Big Data for building Inclusive Agroecosystems

Decoding the big-data ecosystems for efficiency, ecology, economy and impact

Chandrashekhar Biradar

Big Data in Agriculture
10-14 December, 2018, Rabat, Morocco
<table>
<thead>
<tr>
<th>Time</th>
<th>Day1: Monday 10 Dec’18</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30-9:00</td>
<td>Opening Session and Introduction to Course (A Amri; C. Biradar)</td>
</tr>
<tr>
<td>9:00-10:30</td>
<td>CGIAR Approach to Big Data (B. King)</td>
</tr>
<tr>
<td>10:30-11:00</td>
<td>Coffee break</td>
</tr>
<tr>
<td>11:00-12:30</td>
<td>All About Big Data and ICTs in Agriculture (C. Biradar et al)</td>
</tr>
<tr>
<td>12:30-14:00</td>
<td>Lunch break</td>
</tr>
<tr>
<td>14:00-16:00</td>
<td>Harmonizing CGIAR Data (M. Devare)</td>
</tr>
<tr>
<td>16:00-16:30</td>
<td>Coffee break</td>
</tr>
<tr>
<td>16:30-18:00</td>
<td>GDPR and IP Rights (A. Nour)</td>
</tr>
<tr>
<td></td>
<td>Intro Repositories - E.B.</td>
</tr>
<tr>
<td></td>
<td>Lunch break</td>
</tr>
<tr>
<td>19:30-21:00</td>
<td>Core group discussion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Day2: Tuesday 11 Dec’18</th>
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<tbody>
<tr>
<td>8:30-9:00</td>
<td>Big Data Big Picture</td>
</tr>
<tr>
<td>9:00-10:30</td>
<td>Data Collection and Curation</td>
</tr>
<tr>
<td>10:30-11:00</td>
<td>Debriefing previous day (C. Biradar)</td>
</tr>
<tr>
<td>11:00-12:30</td>
<td>Data Repositories &amp; Archiving (DV, Dspace, Schema - E. Bonaiuti)</td>
</tr>
<tr>
<td>12:30-14:00</td>
<td>Lunch break</td>
</tr>
<tr>
<td>14:00-16:00</td>
<td>RALS Data, People and Process (M. Hilali)</td>
</tr>
<tr>
<td></td>
<td>WLEP Data, People and Process (M. Haddad)</td>
</tr>
<tr>
<td></td>
<td>Lunch break</td>
</tr>
<tr>
<td>16:30-18:00</td>
<td>Metadata, Spatial Data Curation (L. Atassi et al)</td>
</tr>
<tr>
<td></td>
<td>Big Data and Tools (GBDX, aWhere, etc) (S. Ghosh, and C Biradar)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Day3: Wednesday 12 Dec’18</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30-9:00</td>
<td>Geolocalization &amp; Field Day</td>
</tr>
<tr>
<td>9:00-10:30</td>
<td>Debriefing previous day (F. Bonechi)</td>
</tr>
<tr>
<td>10:30-11:00</td>
<td>Big Data in Agriculture Analytics (S. Faissal)</td>
</tr>
<tr>
<td>11:00-12:30</td>
<td>Lunch break</td>
</tr>
<tr>
<td>12:30-14:00</td>
<td>Field Exercise and Demos in INRA/ICARDA premises (All)</td>
</tr>
<tr>
<td>14:00-16:00</td>
<td>International Nursery, Interaction, Data and Use (A. Niane and K. El-Shama)</td>
</tr>
<tr>
<td></td>
<td>Lunch break</td>
</tr>
<tr>
<td>16:30-18:00</td>
<td>Ontologies: Why should we use them? (E. Arnaud)</td>
</tr>
<tr>
<td></td>
<td>Big Data in Agriculture Analytics</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Day4: Thursday 13 Dec’18</th>
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</thead>
<tbody>
<tr>
<td>8:30-9:00</td>
<td>All about FAIR Data</td>
</tr>
<tr>
<td>9:00-10:30</td>
<td>FAIR Data Principles and Applications (V. Graziano)</td>
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<tr>
<td>10:30-11:00</td>
<td>Coffee break</td>
</tr>
<tr>
<td>11:00-12:30</td>
<td>Lunch break</td>
</tr>
<tr>
<td>12:30-14:00</td>
<td>Field Exercise and Demos in INRA/ICARDA premises (All)</td>
</tr>
<tr>
<td>14:00-16:00</td>
<td>Data Curation of Existing Datasets (F. Bonechi)</td>
</tr>
<tr>
<td></td>
<td>Lunch break</td>
</tr>
<tr>
<td>16:30-18:00</td>
<td>Build your own Course in Moodle (B. Mueller)</td>
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</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Day5: Friday 14 Dec’18</th>
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<tbody>
<tr>
<td>8:30-9:00</td>
<td>Catalyst of Integration</td>
</tr>
<tr>
<td>9:00-10:30</td>
<td>All About Big Data and ICTs in Agriculture (C. Biradar et al)</td>
</tr>
<tr>
<td>10:30-11:00</td>
<td>Coffee break</td>
</tr>
<tr>
<td>11:00-12:30</td>
<td>Lunch break</td>
</tr>
<tr>
<td>12:30-14:00</td>
<td>Field Exercise and Demos in INRA/ICARDA premises (All)</td>
</tr>
<tr>
<td>14:00-15:00</td>
<td>How Big Data Shaping CGIAR Ag Research (J. Koo)</td>
</tr>
<tr>
<td>16:00-16:30</td>
<td>Lunch break</td>
</tr>
<tr>
<td>16:30-18:00</td>
<td>International Nursery, Interaction, Data and Use (A. Niane and K. El-Shama)</td>
</tr>
<tr>
<td></td>
<td>Lunch break</td>
</tr>
<tr>
<td>19:30-21:00</td>
<td>Wrap up, Certification and Closing Ceremony (B. Mueller, C. Biradar)</td>
</tr>
</tbody>
</table>

