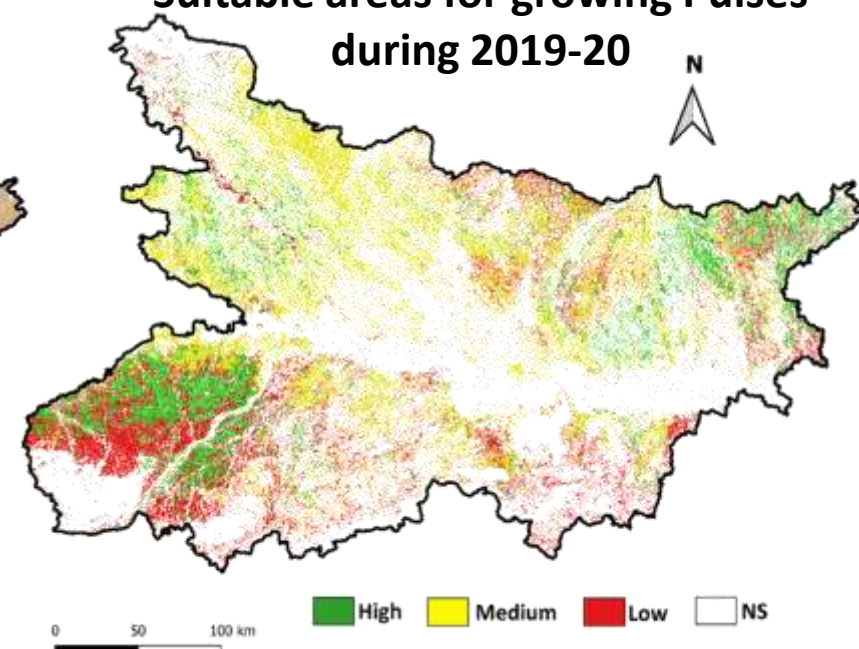
Real Time Rice Fallows



Real Time Soil Moisture



Suitable areas for growing Pulses during 2019-20

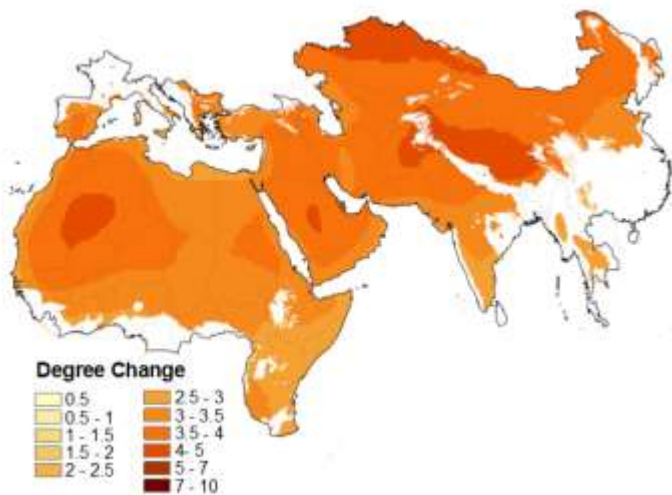


Rice Acreage by MoAFW, Govt of India (2017-18)	Rice Acreage by Sentinel-1 SAR image	All crop Fallows	Rice crop fallows
2.716 Million Ha	2.775 Million Ha	4.25 Million Ha	0.99 Million Ha

