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Science for Better Livelihoods in Dry Areas

Resilient and efficient agro-ecosystems under changing climate and demography

Innovation, Investment, Intervention and Impact

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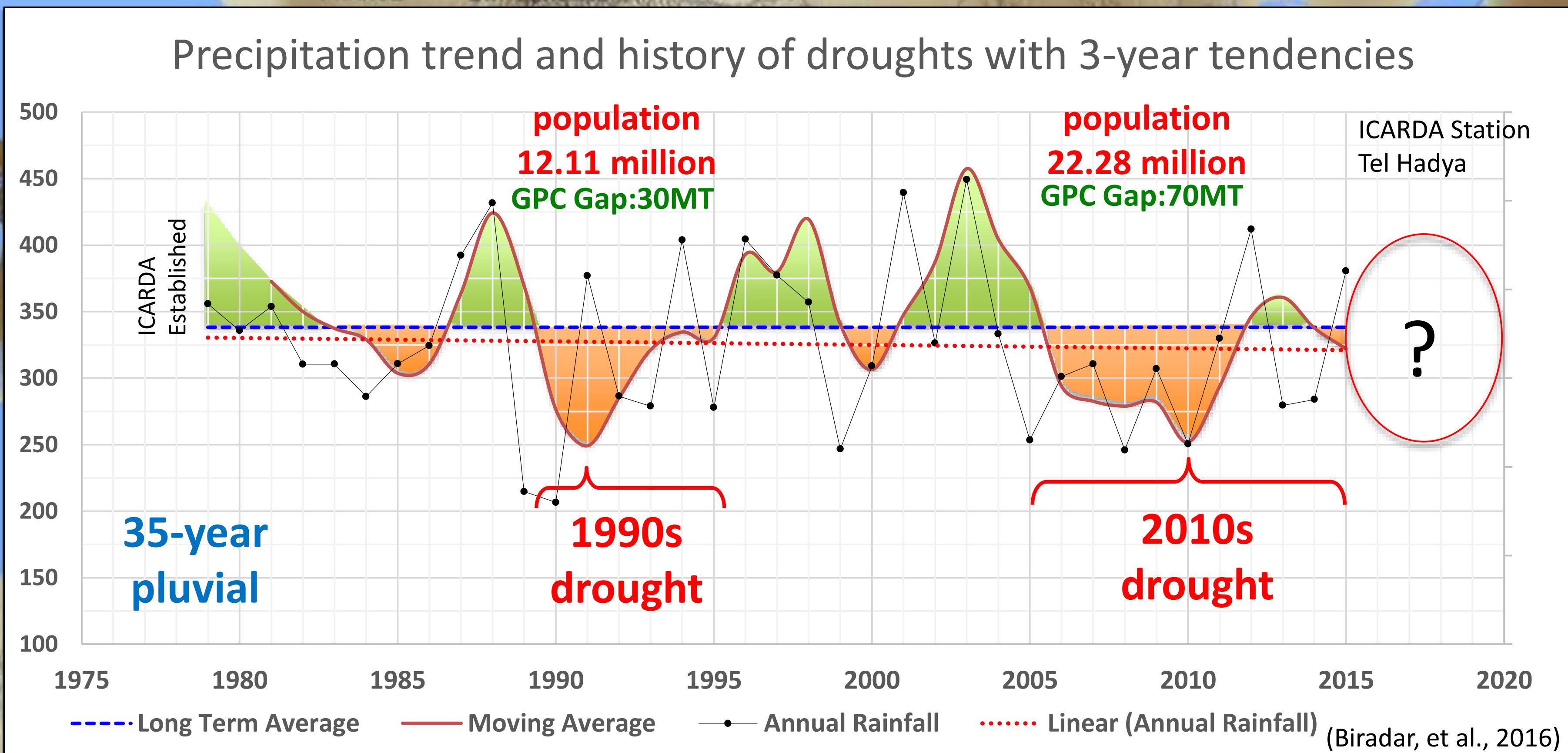
Oct 24-26, 2016
Dharwad, India

Spurring Geospatial Opportunities in Inclusive Agricultural Development

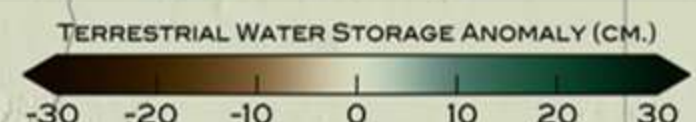
Droughts in Drylands
and the consequences and conflicts

Drought in middle east is worst of past 900 years

Conflicts and migration

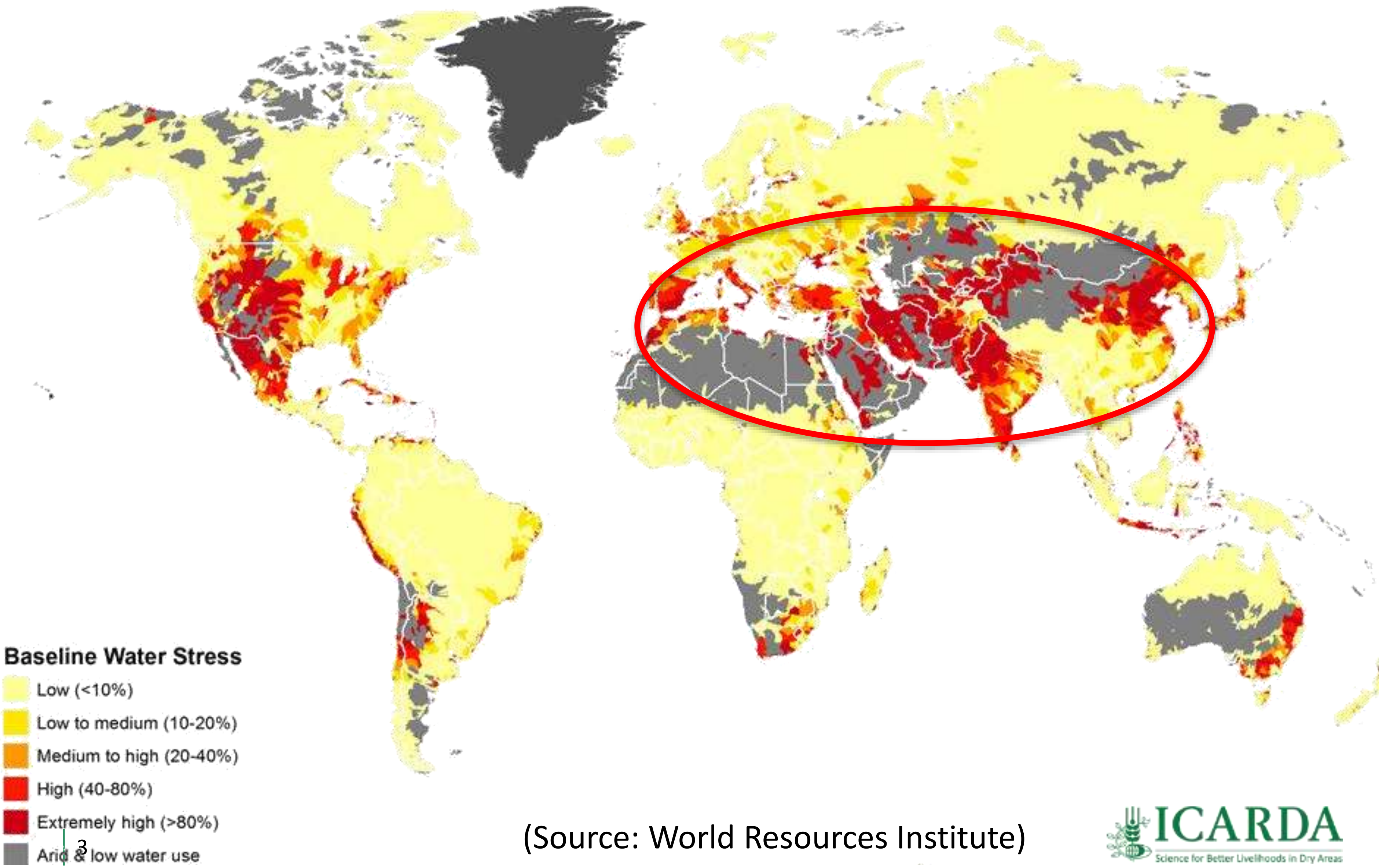


(Biradar, et al., 2016)



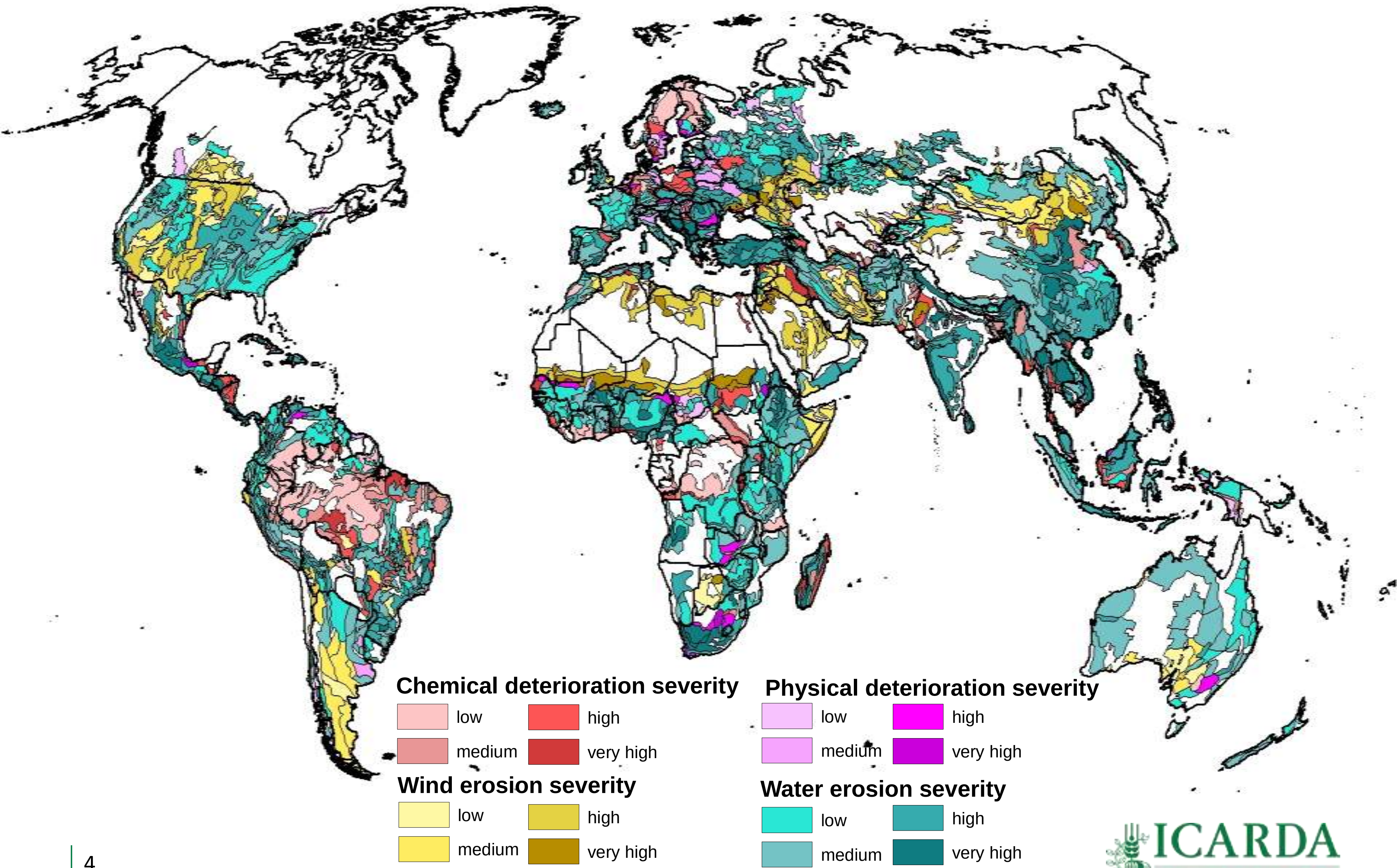
Source: NASA, 2016

Water Stress Around the World

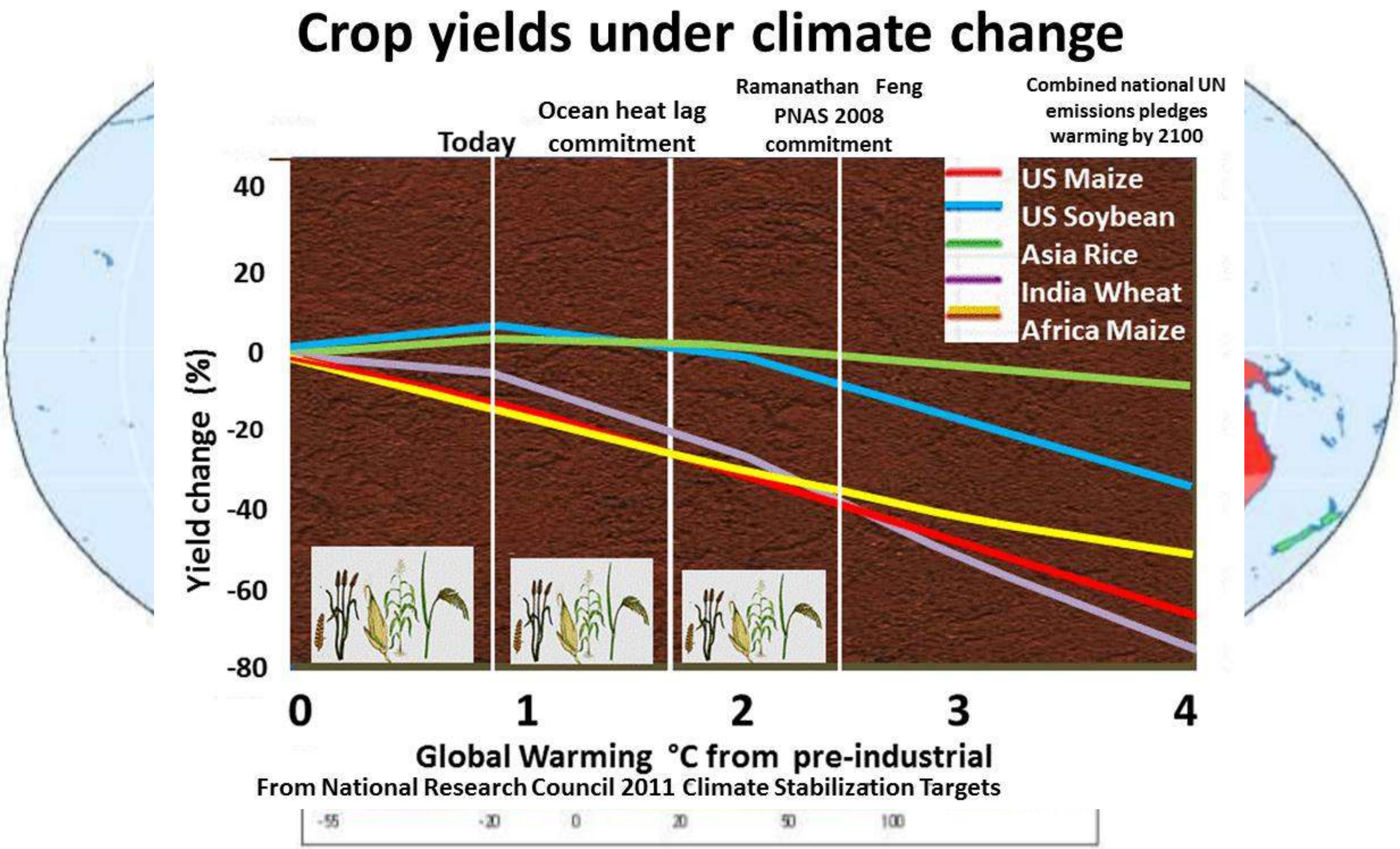


(Source: World Resources Institute)

Land and Soil Degradation



Impact of on agriculture

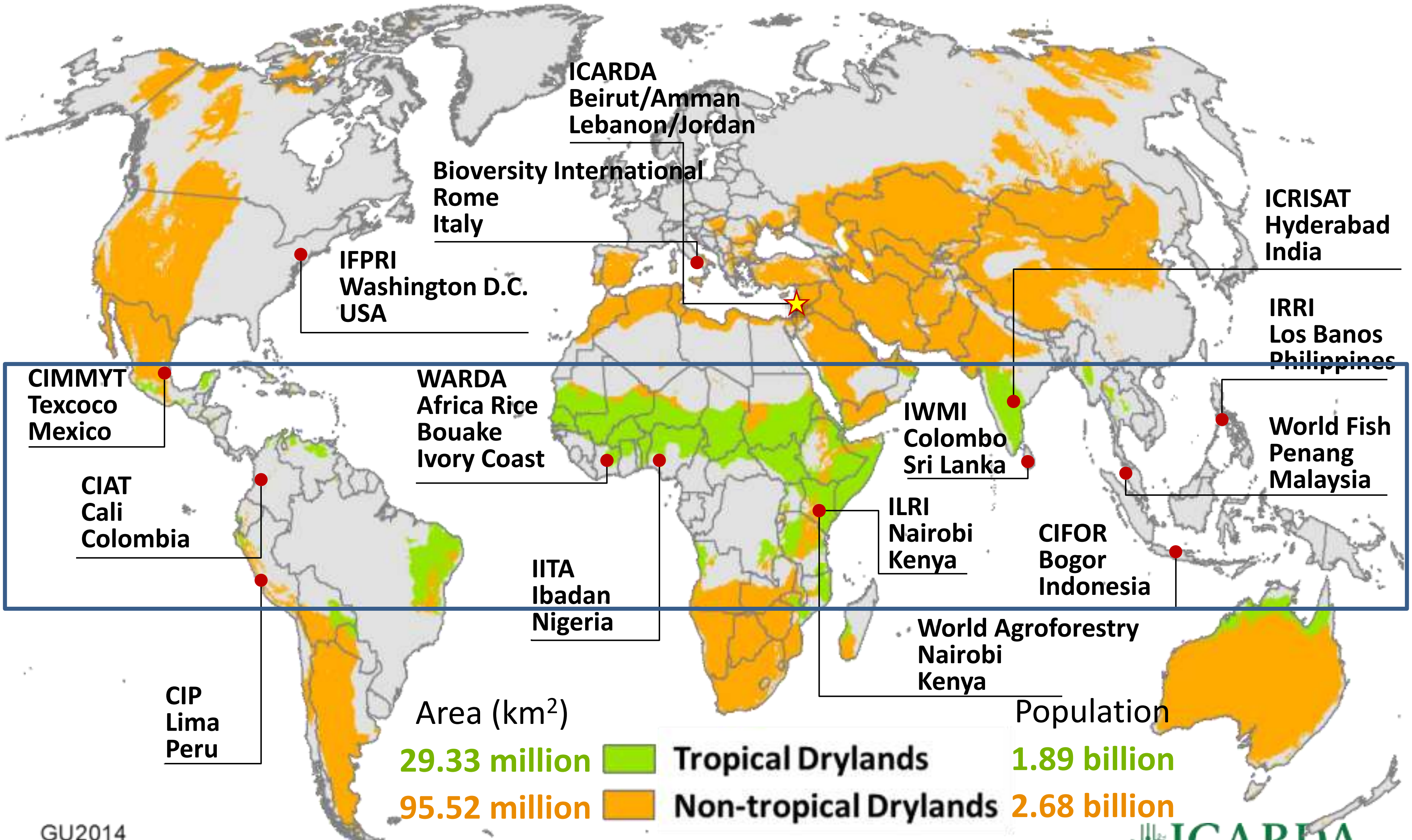


World bank Development report 2010
http://wdronline.worldbank.org/

Wheeler and Baum, 2013.