**Big Data in Agriculture Course - Rabat - 10 - 14 December, 2018**

**Arrival, Accommodation, pre-planning, logistics check**

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**International Center for Agricultural Research in the Dry Areas**

cgiar.org  
A CGIAR Research Center
Global Drylands and CGIAR

Area (km²)
- Tropical Drylands: 29.33 million
- Non-tropical Drylands: 95.52 million

Population
- Tropical Drylands: 1.89 billion
- Non-tropical Drylands: 2.68 billion
The World’s Internet users growing exponentially. As of June 2018, 55% of the world's population has internet access. It's estimated nearly 4 billion people, or over half of the world's population online by the end of the year.

Global Internet Population Growth 2012-2018 (in billions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>2.5</td>
</tr>
<tr>
<td>2014</td>
<td>3.0</td>
</tr>
<tr>
<td>2016</td>
<td>3.4</td>
</tr>
<tr>
<td>2017</td>
<td>3.8</td>
</tr>
<tr>
<td>2018</td>
<td>4.1</td>
</tr>
</tbody>
</table>
Data is growing exponentially and demands new technical and strategic approaches.

Source: Robin Lougee IBM Research
The African Digital Frontier

INTERNET PENETRATION PERCENTAGE BY REGION

- SOUTH AMERICA-CARIBBEAN: 62.5%
- LATIN AMERICA: 12.2%
- AFRICA: 10.8%
- MIDDLE EAST: 54.6%
- INDIA-Pakistan: 41.8%
- CENTRAL ASIA: 29.5%
- EURASIA: 29.4%
- EASTERN EUROPE: 28.9%
- NORTH AMERICA: 26.6%

500 million +
mobile phone subscribers

110 million +
Internet users in 2010
INCREASE OF OVER 2007 31%

The four biggest mobile phone markets are Nigeria, South Africa, Kenya and Ghana.

The largest fixed line broadband market is South Africa, followed in order of market size by Egypt, Morocco, Algeria and Tunisia.

International Internet Usage

In 2004, there were 17 million subscribers to 855 million broadband and data contracts across Africa.

In total, 4.5T Terabytes of cable capacity is available across 13 submarine cables on the African continent - expanding to 34.6 Terabytes by 2011.

South Africa has 1.5 million 3G connections in 2006.