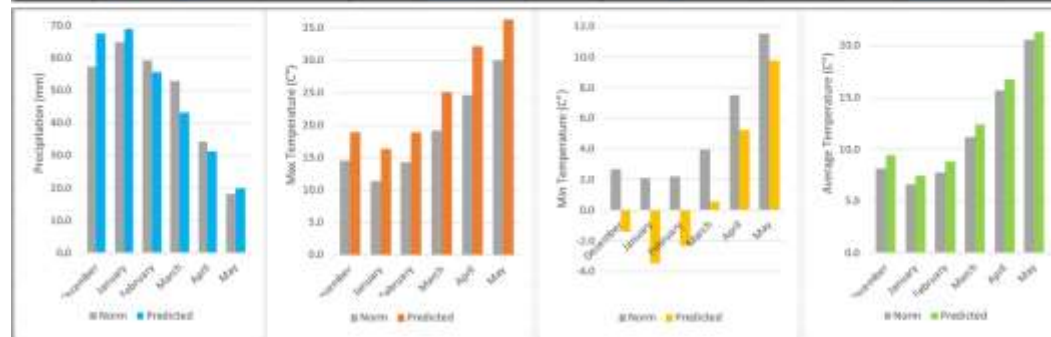
Av. Net Sown Area in Bihar = 5.638 Mha
 # Av. Gross Cultivated area = 7.946 Mha
 # Av. Rice crop Fallows: 0.79 M Ha
 (source: Directorate of Pulses Dev.)

Rice crop fallow areas varies across the years

Potential risks and adaptations for current & future scenarios



Month	Sum Precipitation			Max Temperature			Min Temperature			Average Temperature		
	Norm	Pr. (%norm)	Predicted	Norm	Pr. (%norm)	Predicted	Norm	Pr. (%norm)	Predicted	Norm	Pr. (%norm)	Predicted
December	57.3	58%	67.5	14.6	100%	18.9	2.7	4%	-1.4	8.1	80%	9.5
January	64.8	50%	68.8	11.4	100%	16.3	2.1	3%	-3.5	6.6	68%	7.5
February	59.3	39%	55.7	14.2	97%	18.9	2.2	5%	-2.3	7.7	72%	8.9
March	52.8	29%	43.3	19.2	96%	25.1	4.0	10%	0.6	11.2	74%	12.4
April	34.3	36%	31.2	24.6	100%	32.2	7.5	16%	5.2	15.7	73%	16.8
May	18.1	44%	19.8	30.0	100%	36.3	11.6	14%	9.8	20.6	67%	21.3