Global Drylands and CGIAR

tropical and non-tropical drylands



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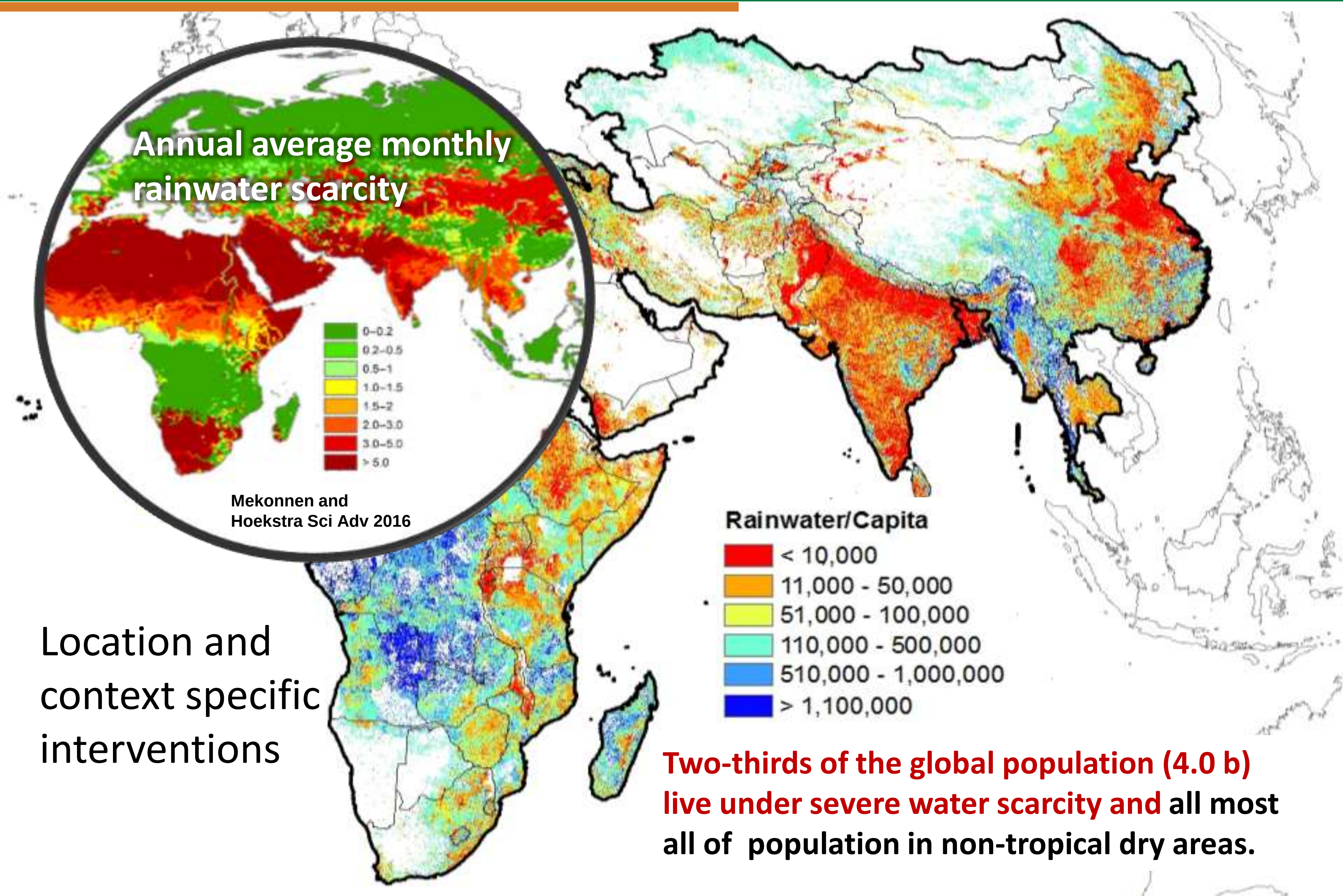
Green Water Resources

rainwater per capita (m^3/person/year)

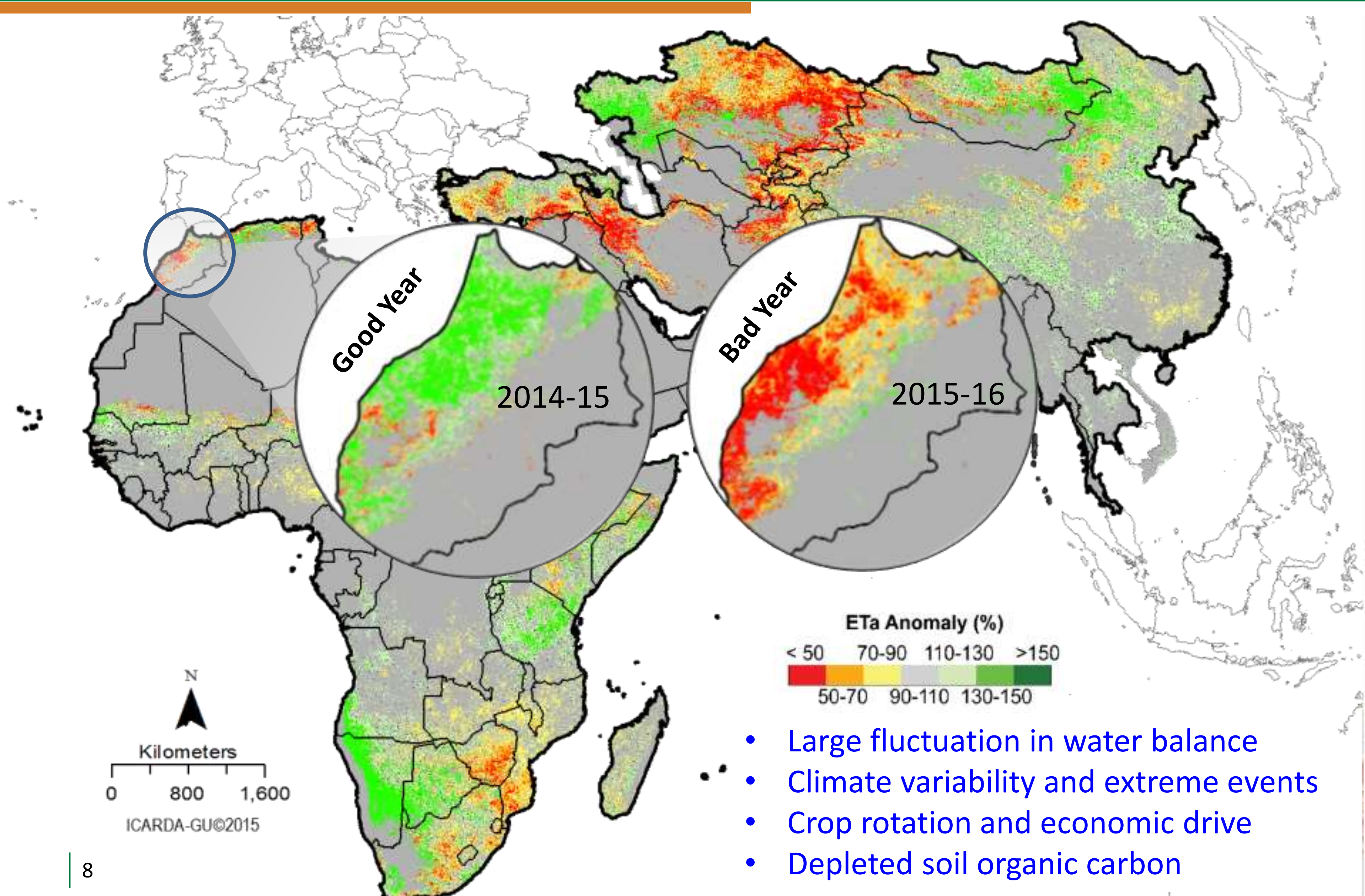


Location and context specific interventions

Two-thirds of the global population (4.0 b) live under severe water scarcity and all most all of population in non-tropical dry areas.

Changing Water Balance

Increasing deviation from long-term averages



- Large fluctuation in water balance
- Climate variability and extreme events
- Crop rotation and economic drive
- Depleted soil organic carbon

Pastoral Agropastoral Rainfed Tree-based Irrigated

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

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

Knowledge based prioritization (space & time) better strategy for intervention, implementation and impact

Eco-Crop Zoning
Water Use Efficacy
Conservation Practices
Adoption/Adaptation
Scaling Technology

- food and environmental security
- cooperative and collective actions
- trade, social security and stability

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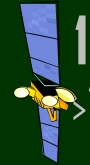
Role of Geospatial Science, Technology and Applications (GeSTA) in Agro-Ecosystems

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



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

5 Key points
1) Ecological intensification, 2) Crop diversification, 3) Input use efficiency, 4) Land degradation, and 5) location specific interventions.

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Food Security

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

Integrated agro-ecosystems: innovative approaches for site integration with common domains and data collection & synthesis

Mapping present, emerging and future land use /land cover dynamics, cropping patterns, rangelands, pest & diseases risks, climate change and impacts

Quantification of agricultural production systems

System modelling for increasing resilience and assist in identifying on-demand mitigation pathways with biophysical, socioeconomic and stakeholder feedback as well as specific needs & constraints

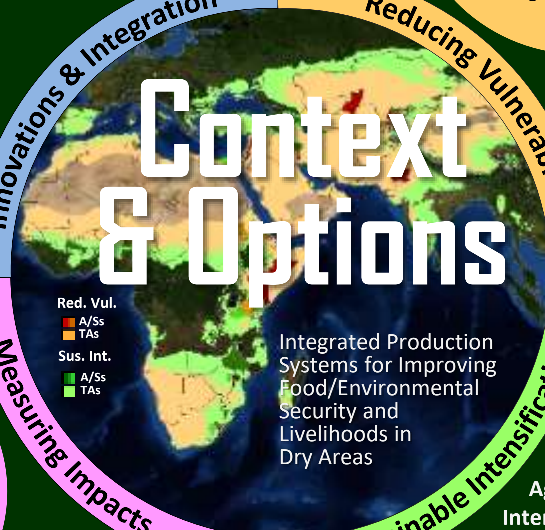
Ensuring Environmental Flows and ESs

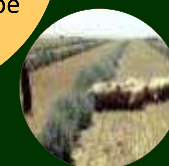
Cooperative Collaborative Research and Partnerships

Characterization of agro-ecosystem production and land/water degradation at farm to landscape scales

Gender
Spatial pattern, distribution and resource access matrix

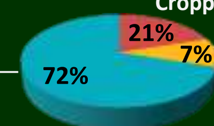
Drylands 41% Earth's land area





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

increased **Food production** potential sources



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

Mapping land/water productivity, potential areas intensification, diversified dryland agriculture, and 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

Status & trends of existing production systems

Delineation of potential, suitable areas for sustainable intensification, diversification, and innovation platforms

People 2.5b Live in Drylands

Assessment of droughts, floods, pests & diseases, extreme events, migration

Health
Changing diet patterns, nutrition and health

Improved Livelihoods

Livestock 1.5b Depend on Drylands

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RESEARCH PROGRAM ON
Dryland Systems
Associated CRPs