10.8%
SOUTH AFRICAN INTERNET PENETRATION PERCENTAGE

SOURCES:
- en.wikipedia.org
- www.internetworldstats.com
- www.niklasb€rger.com
- www.reuters.com
- www.webtrending.com

MORE COOLNESS?
- @KDMACHT
- @replydraco

Infographic designed by
- @chrisawesome
Changing demography and diets

https://landscan.ornl.gov/
Migration and aggregated expansion

2012: Morocco
2012: Egypt
2012: Syria

2017: Morocco
2017: Egypt
2017: Syria
Integrated systems for resilience and risk reduction
[mixed crops, livestock, fish and trees]
Impact on the agricultural systems
Changing Water Balance

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

Frequent deviation from long-term averages

2015-16

2014-15

2000

ETa Anomaly (%)
ICARDA is a **Decentralized R4D** International Institute on **Dryland Agriculture** combining **Component** Research and **Systems** Research

Staff: 450  
Scientists: 80

[www.icarda.org](http://www.icarda.org)

icarda.org
**New 9: 5 SRPs + 4 CCTs**

**Genetic Resources:** Mining crop diversity to develop germplasm resistant to heat, drought, cold, disease, higher nutrients; International public goods (open access)

**Adaption to Climate Change:** Conventional and molecular breeding to develop climate-smart crops and livestock

**Building resilience:** Integrated crop-livestock farming systems to address economic, social, and environmental conditions

**Promoting value chains, policies:** Agriculture as an income-generating business for many poor smallholder households

**Enhancing water, land productivity:** Rainfed, irrigated, and agro-pastoral farming; Reversal of environmental degradation; Enhance intensification

SRPs-strategic research priorities + CCTs-cross cutting themes
Resilient Agroecosystems

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

- more crop per drop - water focus
- in a inch of land and a bunch of crop - system focus

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

Ecological intensification
Target specific interventions
Bridging yield/data gaps
Resource use efficiency
Nutrition and resilience
Halt land/water degradation
Technology scaling

Pulses
Cereals
Animals

- food and nutritional security
- resilience and risk reduction
- agro-ecosystem sustainability
- adaption and mitigation
- citizen science and collective actions
- trade, social security and stability
• Big Data and IC Technologies can support resilient Agri-food systems under Climate Change, Demography, Variability and Uncertainty

• These data driven smart farming systems have huge potential in the dry areas where resource use efficiency is much below its actual potential

• But they can only deliver if applied to Inclusive Farming Systems
**Goal:** to harness the capabilities of **Big Data** to accelerate and enhance the impact of international agricultural research, and *solve development problems faster, better and at greater scale*
Big Data in Building Resilience

Better integration
Better measurements
Better modelling
Resilient Systems

Crop fields for functional productivity are key to exponential efficiency in world largest and oldest industry

“Agroecosystems”
Big Data in Agroecosystems

Agroecosystems
Inclusively integrated

River Flow
Hydrology
Pastures
Energy
Agriculture
Drought
Weather
Floods
Groundwater
Fisheries
Agro-biodiversity
Delta
Forestry
Horticulture
Agroforestry
Communication
Water use

DECODING
The Data Ecosystem

GEOAGRO
Earth Observation Systems for Agro-Ecosystem Research

ACTIVE SATELLITE SENSORS AND CHARACTERISTICS

Very High Resolution (Up to 1 m)

High Resolution (1 to 5 m)

Medium resolution (5 - 30 m)