Impact on
 ↓
 Productivity
 Production
 Quality
 Trade

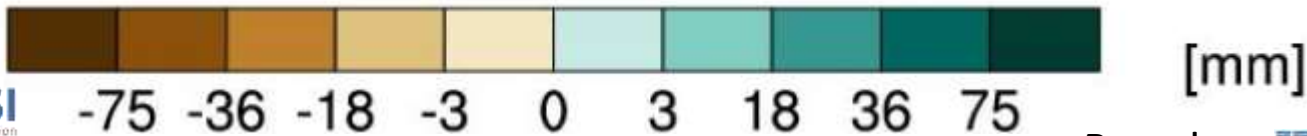
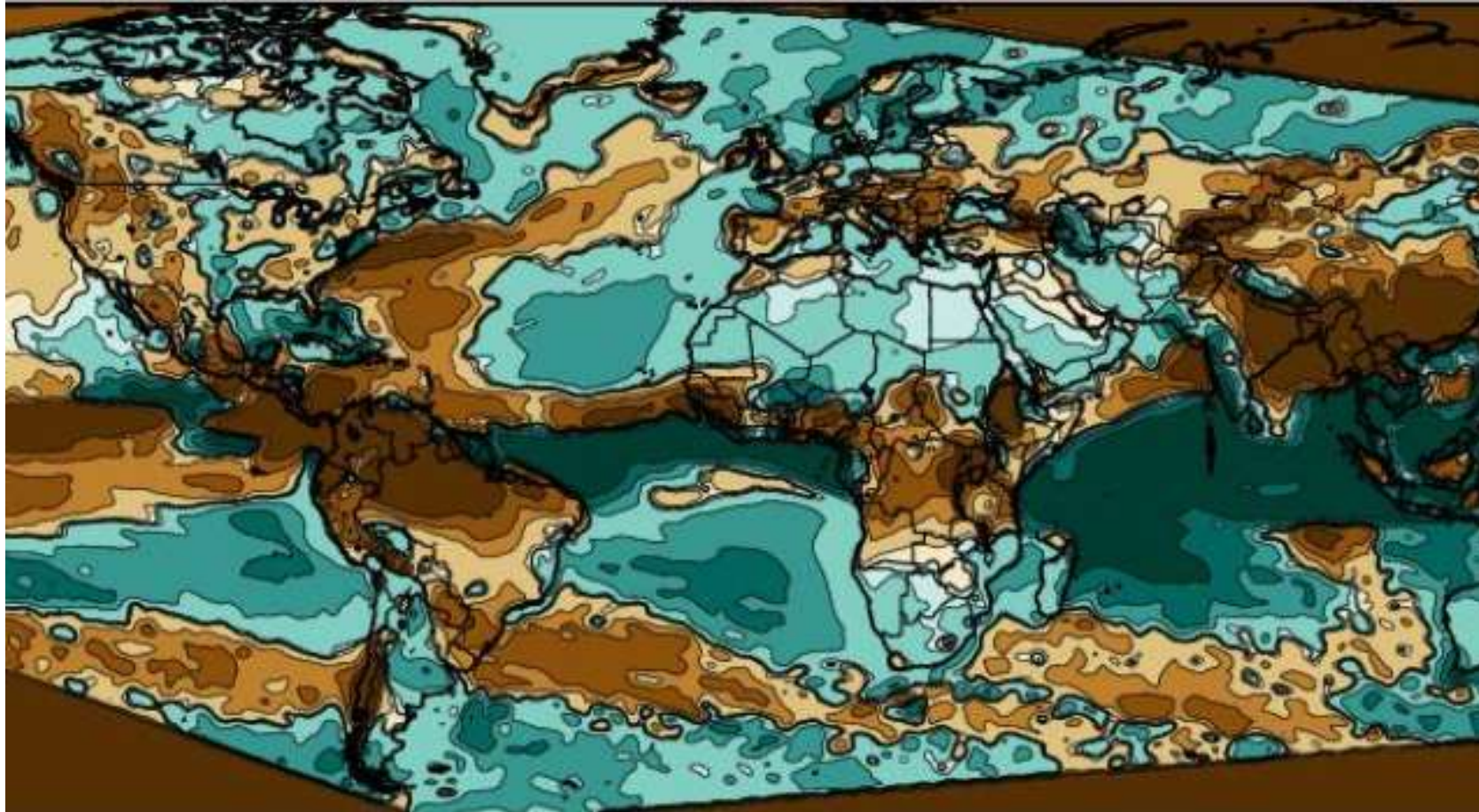


Climate change impacts and scenarios

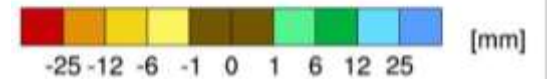
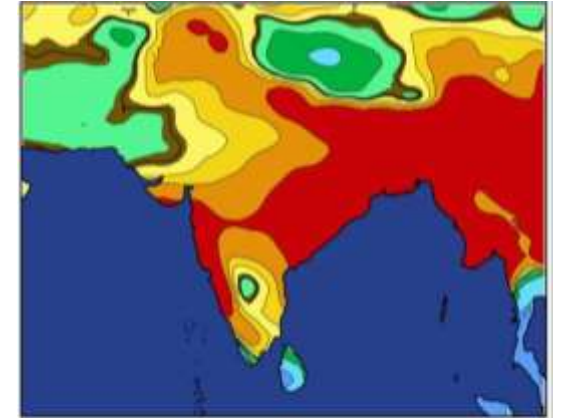
informed decisions in advance
 Predicted risks
 Early warning
 Mitigation measures

Potential climate risk for current and future

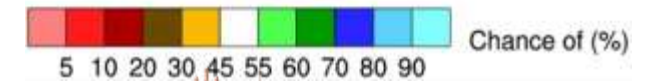
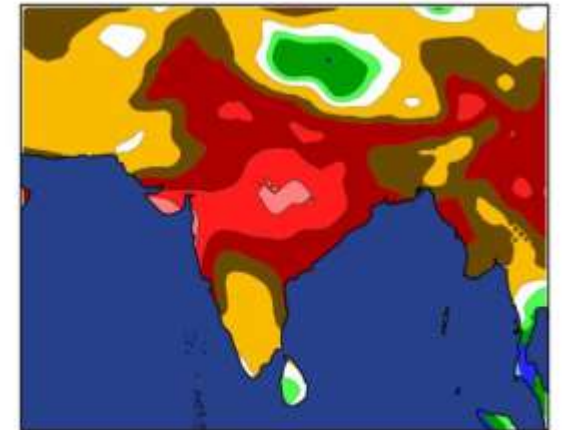
May 2020 - Jul 2020 Precipitation Anomaly Forecast