UASD Research, Outreach and Capacity Building

25 Research & Educations Div.

30 Research Stations

Crop improvement

Genetic screening

Value chains

Pests & Diseases

Biophysical

Biospectral

Climate Change

System Approach

Input efficiency

Yield gaps

Soil health

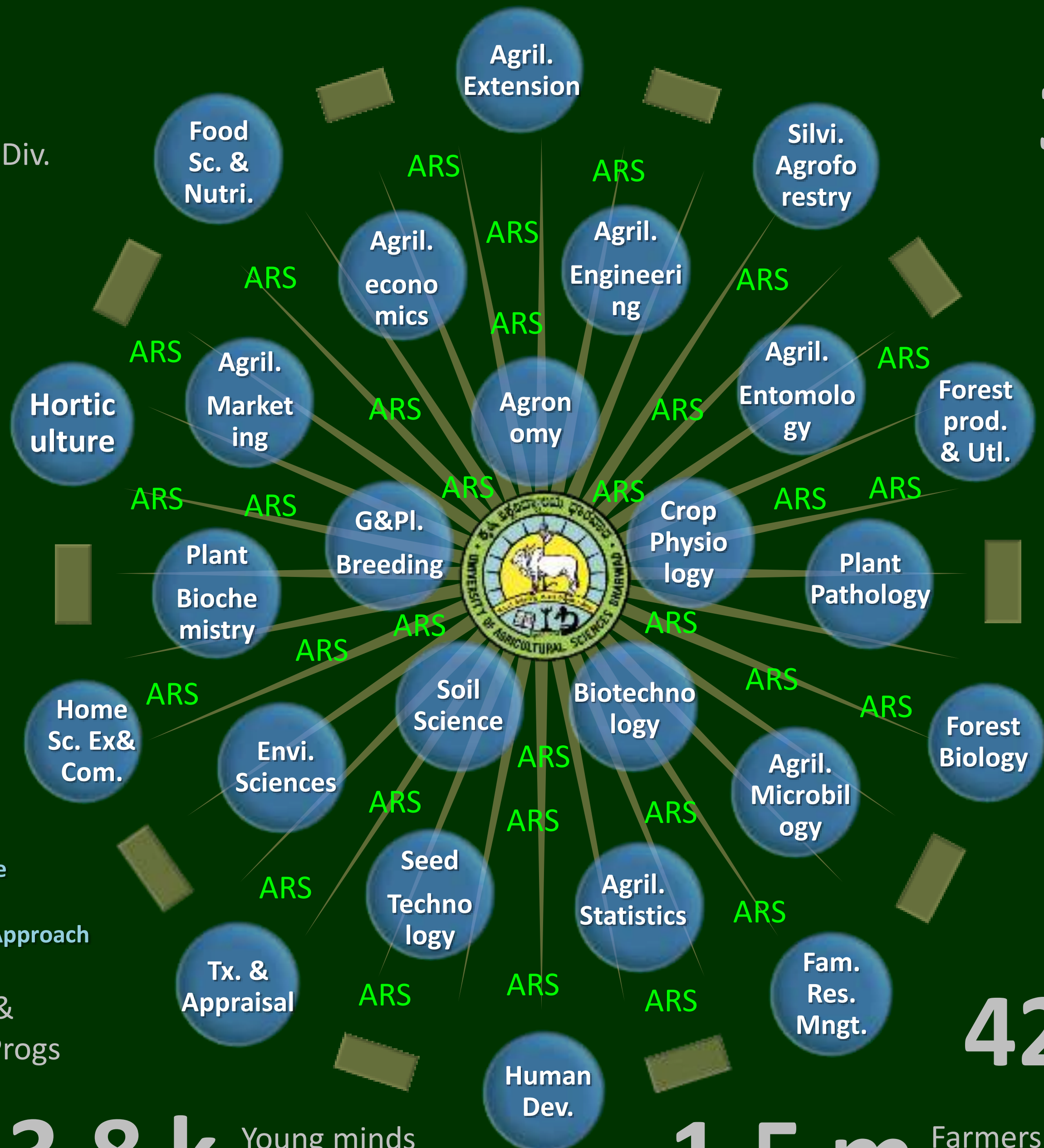
Conservation

Agro-biodiversity

Intensification

Diversification

M & E

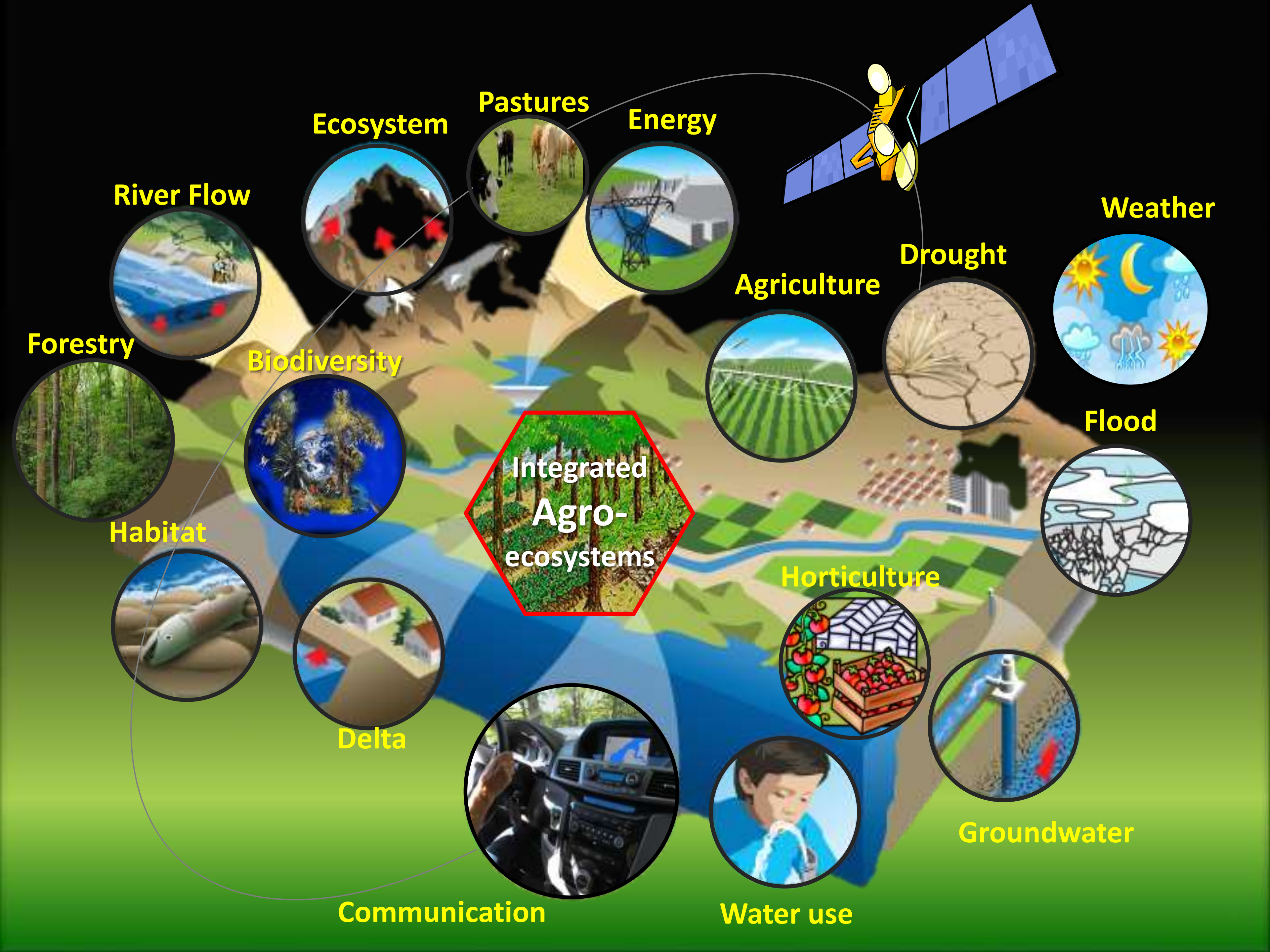


47 Doctoral & Masters Progs

425 Scientists & Faculties

3.8 k Young minds Students

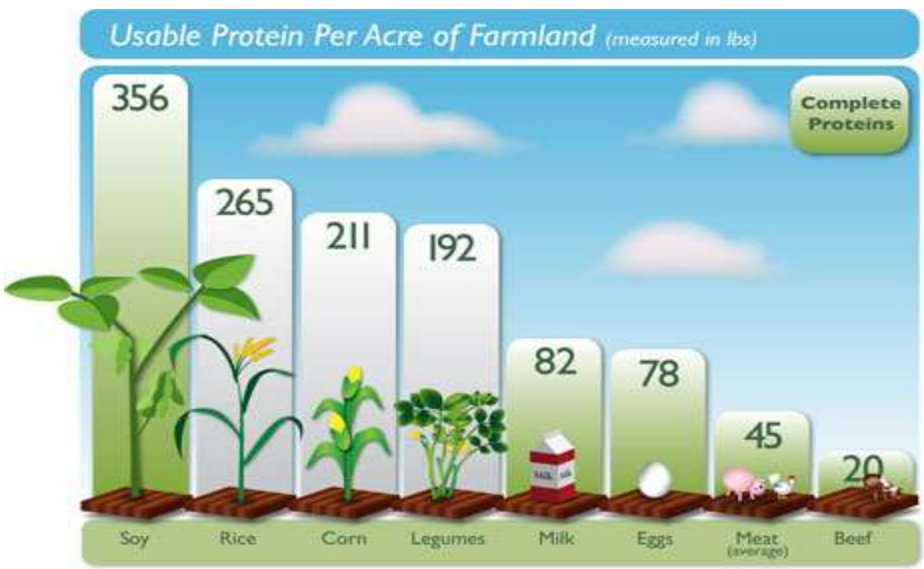
1.5 m Farmers attend Krishi Mela


Pastures
Ecosystem
Energy
River Flow
Weather
Drought
Agriculture
Forestry
Biodiversity
Flood
Integrated
Agro-
ecosystems
Habitat
Horticulture
Delta
Groundwater
Communication
Water use

Water, Nutrition, Ecology and Climate Change

Why dryland crops and crop diversification?

- Economically-Nutritious
- Ecological-Soil Health
- Improved Productivity
- More Climate Resilient
- Reduce Virtual Water Trade



http://www.soyfoods.org/

USDA; FAO/WHO/UNICEF Protein Advisory Group (2004)

Reduce Loss and Produce More

Water-Efficient-Ecological Food Production

Daal/Falafel (1kg)
1,250 liters

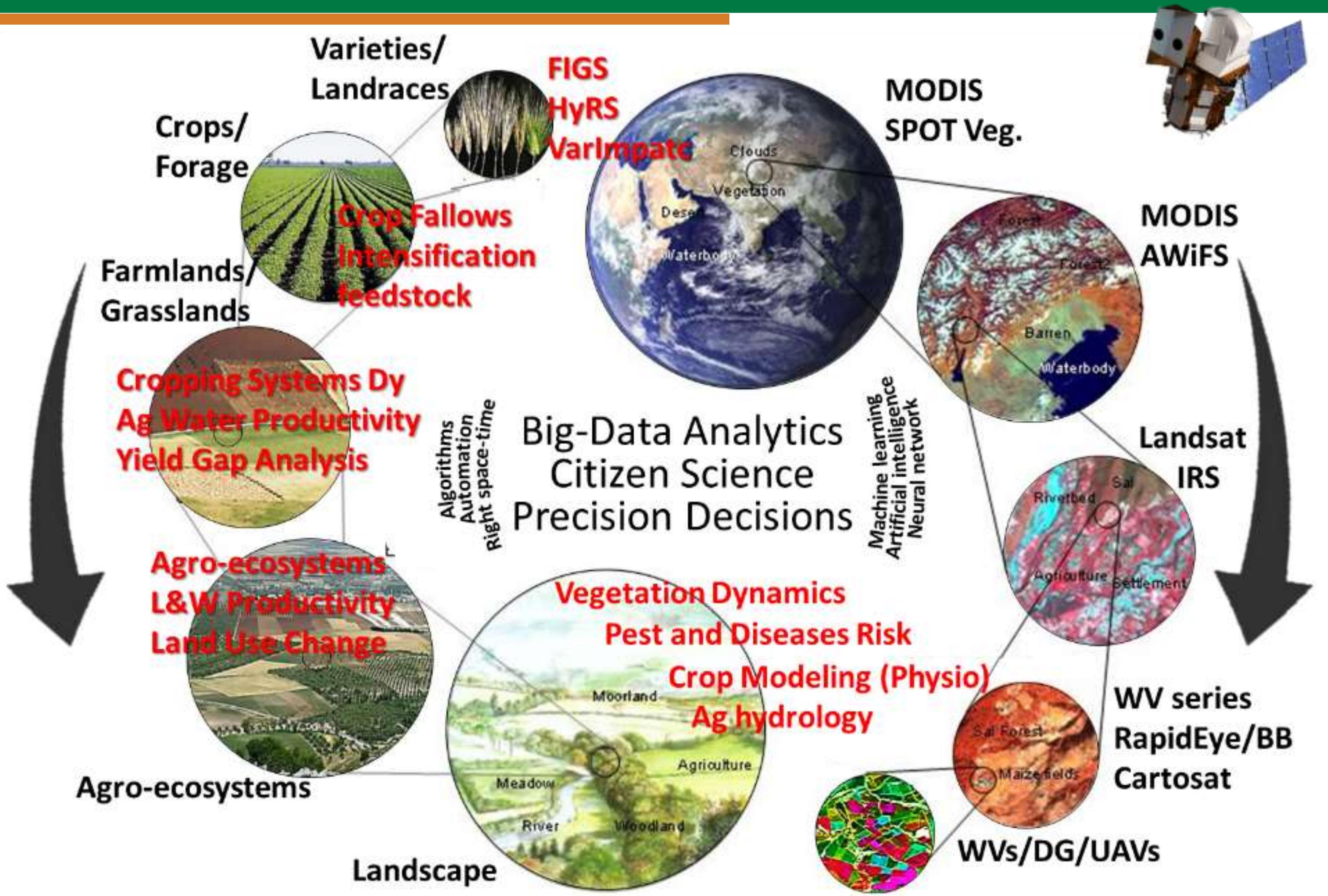
Chicken (1kg)
4,325 liters

Mutton (1kg)
5,520 liters

Beef (1kg)
13,000 liters

EOS in Agricultural RDO

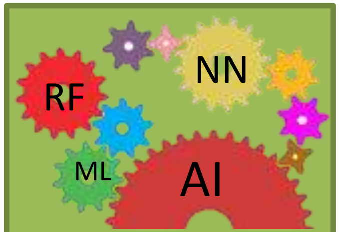
Scaling Trade-on/offs
Farmscapes to Landscapes



Digital Agriculture Platform

Image Based, Open Source Precision Decision at Farm scales

Citizen Science
Community of Practices



Cadastral, Object & Pixel based

Biophysical and socio-ecological

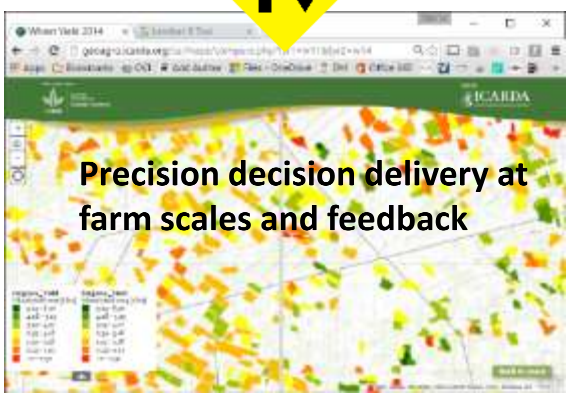
Machine Learning
Crop types, crop intensity, pattern, fallows, crop stress, AET-l8, soil moisture-SMAP

Citizen-Science Cellphone feedback

Direct Access and Markets/Trade

Precision-Decision

Timely-Access-Application-Trading (TAAT)



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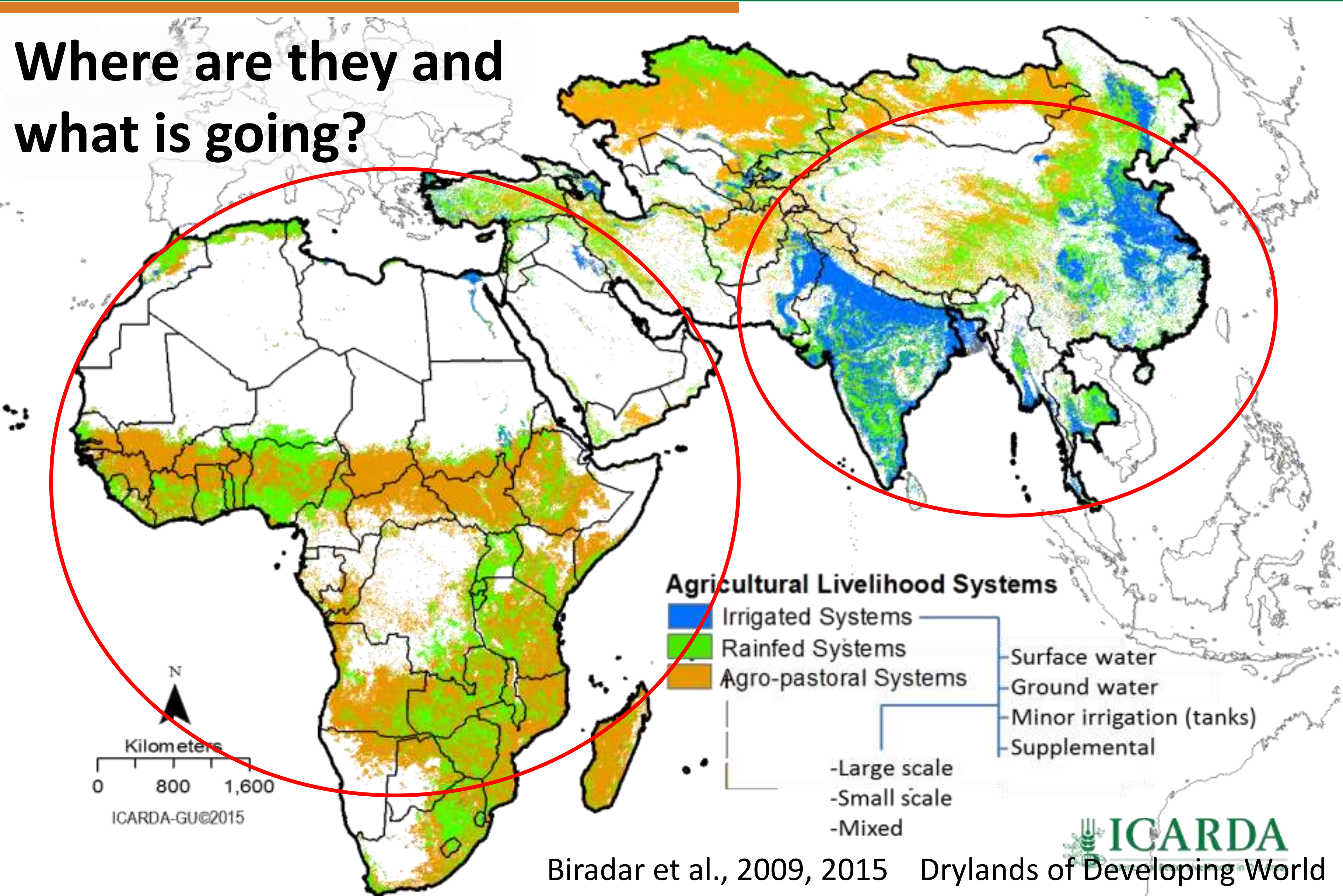
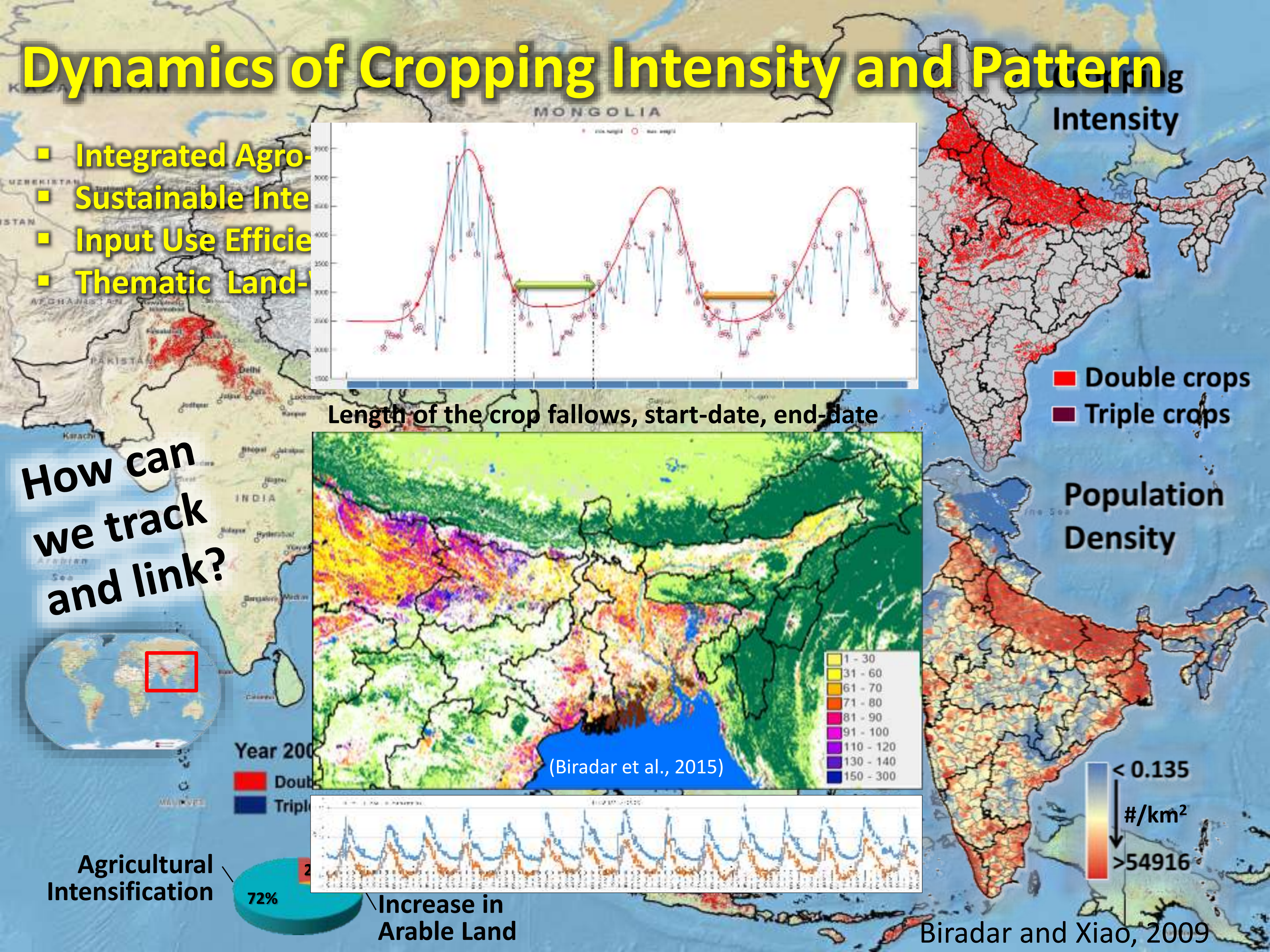
Existing Agricultural Production Systems

Where are they and what is going?