Radar Satellites

Low or Medium resolution
### EOS Matrix at Farmscape to Landscape

#### Example of One Sensor in Each Platform/Scale

<table>
<thead>
<tr>
<th>Platforms</th>
<th>Ground/in-situ</th>
<th>Airborne</th>
<th>Spaceborne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>Hyperspectral</td>
<td>Multispectral</td>
<td>Optical</td>
</tr>
<tr>
<td>Sensor</td>
<td>ASD FieldSpec</td>
<td>M× Camera</td>
<td>APs/UAVs</td>
</tr>
<tr>
<td>Spectral</td>
<td>350-2500nm</td>
<td>4 bands</td>
<td>3-4 bands</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>0.1-1.5m</td>
<td>0.1-0.2m</td>
<td>1-m</td>
</tr>
<tr>
<td>Swath</td>
<td>1-4m</td>
<td>2-10m</td>
<td>--</td>
</tr>
<tr>
<td>Revisit</td>
<td>--</td>
<td>--</td>
<td>3-year</td>
</tr>
<tr>
<td>Plant biomass</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Plant height</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>LAI, fPAR, LST</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NDVI, EVI, LSWI</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Erosion, Salinity</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Plant water</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>GPP</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NPP</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>land cover/use</td>
<td>x</td>
<td>x</td>
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<td>phenology</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Irrigation</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>DEM</td>
<td>x</td>
<td>x</td>
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<td>Derivatives</td>
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<td>x</td>
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<tr>
<td>Tier 1 AOs</td>
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<td>x</td>
<td>x</td>
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<tr>
<td>Tier 2 action sites</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Tier 3 AEZs</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Tier 4 Target</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

#### Biospectral – Biophysical

- **Leaf Area Index (NDVI)**
- **Leaf Pigments (Leaf Chlorophyll)**
- **EVI**

**Characteristics**
- Ground/in-situ
- Airborne
- Spaceborne

**Platforms**
- Hyperspectral
- Multispectral
- Optical
- LiDAR

**SAR**
- ICESat
- PALSAR
Applications across the disciplines and scales
## Satellite constellations for Agricultural Applications

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Wavelengths</th>
<th>Spatial Resolution</th>
<th>Revisit frequency</th>
<th>Temporal coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat</td>
<td>Optical (6-9) + thermal</td>
<td>30,60m</td>
<td>16 day</td>
<td>1984-present</td>
</tr>
<tr>
<td>RapidEye</td>
<td>Optical (5)</td>
<td>5 m</td>
<td>5 day</td>
<td>2009-present</td>
</tr>
<tr>
<td>Skysat</td>
<td>Optical (4)</td>
<td>1m</td>
<td>~weekly</td>
<td>2013-present</td>
</tr>
<tr>
<td>WV-2/3</td>
<td>Optical (8)</td>
<td>0.3, 1m</td>
<td>5 day</td>
<td>2015-present</td>
</tr>
<tr>
<td>Planet Scope</td>
<td>Optical (4)</td>
<td>3 m</td>
<td>~daily</td>
<td>2014-present</td>
</tr>
<tr>
<td>Sentinel-1</td>
<td>C-band radar</td>
<td>10, 20m</td>
<td>6 day</td>
<td>2014-present</td>
</tr>
<tr>
<td>Sentinel-2</td>
<td>Optical (13)</td>
<td>10,20,60m</td>
<td>5 day</td>
<td>2015-present</td>
</tr>
<tr>
<td>Sentinel-3</td>
<td>Optical (13)</td>
<td>10,20,60m</td>
<td>3 day</td>
<td>2015-present</td>
</tr>
</tbody>
</table>

Data fusion has huge potential!
New era of analytics

Tabulating Systems Era

Programmable Systems Era

Cognitive Systems Era

Conscious Systems Era
Reflectance-Based Characterization of Bio-Physical Traits

@ cell, leaf, canopy and landscape

Main factors controls leaf reflectance

Primary absorption bands

ICARDA’s Mandate Crops: Barley, Lentil, Wheat, Chickpea, Faba Bean, Grasspea

Rainfed Wheat
Sup. Irrigated Wheat
Irrigated Wheat

Difference NIR-R, healthy vegetation

Water absorption

Water content

Leaf Pigments

Cell structure

Chlorophyll absorption

Leaf Pigments

Visible
Near-Infrared
Middle and shortwave Infrared

ICARDA’s Mandate Crops: Barley, Lentil, Wheat, Chickpea, Faba Bean, Grasspea
Use of Portable Observation Systems in Research

- **Hyperspectral**
- **Thermal Infrared**

UAV/UAS/AgDrones

- **Thermal Palettes**
Advanced Sensors and Tools: Hyperspectral, Multispectral, Thermal, Ultraspatial

Big Data + ICT=GeSTA

HyperSpectral signature of 20 Wheat varieties

Portable spectral devices (Biradar et al., 2012)
Sentinel-2 provides high-resolution imagery in the visible and infrared part of the spectrum aiming to support the monitoring of vegetation, soil and water cover, inland waterways and coastal areas. EO Browser provides data processed to two levels: L1C (orthorectified Top-Of-Atmosphere reflectance) and L2A (orthorectified Bottom-Of-Atmosphere reflectance).