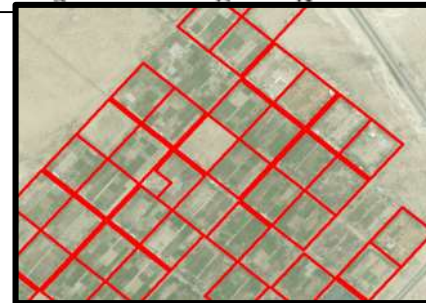
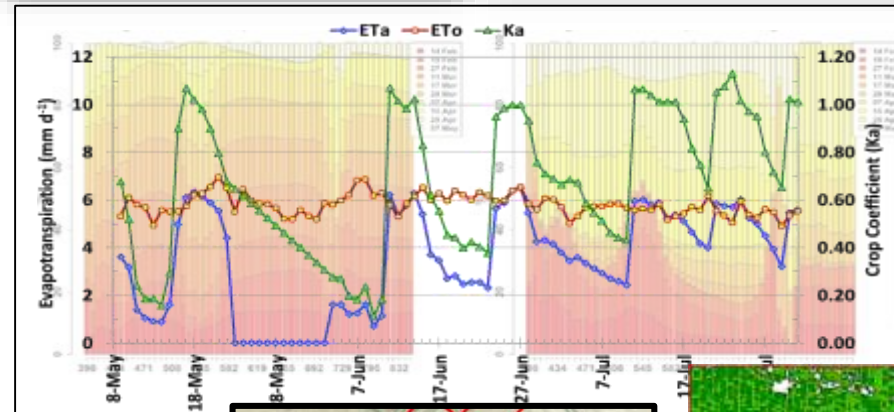
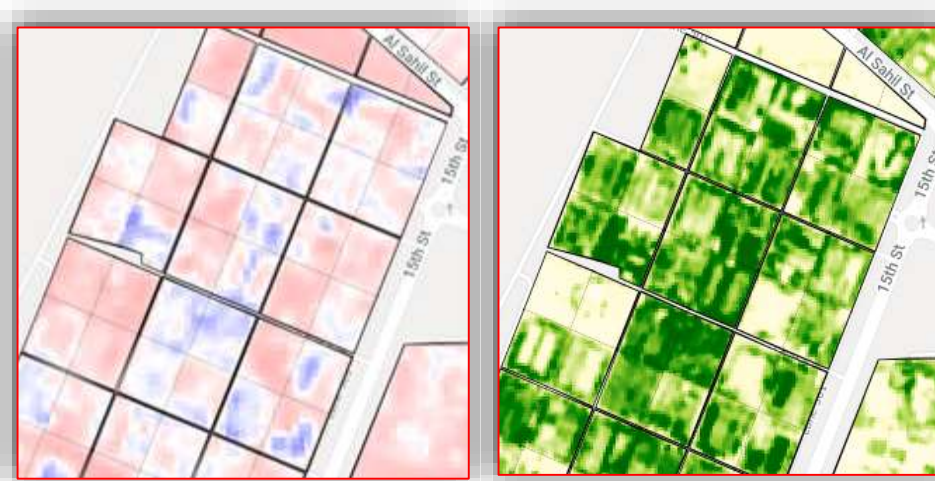
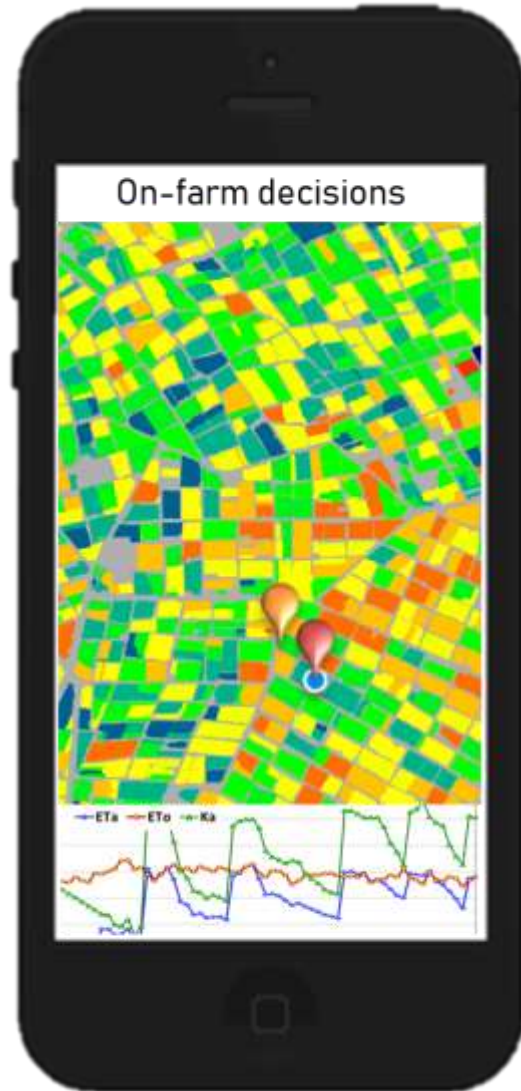
May 2020 Precipitation Anomaly Forecast