Biradar et al., 2009, 2015 Drylands of Developing World


Dynamics of Cropping Intensity and Pattern
Integrated Agro-
Sustainable Inte
Input Use Efficie
Thematic Land-
Length of the crop fallows, start-date, end-date
How can we track and link?
(Biradar et al., 2015)
1 - 30
31 - 60
61 - 70
71 - 80
81 - 90
91 - 100
110 - 120
130 - 140
150 - 300
Cropping Intensity
Double crops
Triple crops
Population Density
< 0.135
#/km2
>54916
Year 200
Doub
Tripl
Agricultural Intensification
72%
Increase in Arable Land
Biradar and Xiao, 2009

Quantification of its dynamics

Under changing Climate and Demography

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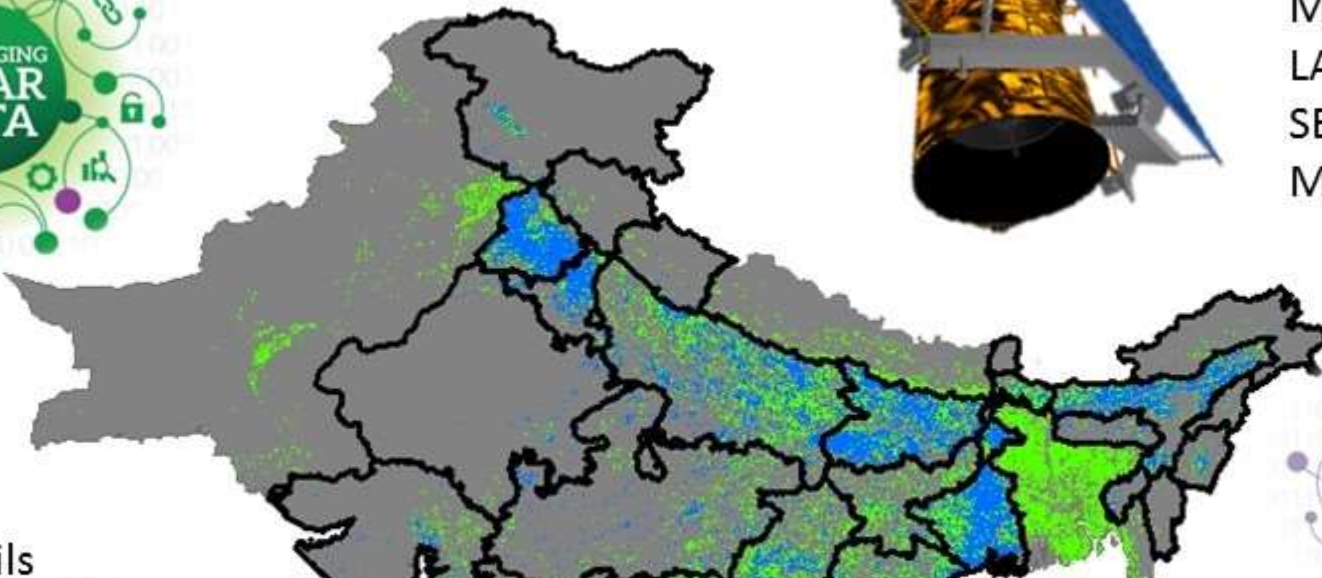
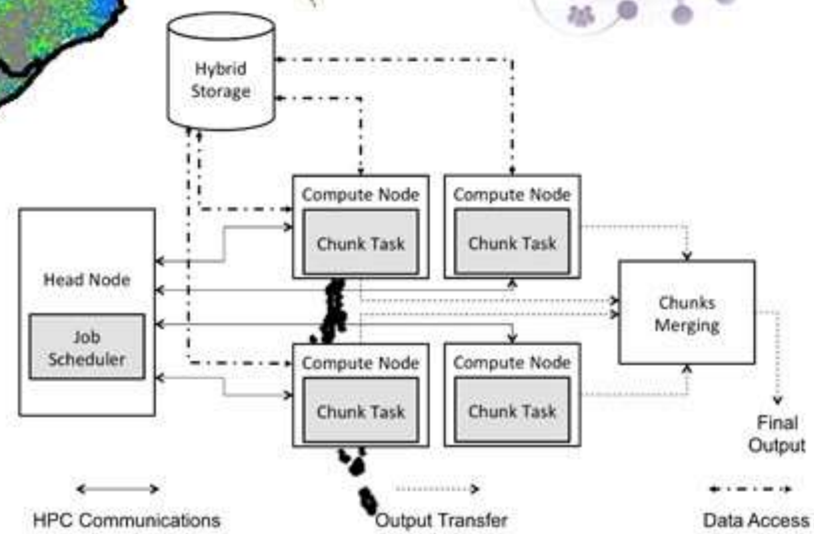
Remote Sensing
- MODIS
- LANDSAT
- SENTINEL
- MICROS



GeoStats
AgCensus
Climate, Soils
Demography

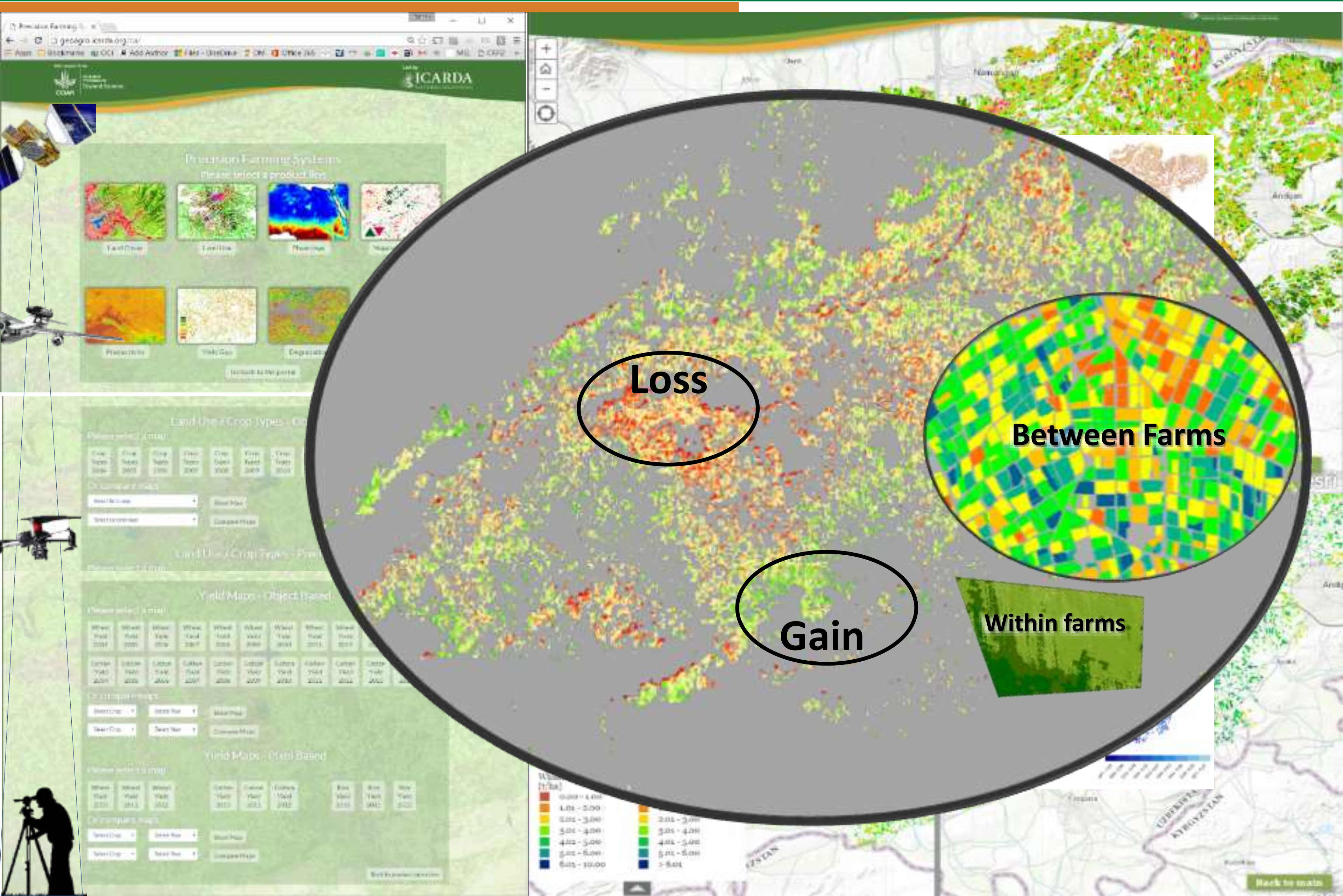
Open Source
Cloud Computing
Algorithms

Biradar, 2016*



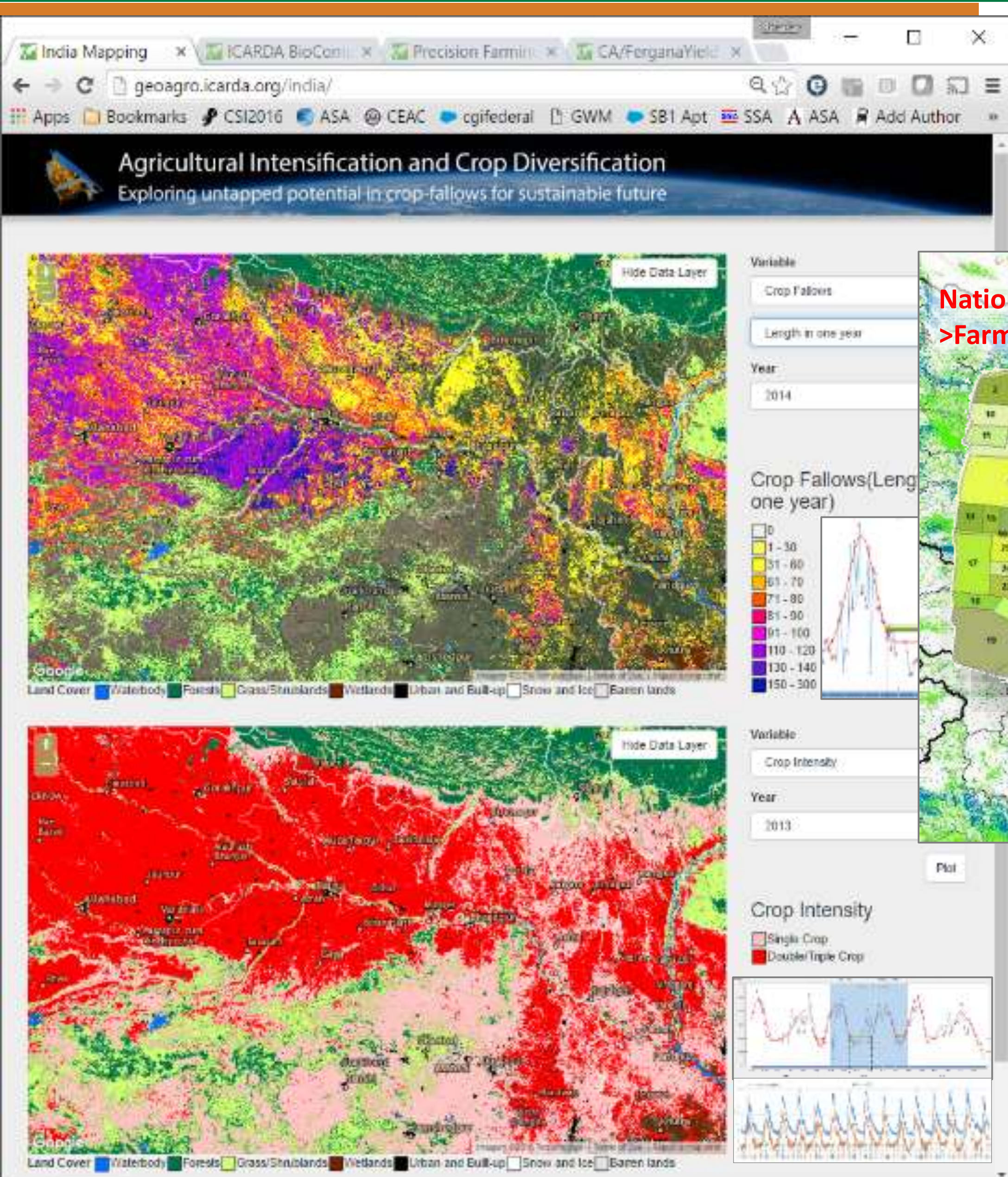
EOS in Precision Decisions

Automated workflow for operational mapping, monitoring and rural advisory

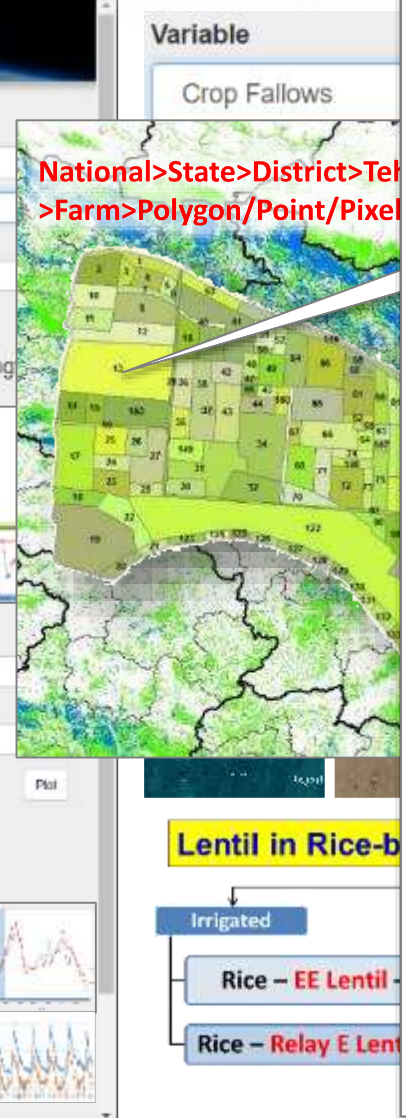


Ag Intensification & Diversification

Bet…ws
for…



Near real-ti…
pixel to land…



Cropping System
Crop Intensity
Crop Calendar
Crop Rotation
Cropped Area

Fallow Dynamics
-Fallow area
-Duration
-Start date
-End date

Yield Potential
-Current
-Achievable

Suitable Crop/Variety
-Legumes
-Oil Seeds

Soils
Soil Health (SHC)
Soil Moisture (SMAP)

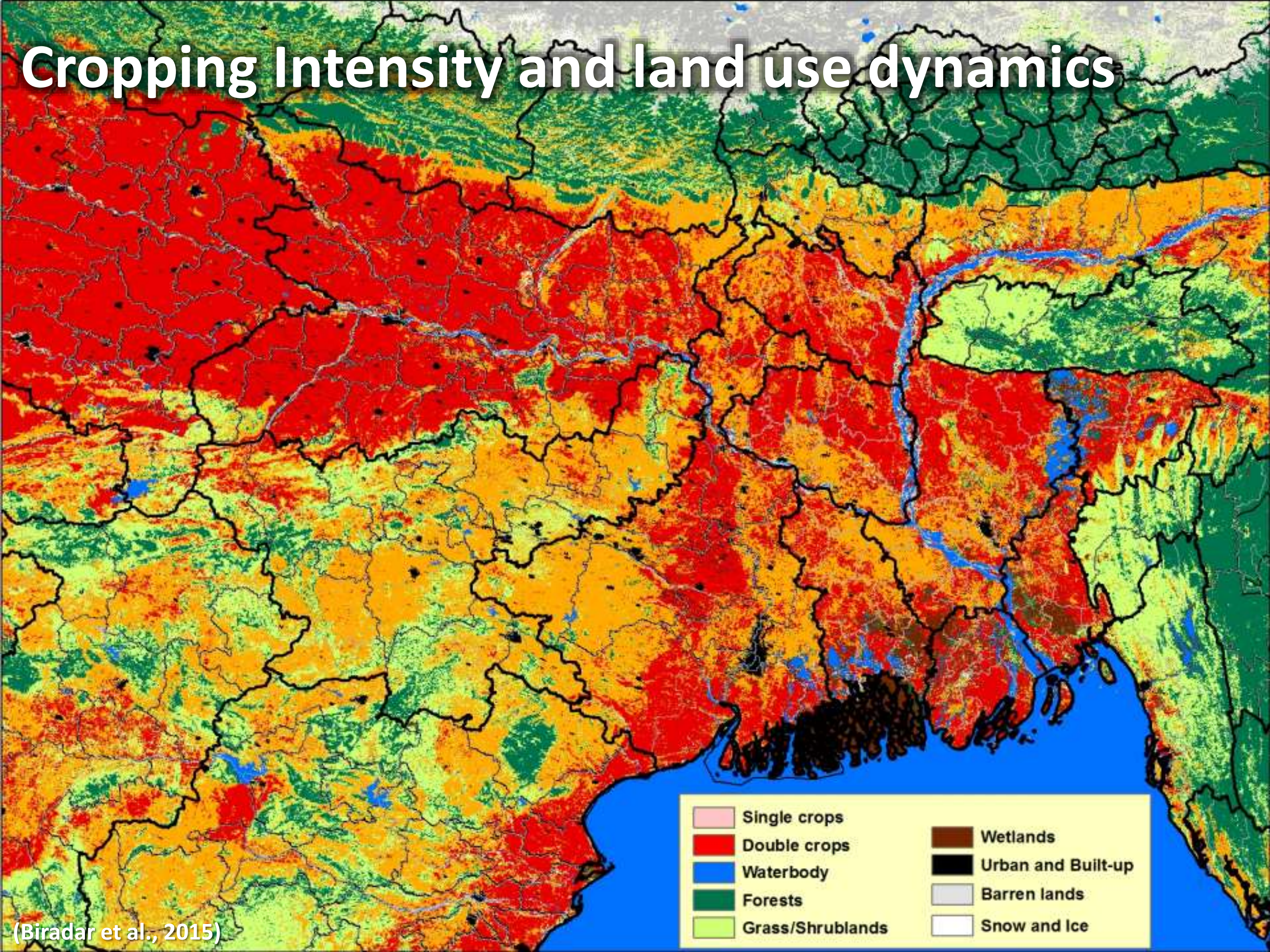
Water use
Evapotranspiration
Allocation/Irri. Sch.