May 2020 Precip Chance of Above 100% of Normal

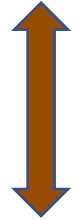


GeoAgro based decisions and dissemination



We need Systemic Innovation for a Sustainable Transformation of Agri-food Systems

Resilience with Farm Diversity



Sustainability with Landscape management




Livelihoods with Market Linkages

 Rainfed



 Irrigated



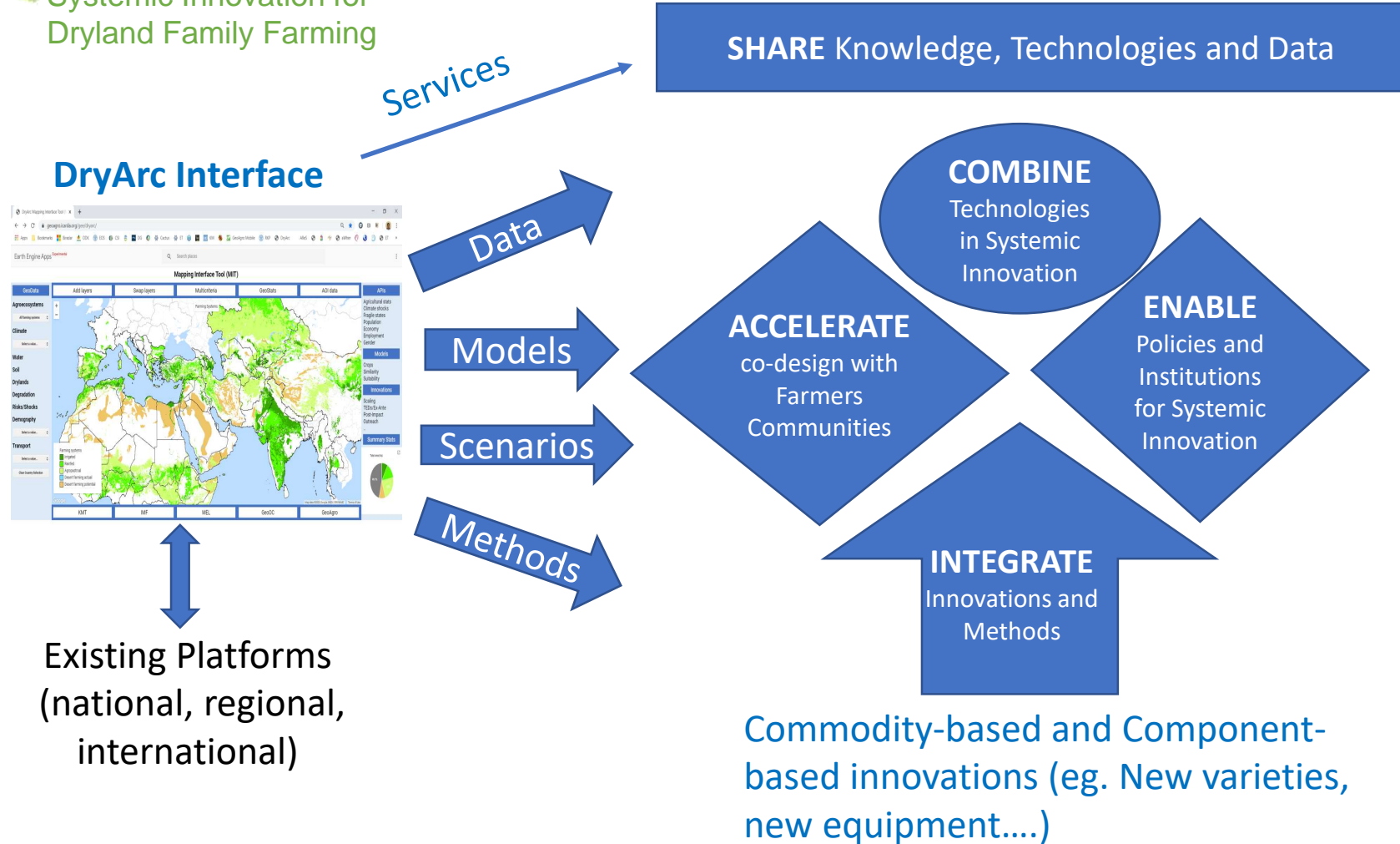
 Agro-Sylvo- Pastoral



 Desert Farming



Five MODULES supported by a Digital Interface to Design and Manage R4D Projects for Systemic Transformation of Dryland Agri-food systems