Markets
-ePlatform
-Ag Supply Chain
-Access (I/O)

Monitoring
-Pest/Diseases
-Crop Stress

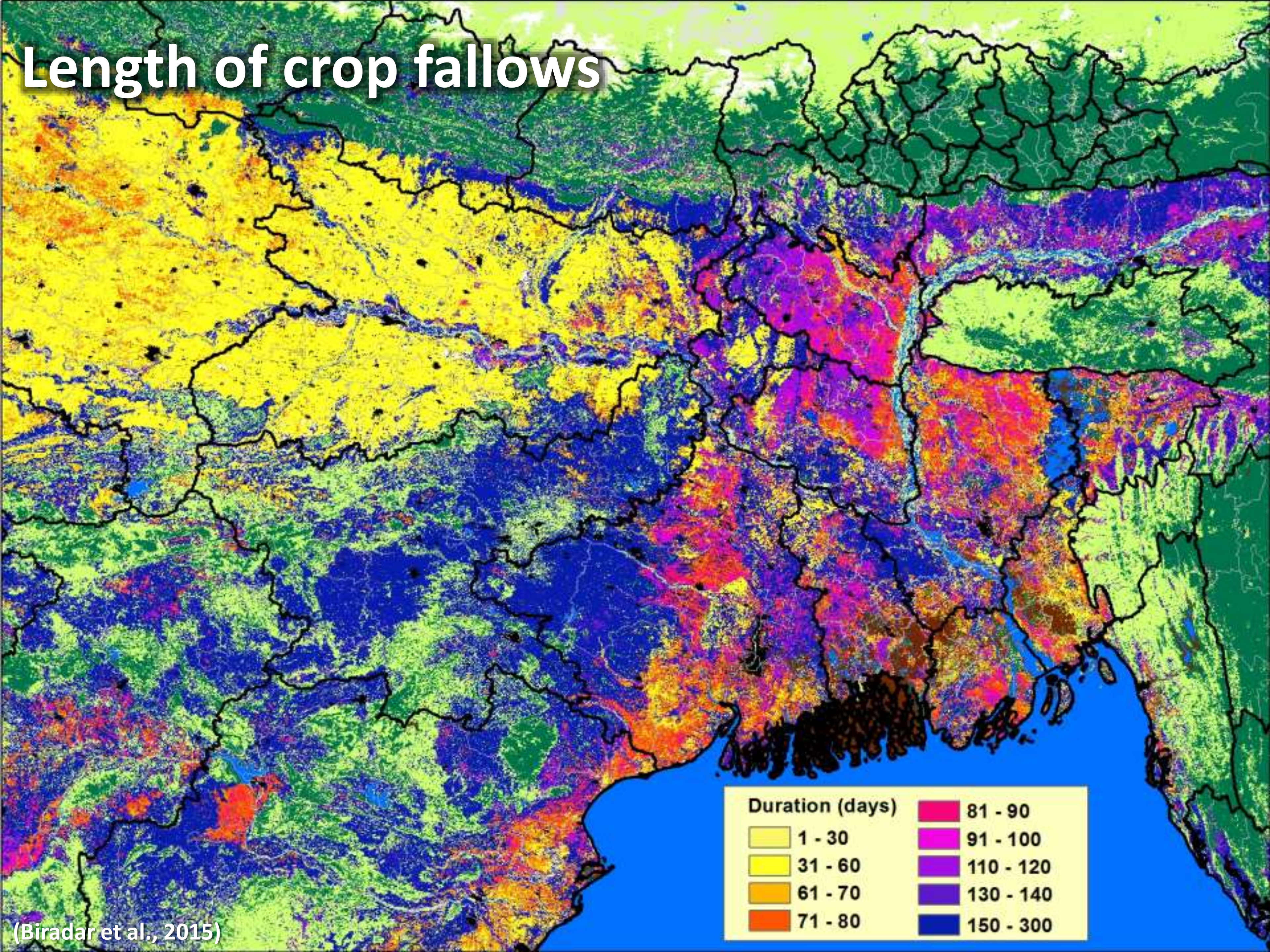
Citizen Science

Cropping Intensity and land use dynamics



(Biradar et al., 2015)

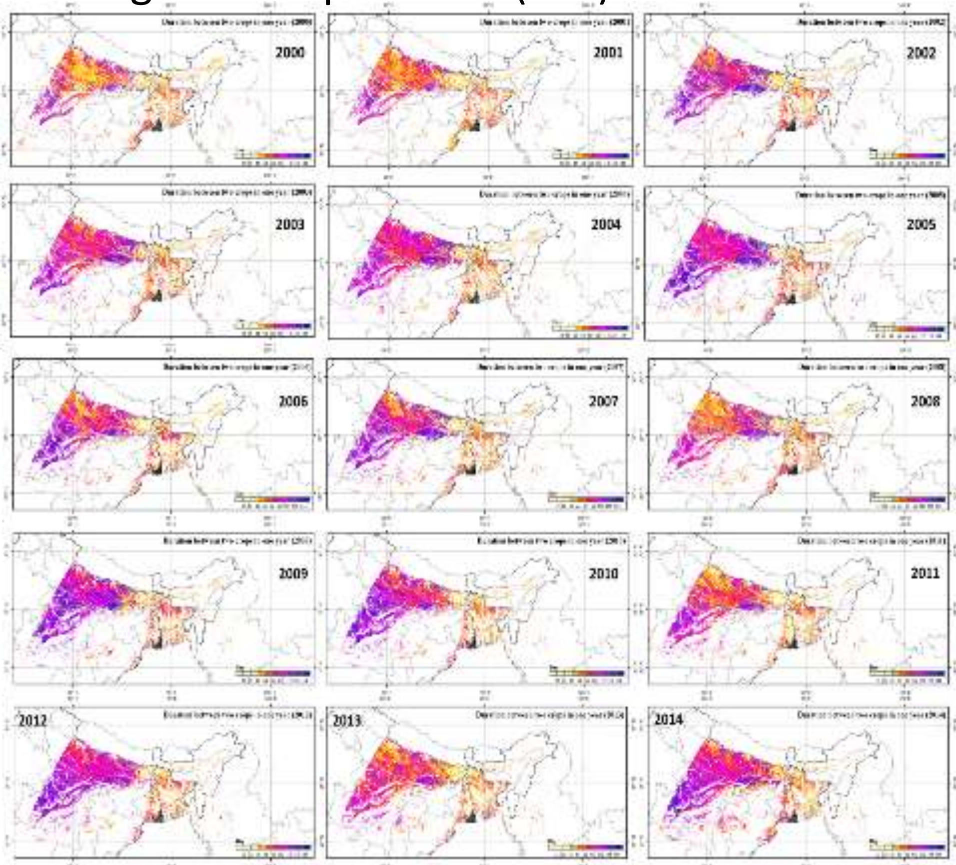
Length of crop fallows



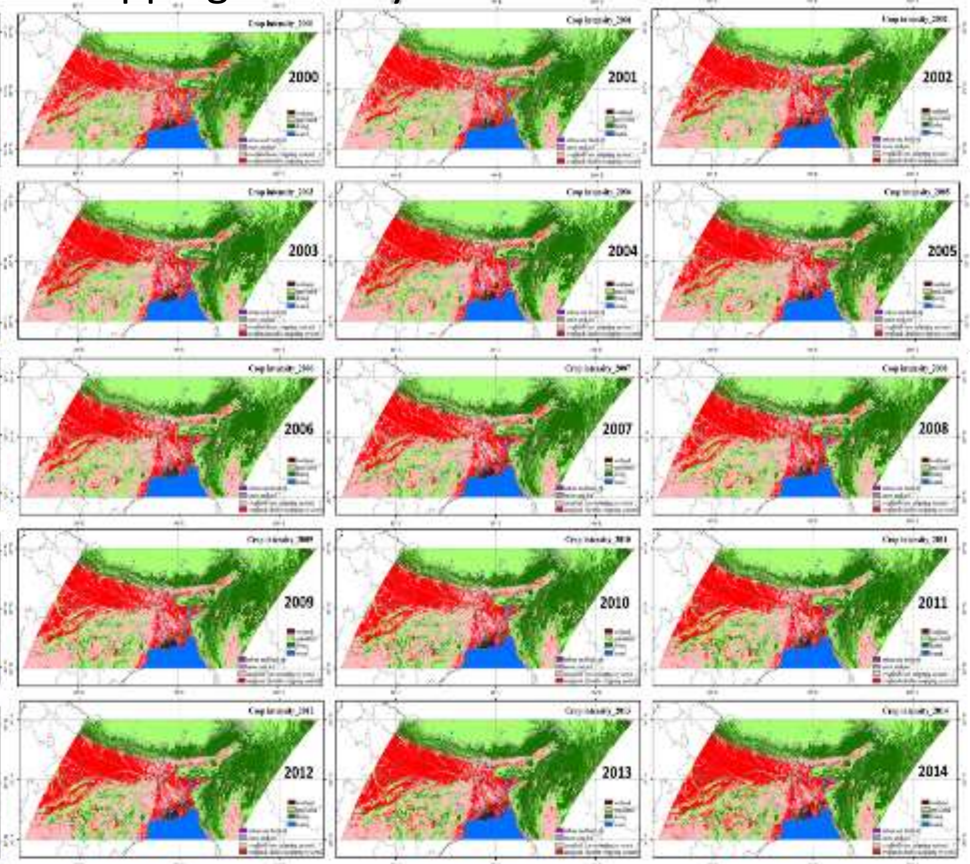
(Biradar et al., 2015)

Inter and Intra Annual Dynamics over Decades

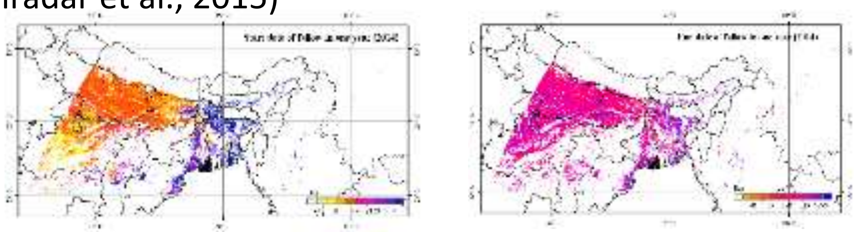
Length of Crop Fallows (LCP): 2000-2015



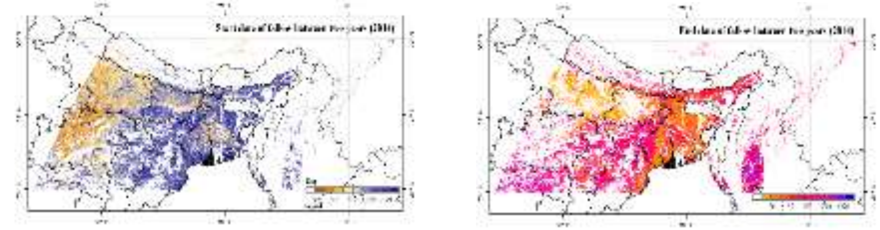
Cropping Intensity and land cover: 2000-2014



(Biradar et al., 2015)



Start and End Dates of Inter-annual Fallows

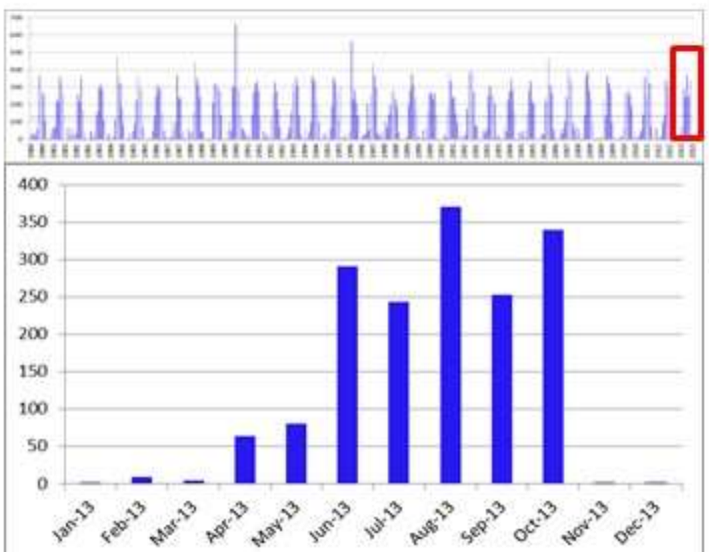


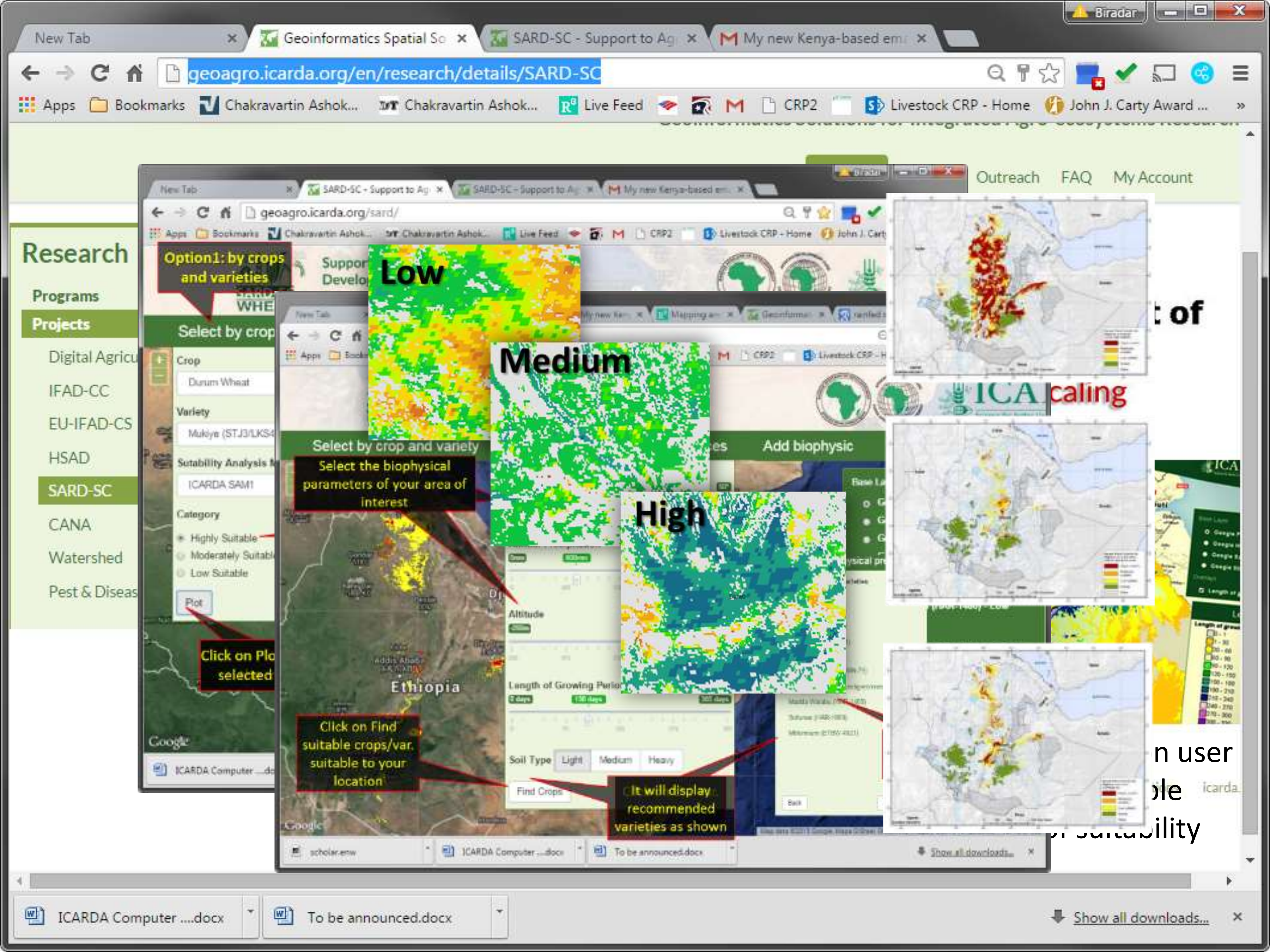
Start and End Dates of Intra-annual Fallows

Crop-fallows for intensification

On-farm water management

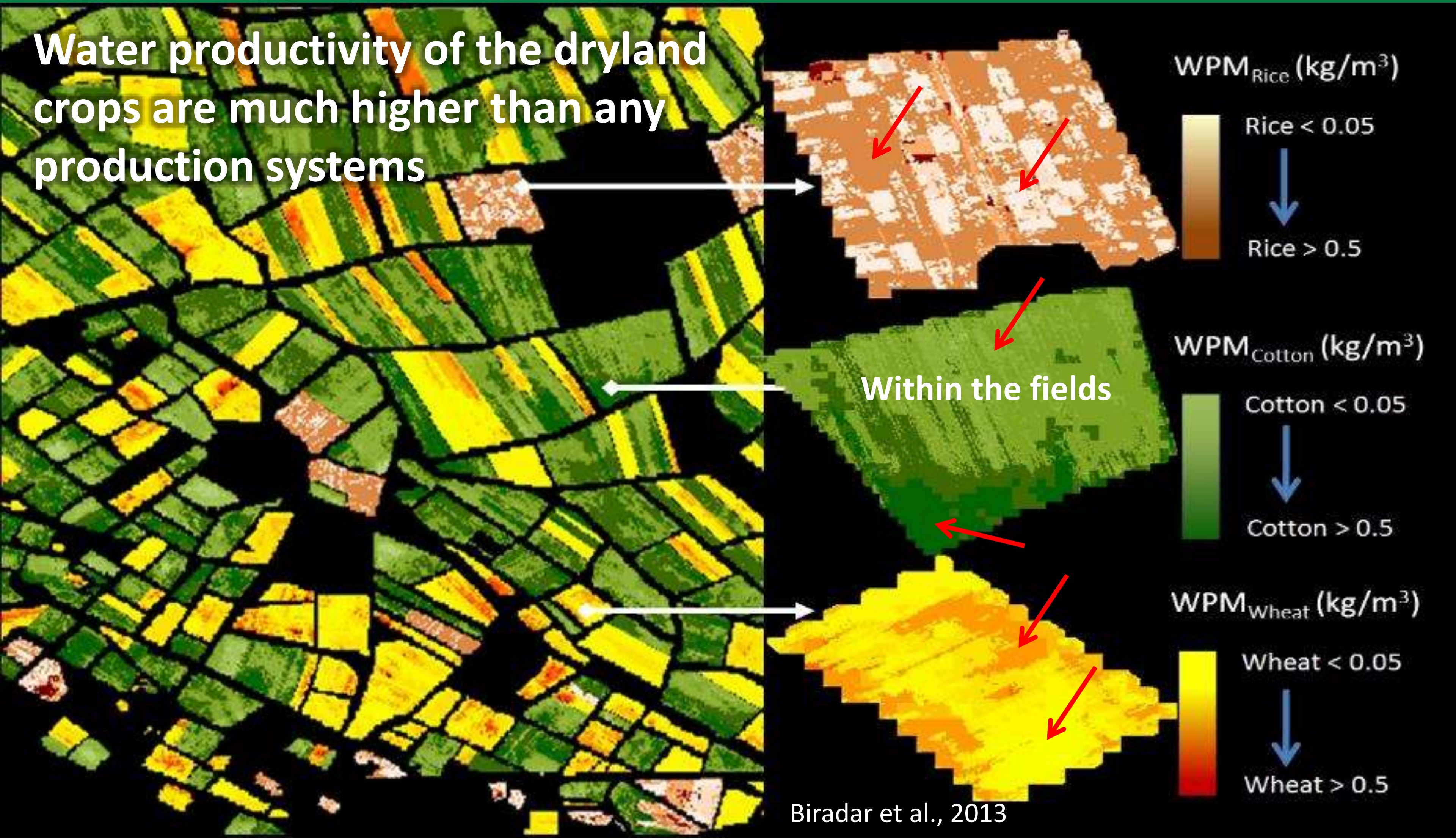
Fallow from July to January (7 months)




New Tab
Geoinformatics Spatial So
SARD-SC - Support to Ag
My new Kenya-based em
geoagro.icarda.org/en/research/details/SARD-SC
Apps
Bookmarks
Chakravartin Ashok...
Live Feed
CRP2
Livestock CRP - Home
John J. Carty Award ...
Outreach
FAQ
My Account
Research
Programs
Projects
Digital Agricu
IFAD-CC
EU-IFAD-CS
HSAD
SARD-SC
CANA
Watershed
Pest & Diseas
geoagro.icarda.org/sard/
Option1: by crops and varieties
Select by crop
Crop
Durum Wheat
Variety
Category
Highly Suitable
Moderately Suitabl
Low Suitable
Plot
Click on Plo
selected
Low
Medium
High
Select by crop and variety
Add biophysic
Select the biophysical parameters of your area of interest
Ethiopia
Altitude
Length of Growing Perio
Soil Type
Light
Medium
Heavy
Find Crops
Click on Find suitable crops/var. suitable to your location
It will display recommended varieties as shown
ICARDA Computer ....docx
To be announced.docx
Show all downloads...

Where are those Yield 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.

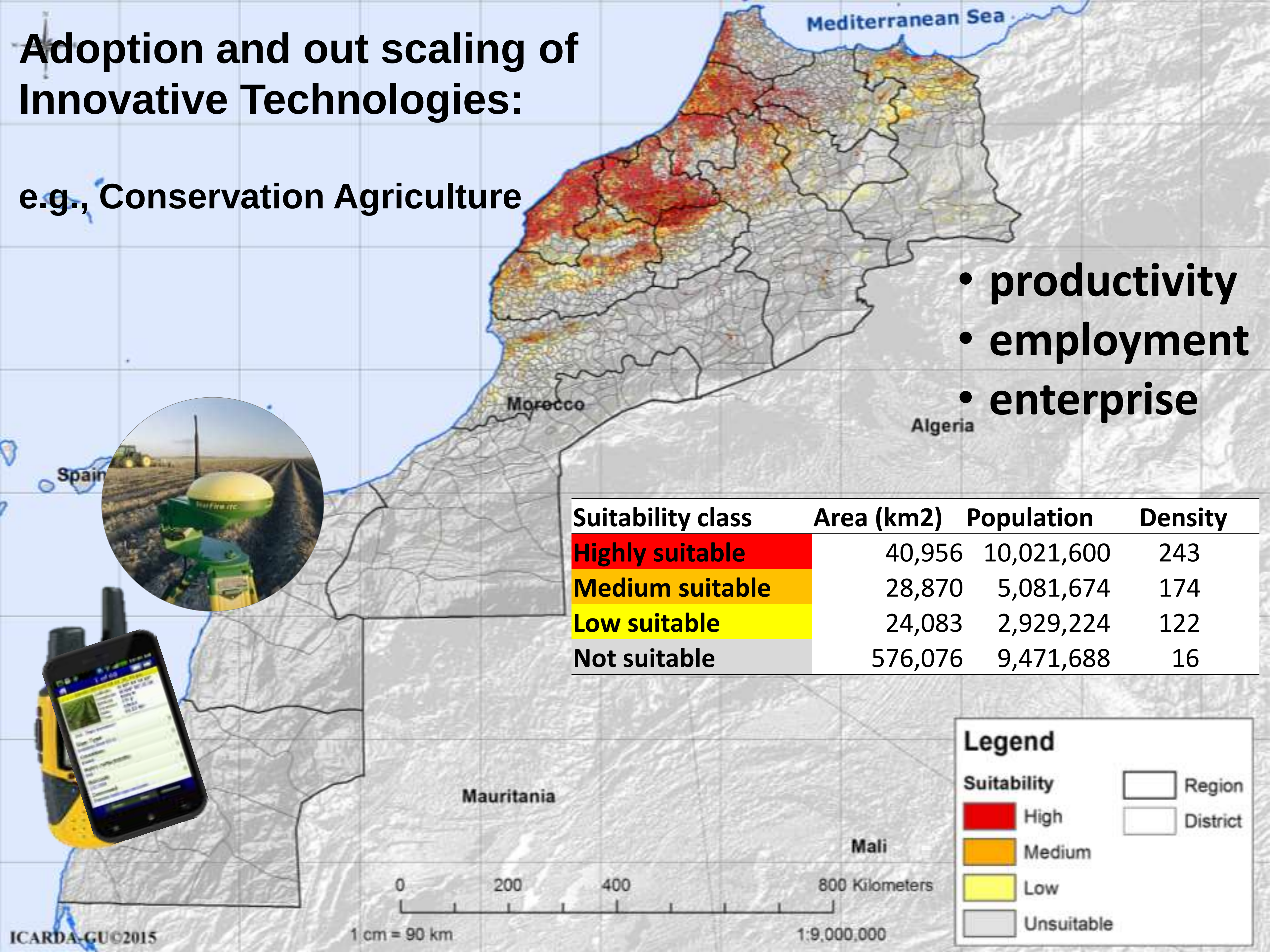
WP of Cotton	0.42 kg/m^3	0.50 USD/m^3
WP of Wheat	0.60 kg/m^3	0.33 USD/m^3
WP of Rice paddy	0.50 kg/m^3	0.10 USD/m^3

Adoption and out scaling of Innovative Technologies:

e.g., Conservation Agriculture

- **productivity**
- **employment**
- **enterprise**

Suitability class	Area (km2)	Population	Density
Highly suitable	40,956	10,021,600	243
Medium suitable	28,870	5,081,674	174
Low suitable	24,083	2,929,224	122
Not suitable	576,076	9,471,688	16



Agroforestry systems: Trees in farm lands

Length of farm bunds available for tree planting: 6.6 m km

Area under agroforestry in India: 7.4 million ha

(Zomer et al., 2007)

Its role in carbon sequestration 18-38 Mg C ha-1

(Various studies and estimates)