Dryland Family Farming



Rice fallows

Rice fallows

Herbs and Spices

Crop residue burs

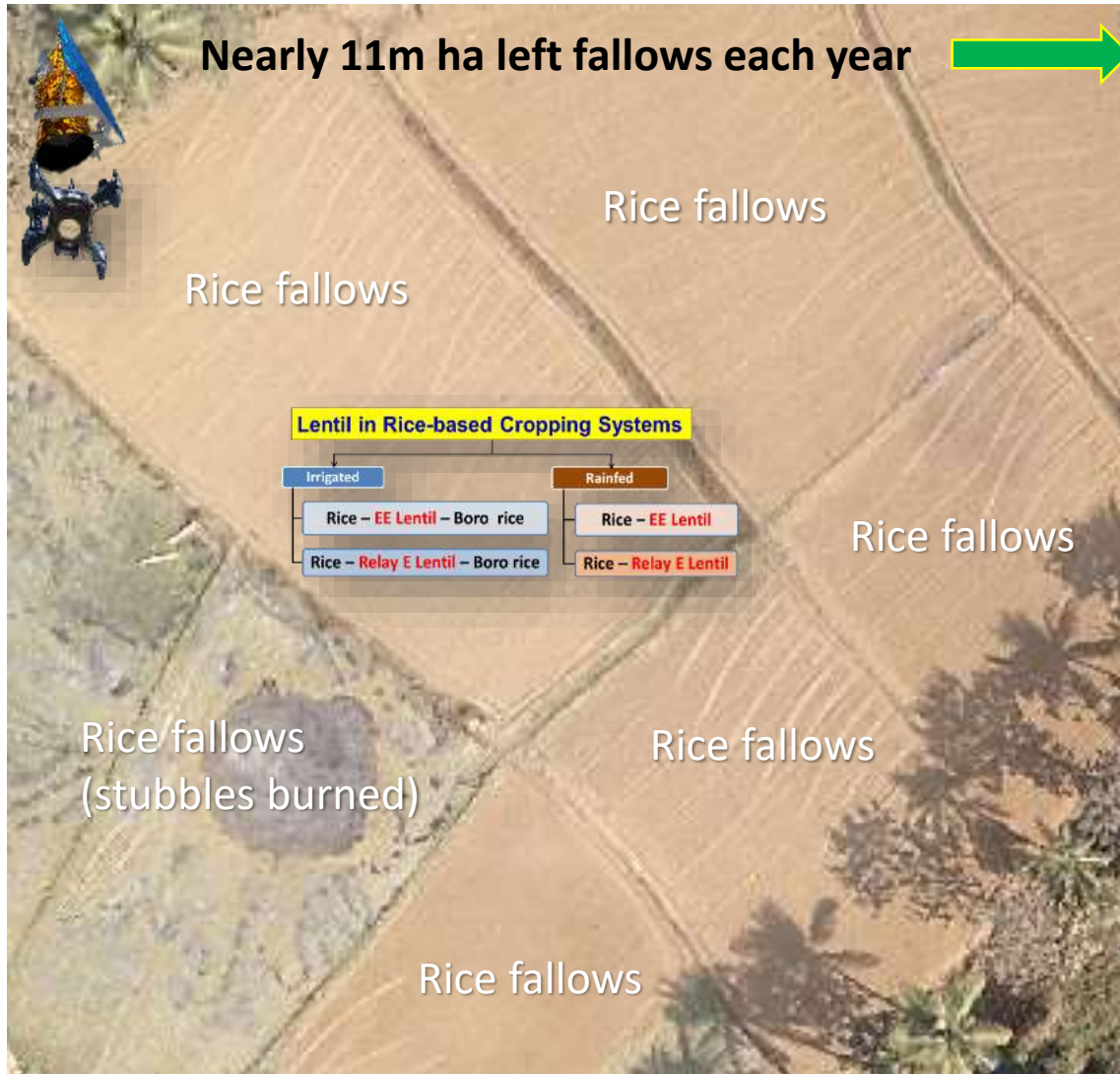
Vegetables
crops

Cash crop
Palm trees

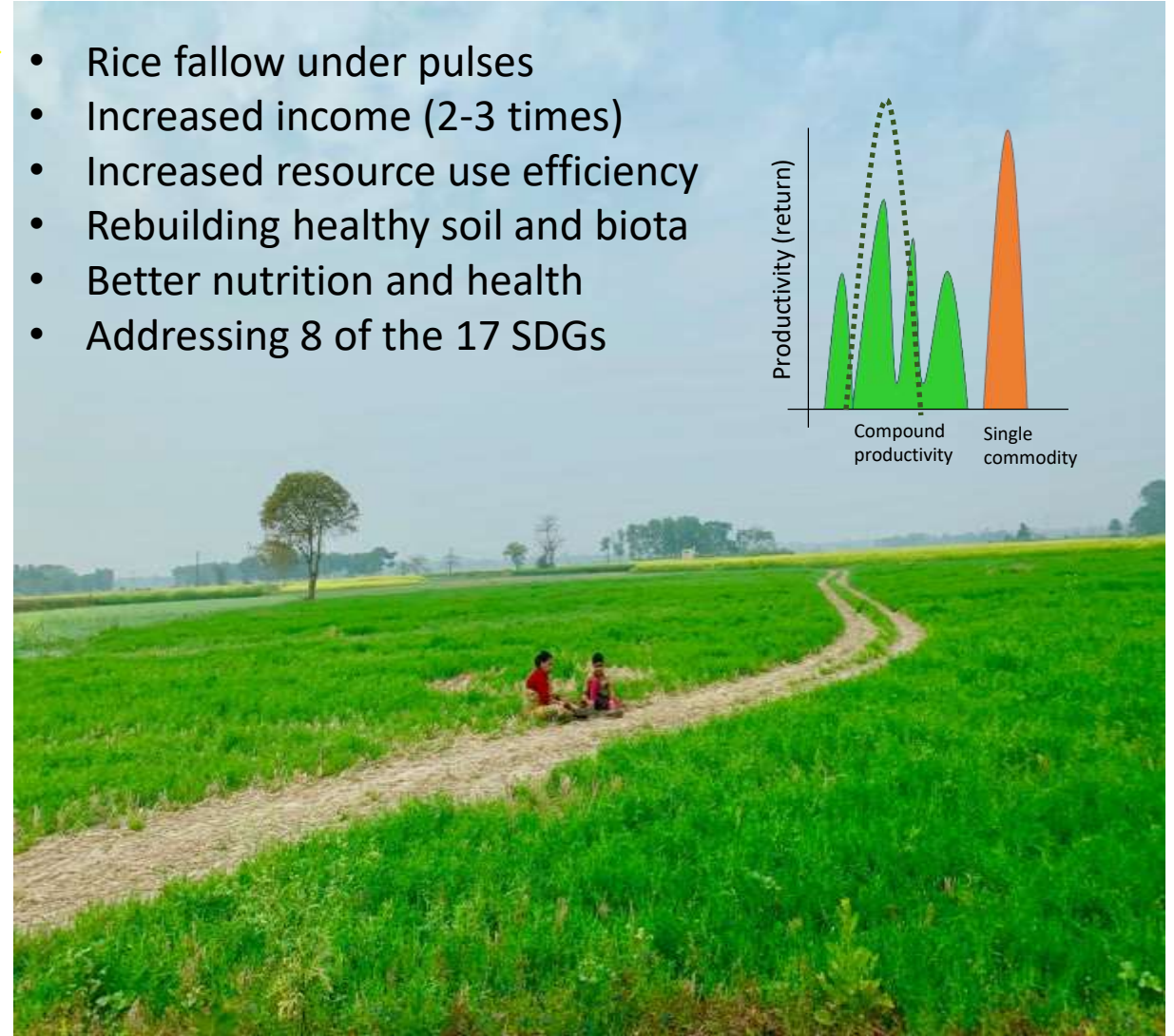
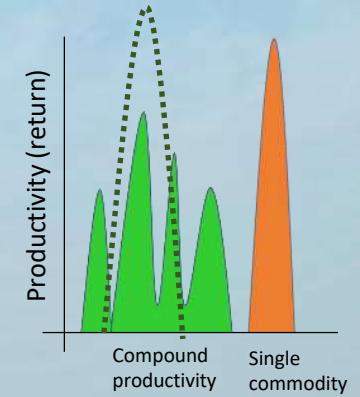
Fruits and Nuts
crops



Drylands (fallows) to Green scapes (pulses)



- 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

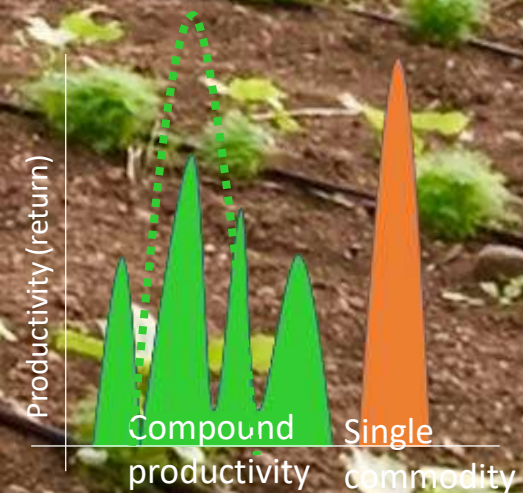


Dryland Family Farming

Planting multiple crops for monthly income while main crop continue to grow

Example1: Growing monthly harvestable crops like salad greens (arugula), red radish, leafy amaranth, coriander, dill, spinach in **main Cotton crop**: high resource use efficiency, less chemical use and high return per unit area with monthly income throughout the season

C. Biradar, own farm experiment



Production follows functions

Let's leverage technology to rebuild functional agri-food systems for sustainable future



Thank You

Special Acknowledgments

Jacques Wery
Deputy Director General-Research

Pasquale Steduto
Senior Water Advisor

All the participating centers and teams