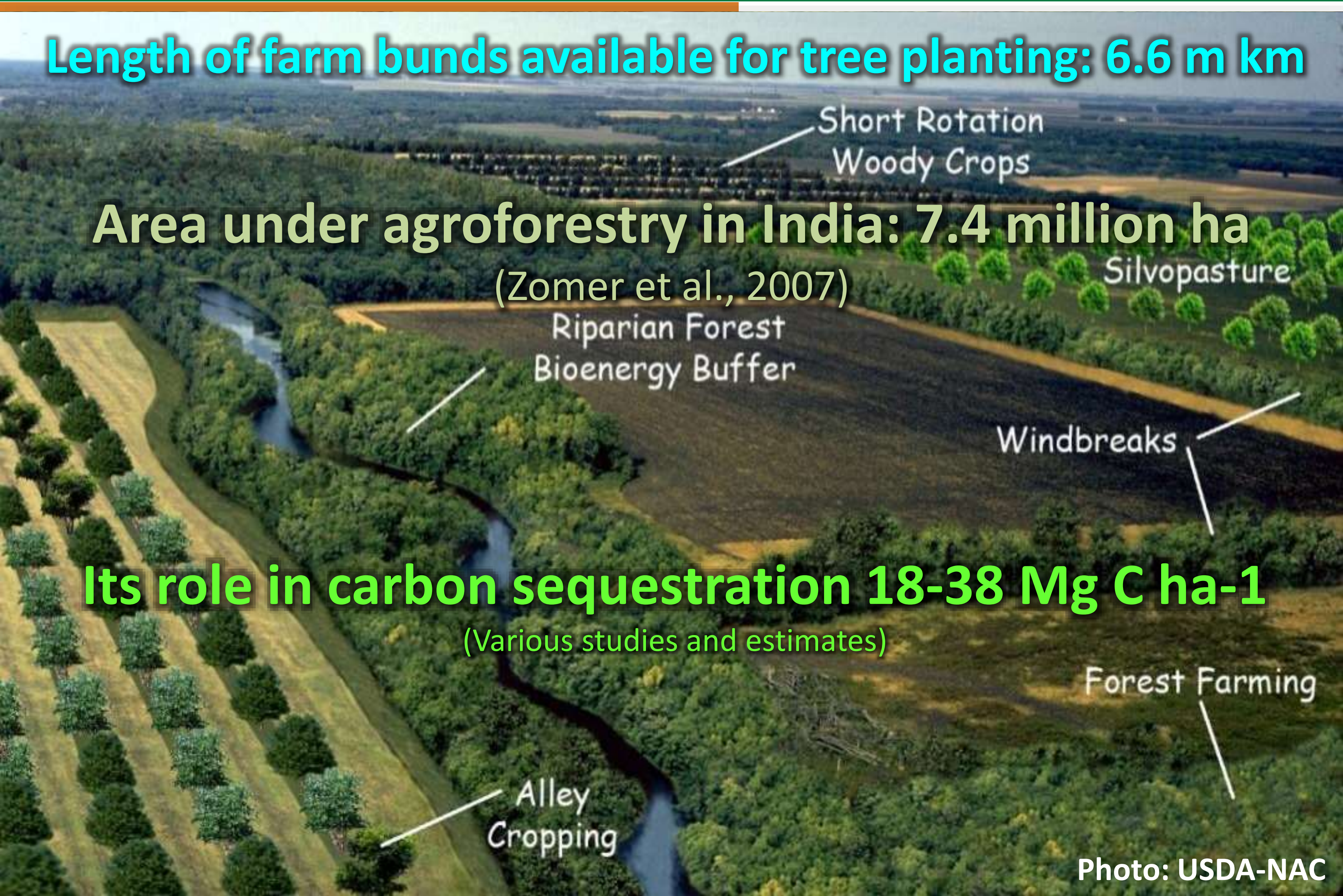


Photo: USDA-NAC

Measuring Impact of Successful interventions

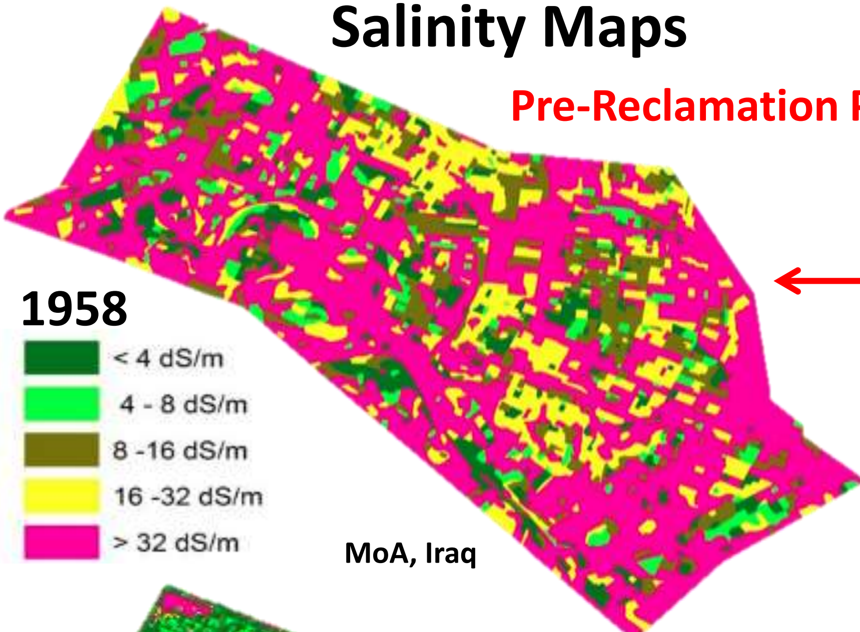
Soil Salinity, Dujaila, Iraq

Salinity Maps

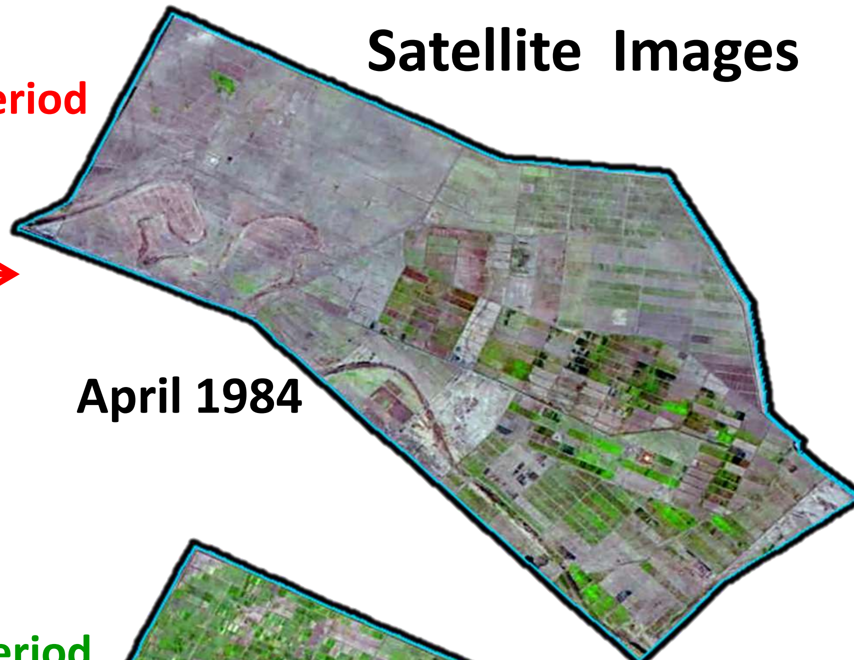
Satellite Images

Pre-Reclamation Period

1958



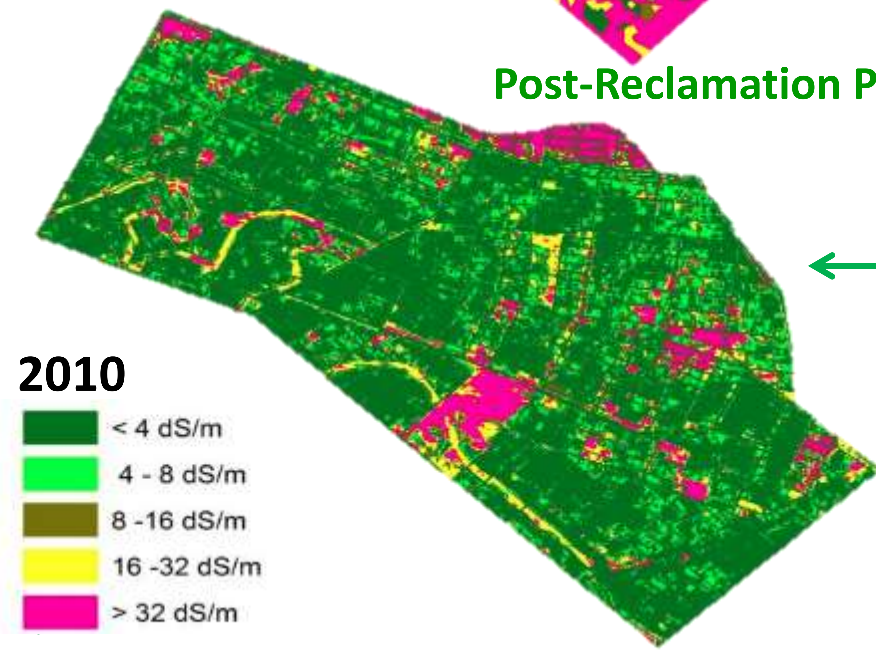
MoA, Iraq

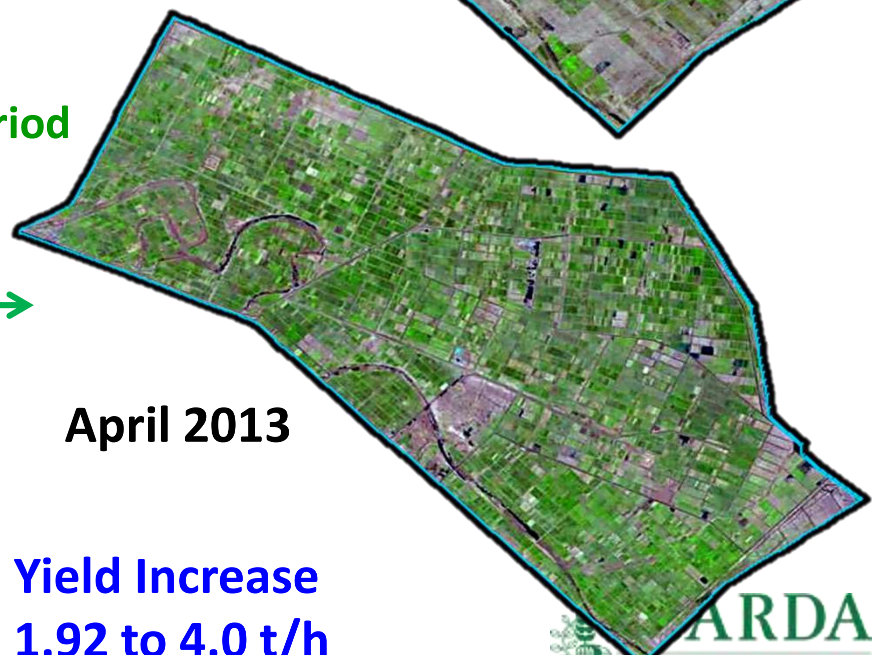


April 1984

Post-Reclamation Period

2010





April 2013

Yield Increase
1.92 to 4.0 t/h

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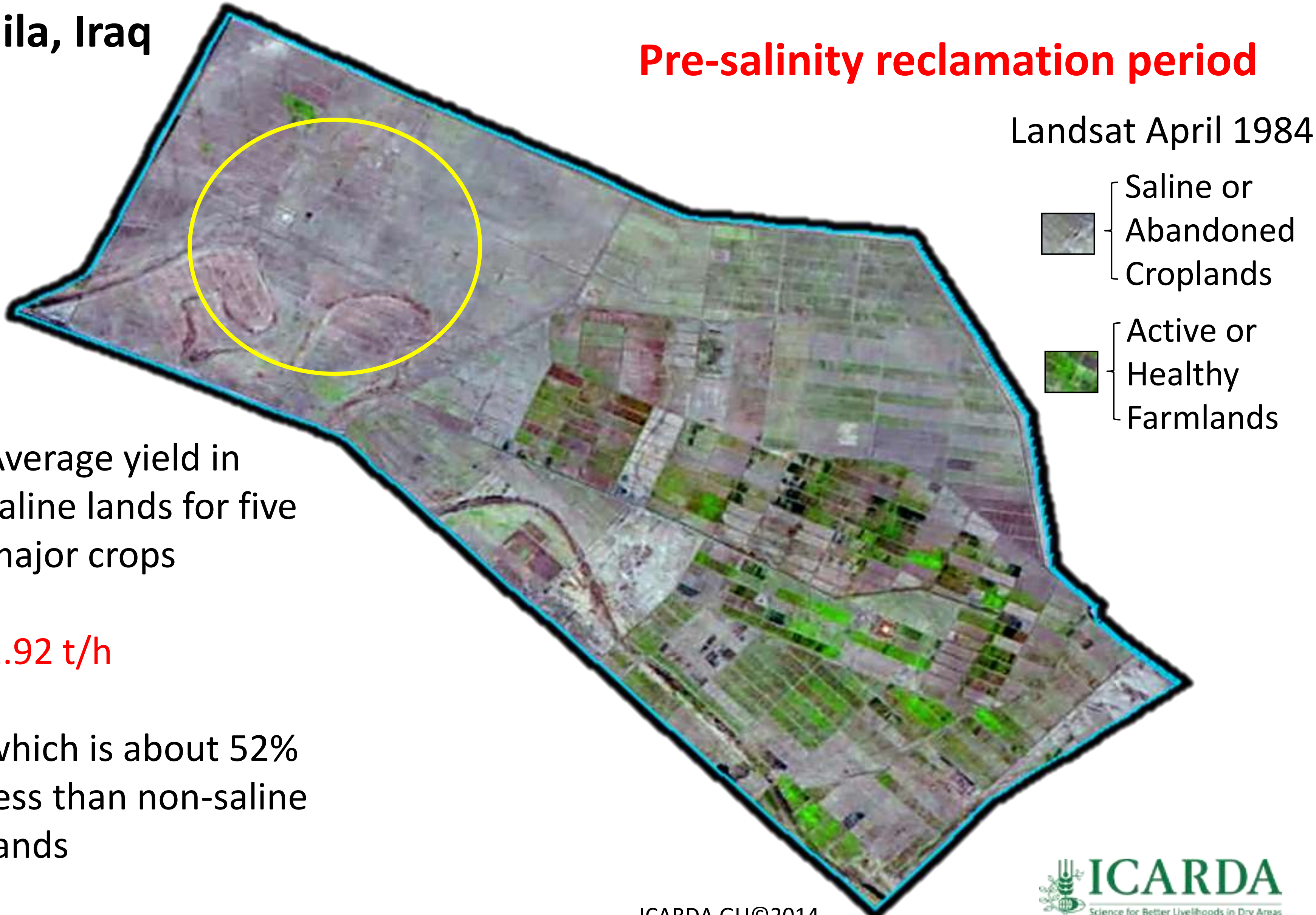
Measuring Impact of Successful interventions

Soil Salinity, Dujaila, Iraq

Dujaila, Iraq

Pre-salinity reclamation period

Landsat April 1984



Average yield in saline lands for five major crops

1.92 t/h

which is about 52% less than non-saline lands

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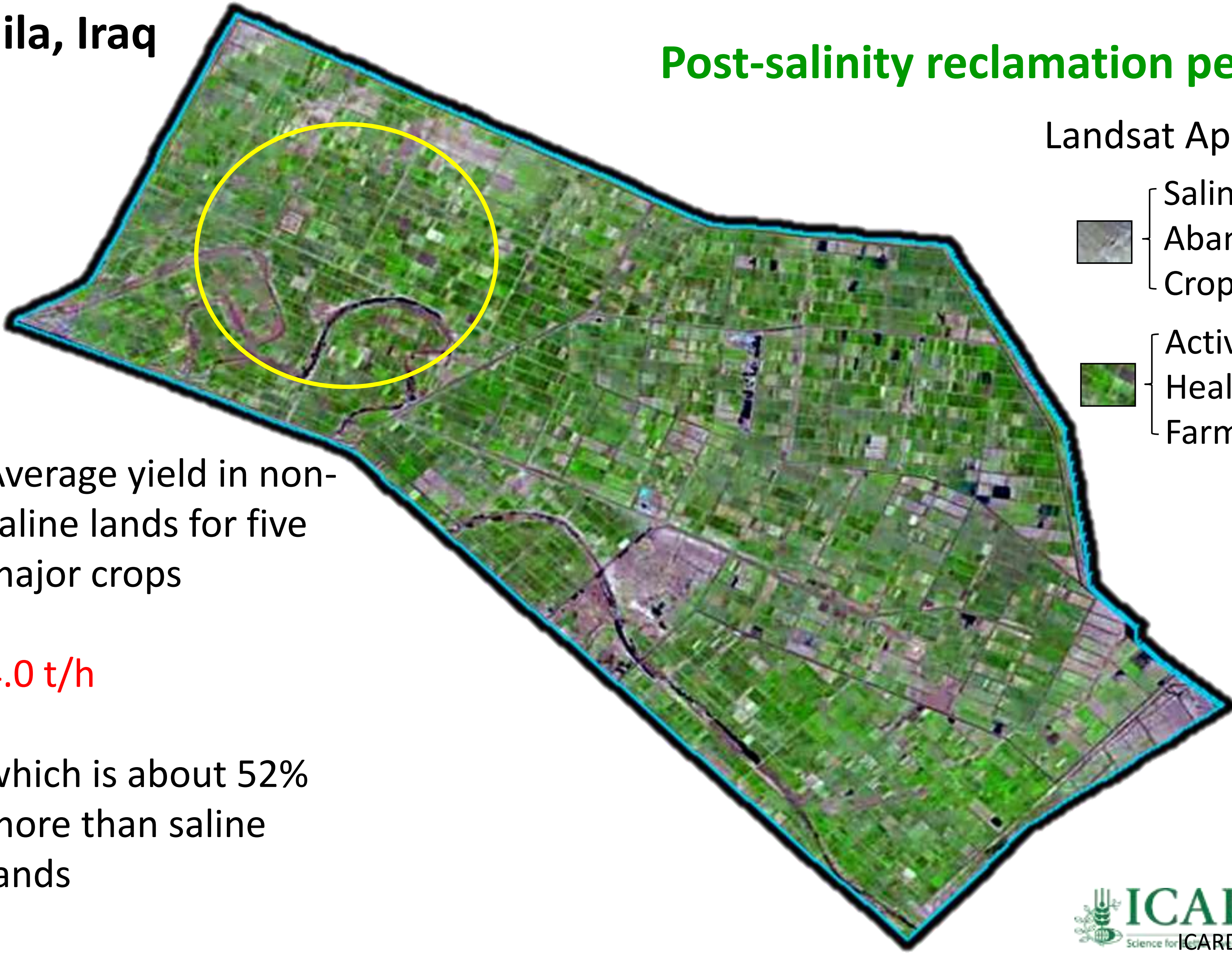
Science for Better Livelihoods in Dry Areas

Measuring Impact of Successful interventions

Soil Salinity, Dujaila, Iraq

Dujaila, Iraq



Post-salinity reclamation period

Landsat April 2013

Saline or Abandoned Croplands

Active or Healthy Farmlands

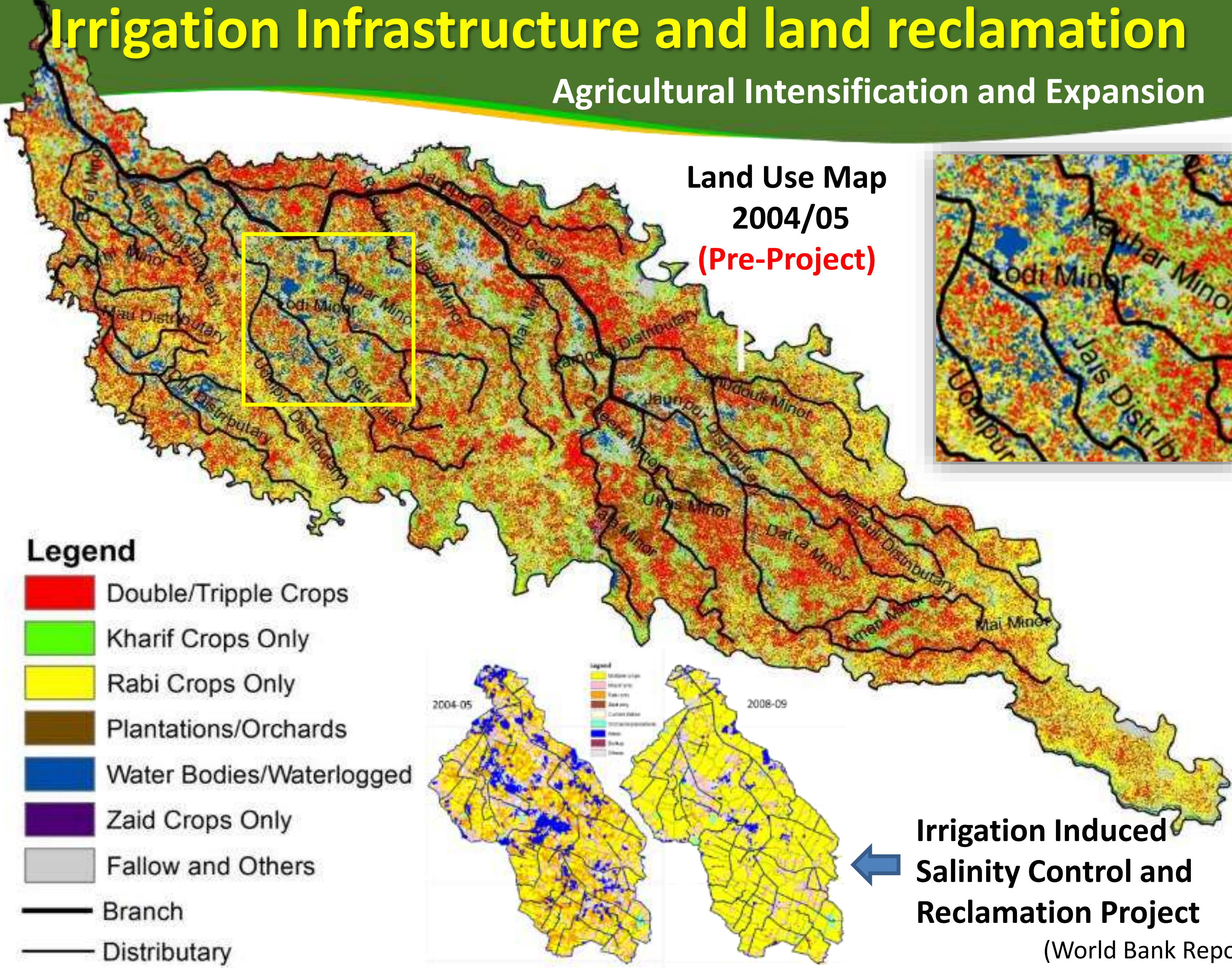
Average yield in non-saline lands for five major crops

4.0 t/h

which is about 52% more than saline lands

Irrigation Infrastructure and land reclamation

Agricultural Intensification and Expansion



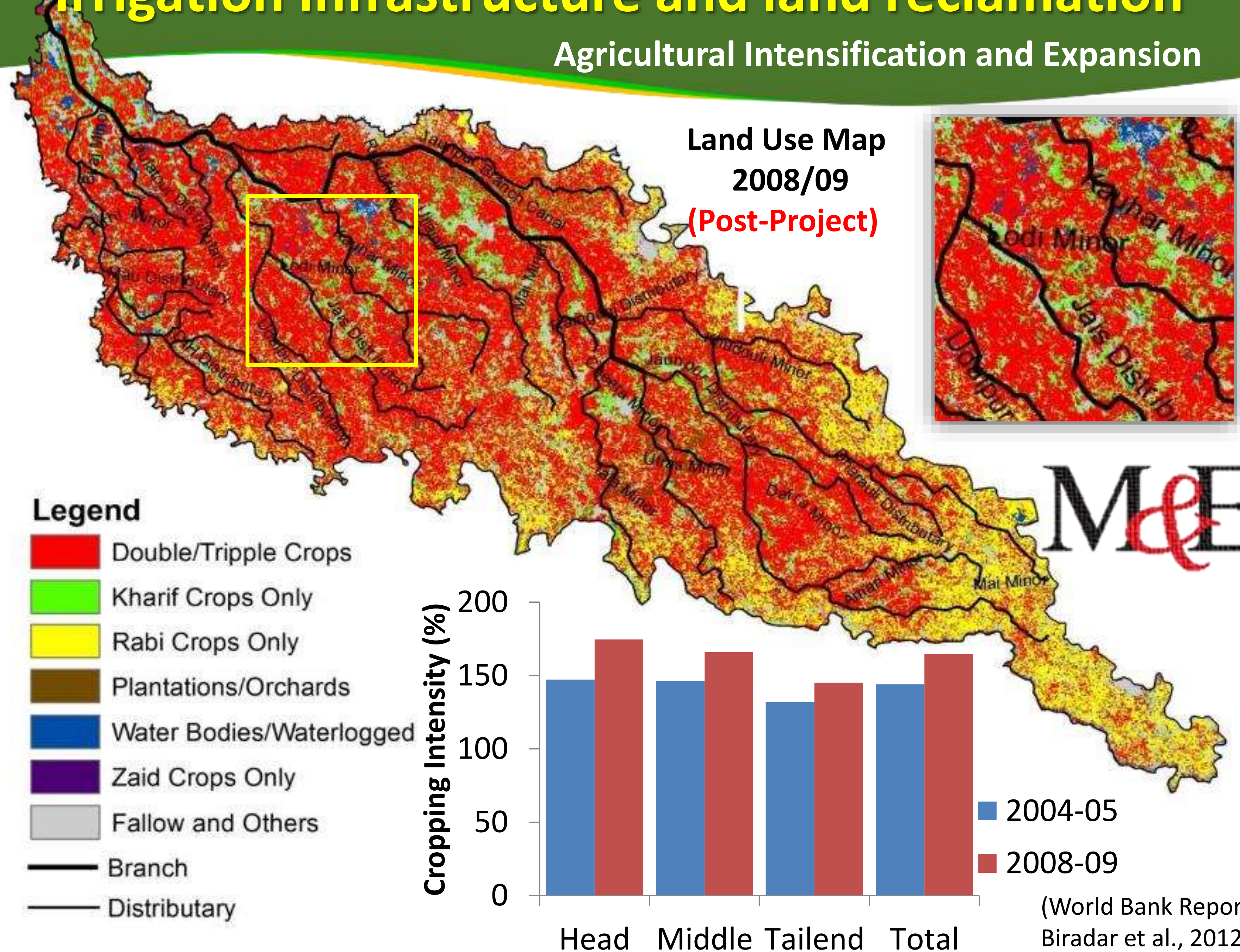
Land Use Map 2004/05
(Pre-Project)

Irrigation Induced Salinity Control and Reclamation Project

(World Bank Report, Biradar et al., 2012)

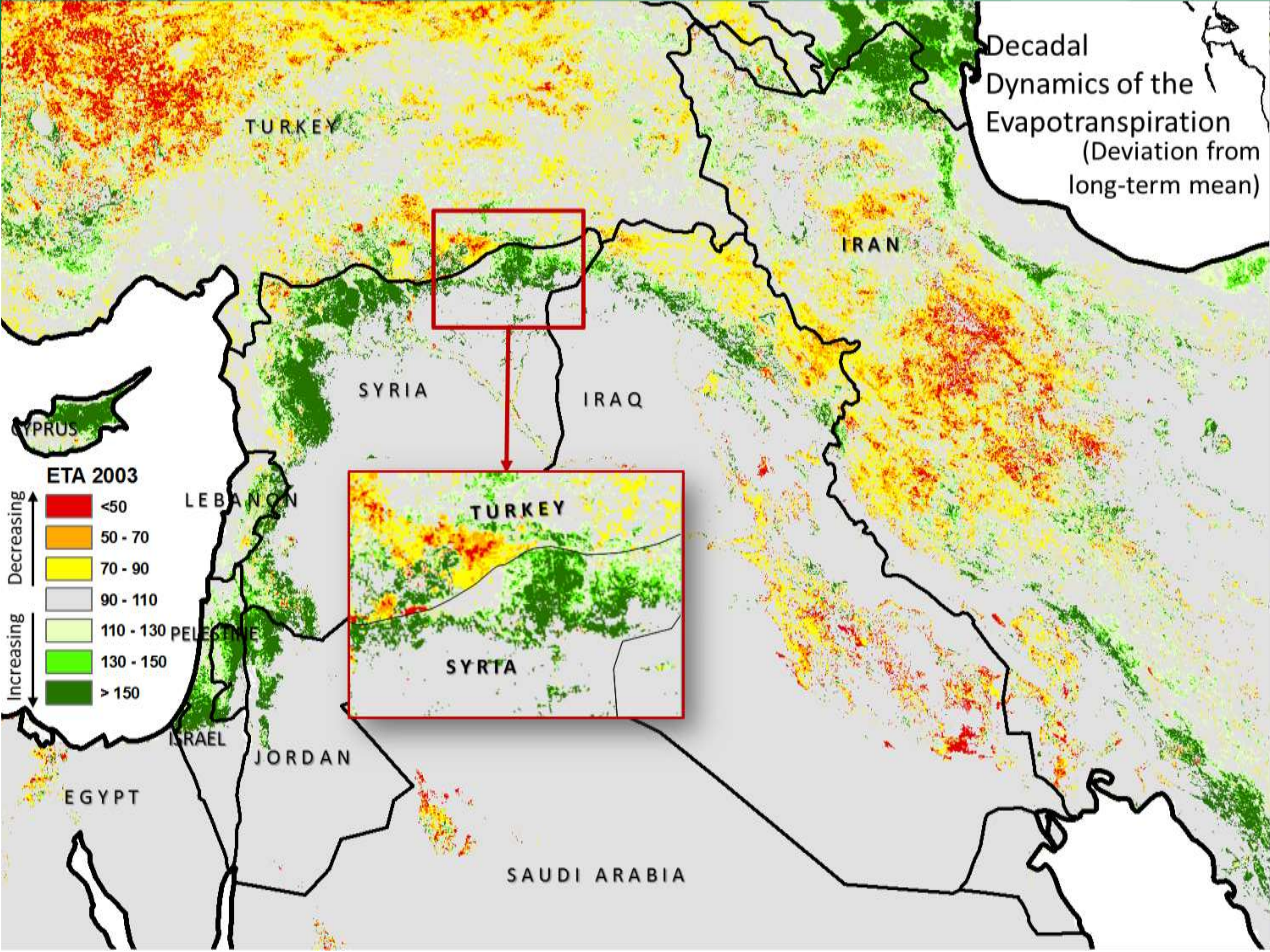
Irrigation Infrastructure and land reclamation

Agricultural Intensification and Expansion

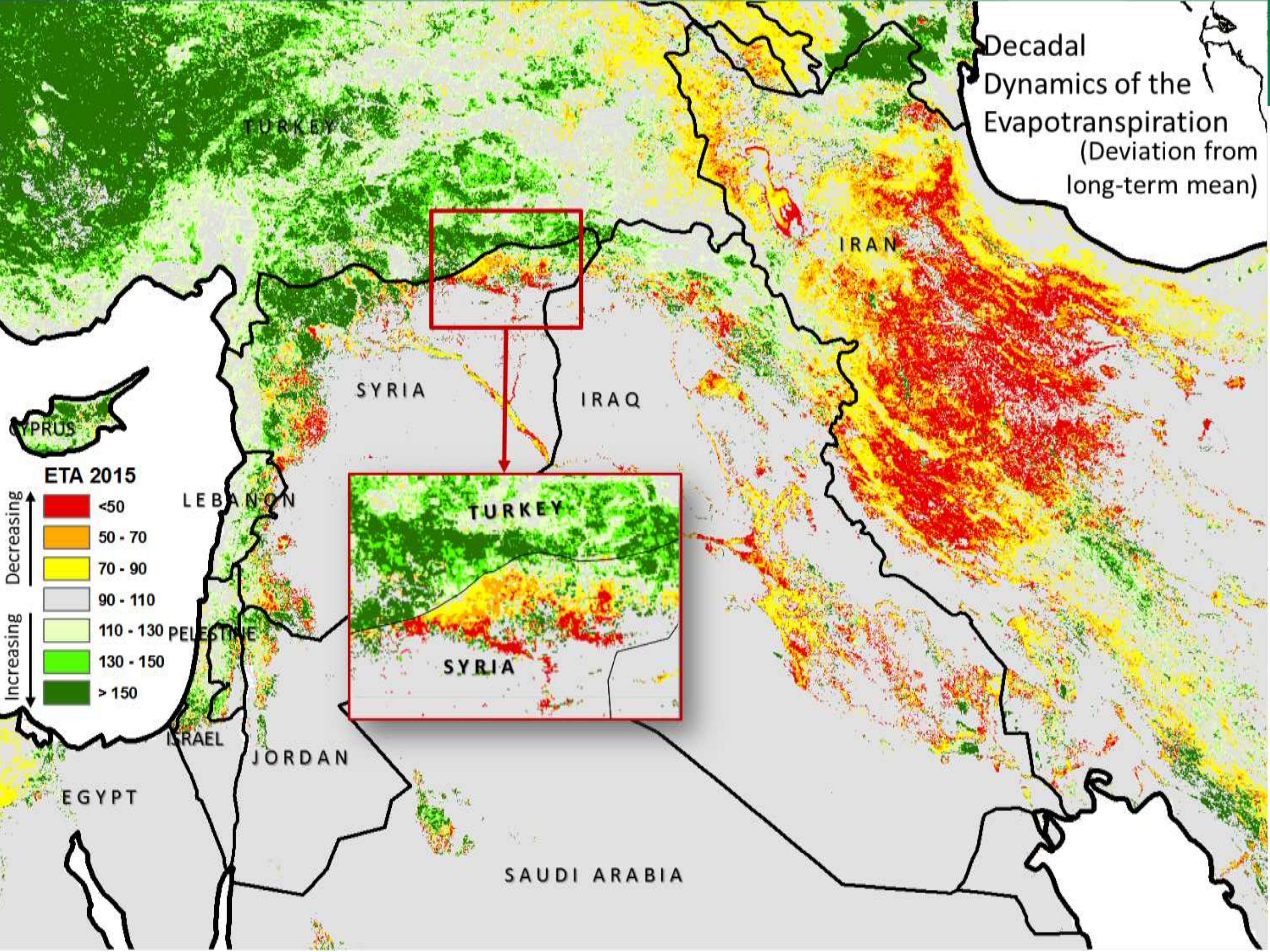


Land Use Map 2008/09
(Post-Project)

(World Bank Reports, Biradar et al., 2012)



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



Decadal Dynamics of the Evapotranspiration
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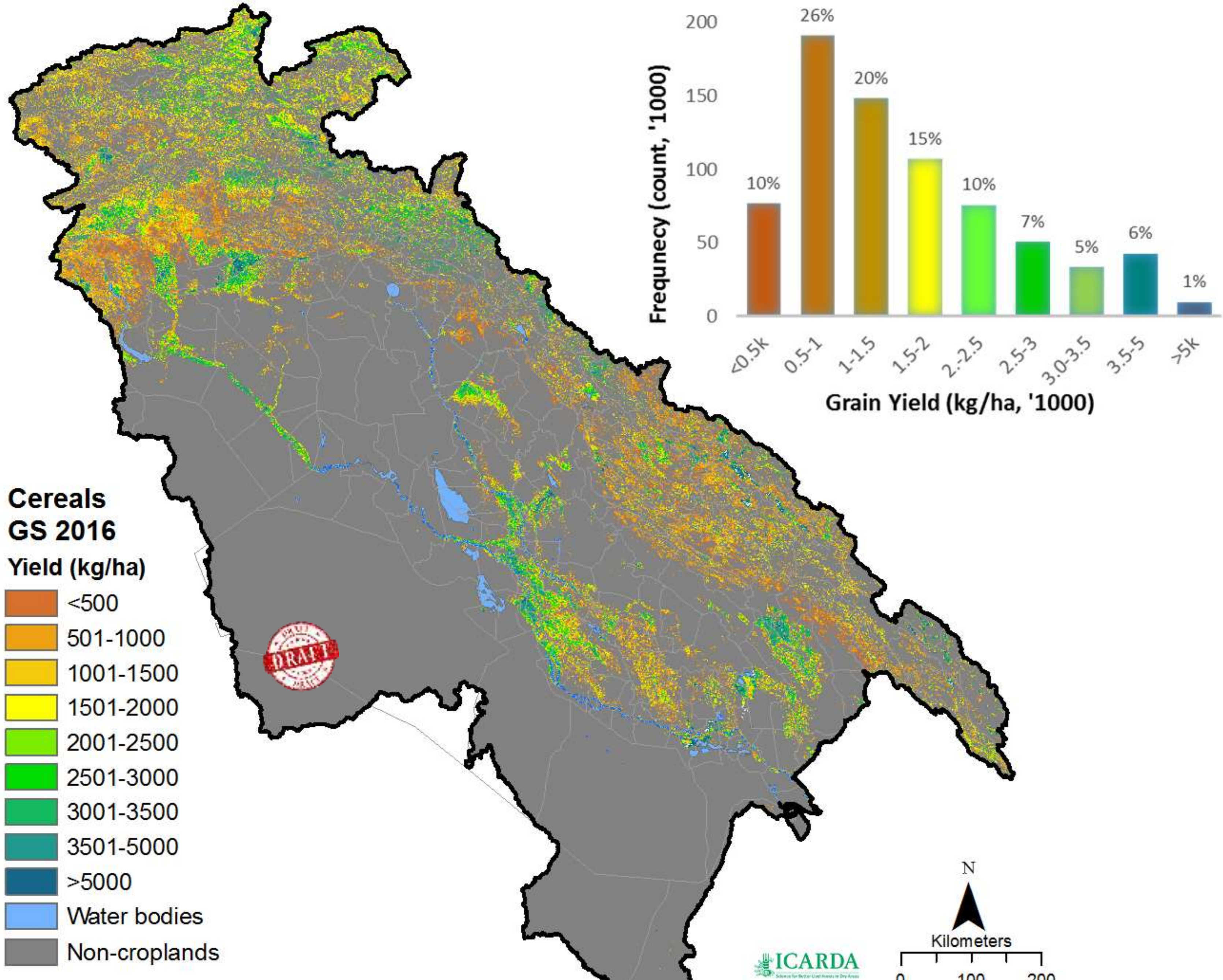
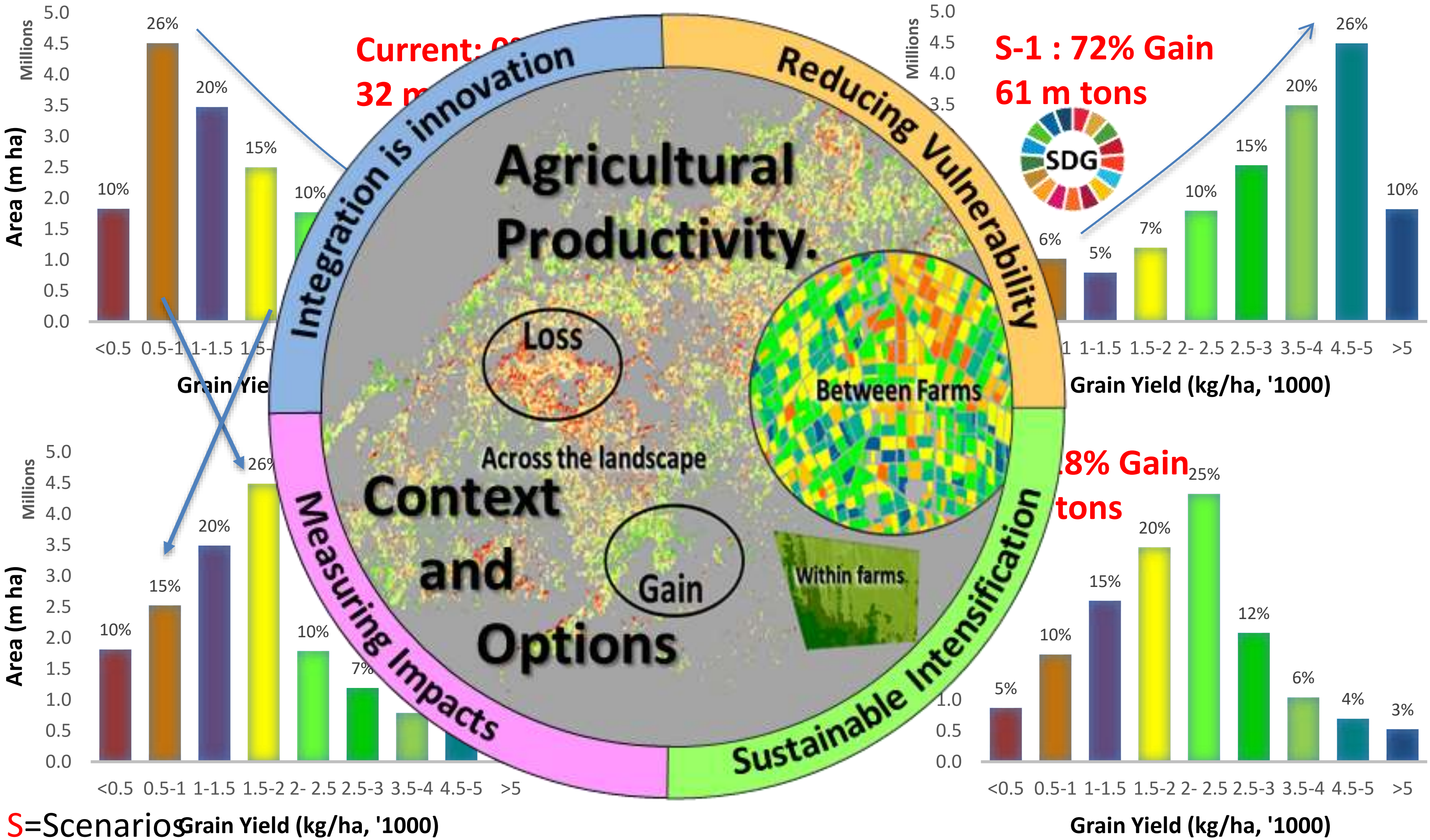
TURKEY
SYRIA

Agricultural Productivity and Production



Biradar, et al., 2016*

Location specific Investment, Interventions and Impacts



S=Scenarios

Biradar, et al., 2016*

Back to the future!

We have heavily compromised sustainable food production and health of the lives and the planet Earth by neglecting minor crops (dryland cereals and legumes)

<u>Go back to the future</u>

Integrated farming systems with better soil and water management for nutritious food for a sustainable future in an inch of land and bunch of crop

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)

avoid the unmanageable and manage the unavoidable

-IPCC Confronting Climate Change:

Thank You

c.biradar@cgiar.org

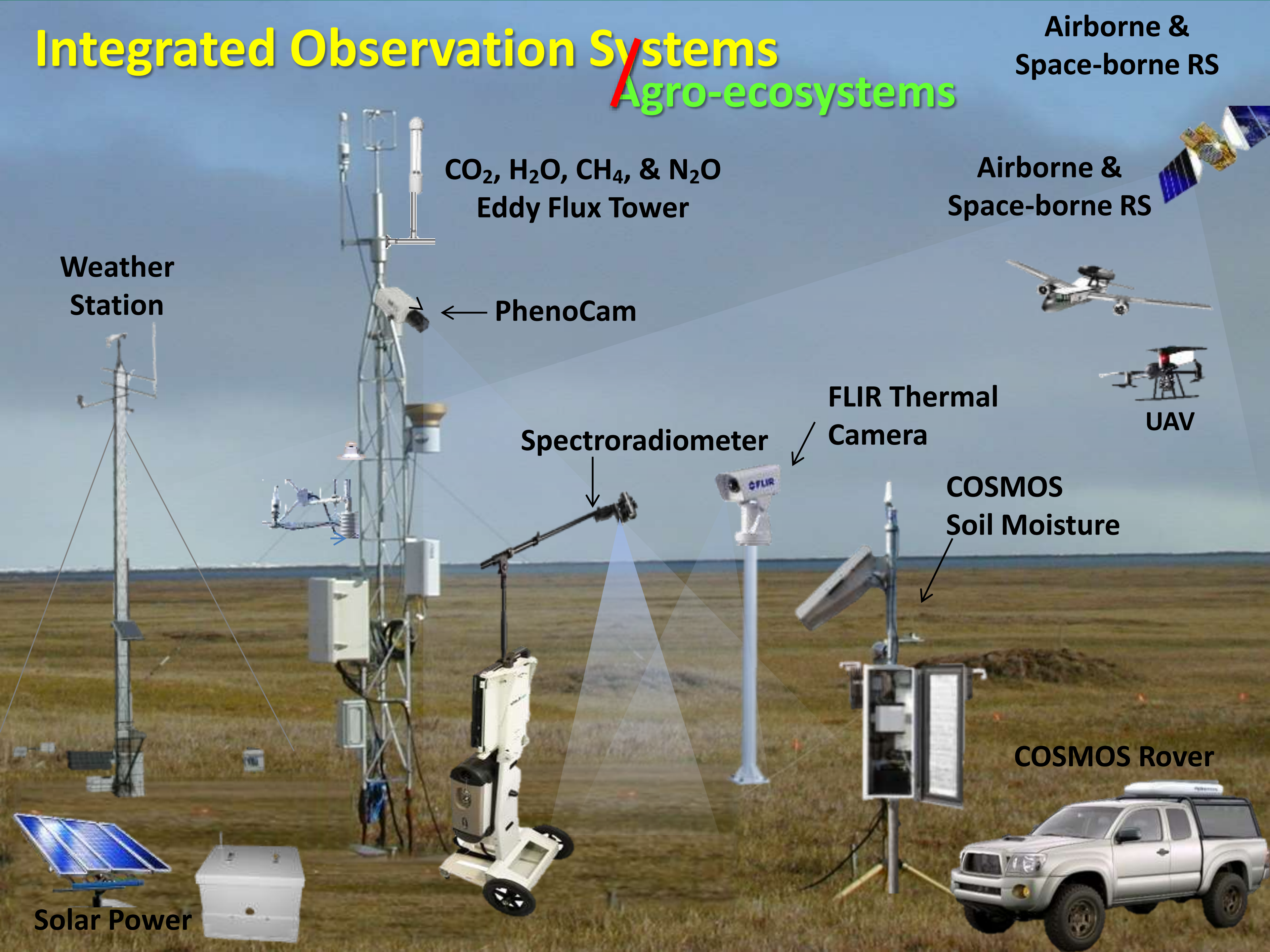
ICARDA
Science for Better Livelihoods in Dry Areas

Geoinformatics in Sustainable Agro-Ecosystems

geoagro.icarda.org

- Ag-Intensification
- Digital Agriculture
- Wheat out-scaling
- CA Adoption
- Thematic Research
- Cereals-Legume System
- Pests & Disease Risks
- Land Degradation
- Crop modelling
- Watershed management
- Climate Change
- System Modelling
- Big-data Analytics

ICARDA
Science for Better Livelihoods in Dry Areas


Integrated Observation Systems
Agro-ecosystems
Airborne &
Space-borne RS
CO$_2$, H$_2$O, CH$_4$, & N$_2$O
Eddy Flux Tower
Airborne &
Space-borne RS
Weather
Station
PhenoCam
FLIR Thermal
Camera
UAV
Spectroradiometer
COSMOS
Soil Moisture
COSMOS Rover
Solar Power