Spatial resolution: 10m, 20m, and 60m, depending on the wavelength.

Revisit time: <= 5 days using both satellites.

Data availability: Since June 2015.

Common usage: Land-cover maps, land-change detection maps, vegetation monitoring, monitoring of burnt areas.

Time range: 2018-11-01 to 2018-12-09

Theme: Default

Powered by Sinergise with contributions from the European Space Agency v2.16.4
Farming system dynamics at given time and scale

<table>
<thead>
<tr>
<th>Farming System</th>
<th>Jamdighri-moved</th>
<th>Pakurseni LDTW</th>
<th>Haripur</th>
<th>Kalisara LDTW</th>
<th>Kundra - IV PDW</th>
<th>Gosain Bundh SFMIS-moved</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Jamdighri</td>
<td>Pakurseni</td>
<td>Haripur</td>
<td>Kalisara</td>
<td>Kundra</td>
<td>Gosain Bundh</td>
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<tr>
<td><strong>FID</strong></td>
<td>11</td>
<td>115</td>
<td>40</td>
<td>24</td>
<td>294</td>
<td>71</td>
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<tr>
<td><strong>BATCH</strong></td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
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<td><strong>Scheme Name</strong></td>
<td>Jamdighri</td>
<td>Pakurseni</td>
<td>Haripur</td>
<td>Kalisara</td>
<td>Kundra</td>
<td>Gosain Bundh</td>
</tr>
<tr>
<td><strong>District</strong></td>
<td>BANKURA</td>
<td>PASCHIM MIDNAPORE</td>
<td>SABANG</td>
<td>MAYURESWARI</td>
<td>BIRBHUM</td>
<td>PURULIA</td>
</tr>
<tr>
<td><strong>Block</strong></td>
<td>JOYPUR</td>
<td>NARAYANGAR</td>
<td>SABANG</td>
<td>MAYURESWARI</td>
<td>RAJINAGAR</td>
<td>KASHIPUR</td>
</tr>
<tr>
<td><strong>Scheme Type</strong></td>
<td>MDTW</td>
<td>TW</td>
<td>LDTW</td>
<td>LDTW</td>
<td>PDW</td>
<td>SFMIS(40ha)</td>
</tr>
<tr>
<td><strong>Village Mo</strong></td>
<td>Jamdighri</td>
<td>Pakurseni</td>
<td>Haripur</td>
<td>Kalisara</td>
<td>Kundra</td>
<td>Ulubena</td>
</tr>
<tr>
<td><strong>Lat</strong></td>
<td>23.07006</td>
<td>22.19834</td>
<td>22.138147</td>
<td>24.05688</td>
<td>23.965694</td>
<td>23.477367</td>
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<tr>
<td><strong>Long</strong></td>
<td>87.47454</td>
<td>87.44417</td>
<td>87.530084</td>
<td>87.84444</td>
<td>87.356805</td>
<td>86.793037</td>
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<tr>
<td><strong>PhysicalPr</strong></td>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Directions:** To here - From here

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Highly intensive systems

Less intensive systems
Mapping Yield Gaps

Grain yield at national average (FAO, 2015)

<table>
<thead>
<tr>
<th>Country</th>
<th>2014</th>
<th>15 yrs ave</th>
<th>15 yr trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morocco</td>
<td>1713</td>
<td>1495</td>
<td></td>
</tr>
<tr>
<td>Algeria</td>
<td>1475</td>
<td>1404</td>
<td></td>
</tr>
<tr>
<td>Tunisia</td>
<td>2149</td>
<td>1820</td>
<td></td>
</tr>
<tr>
<td>Libya</td>
<td>1250</td>
<td>871</td>
<td></td>
</tr>
</tbody>
</table>

Actual grain yield measured at farm level

<table>
<thead>
<tr>
<th>Farms</th>
<th>Longitude</th>
<th>Latitude</th>
<th>(kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm1</td>
<td>6.722111</td>
<td>33.620782</td>
<td>2,125</td>
</tr>
<tr>
<td>Farm2</td>
<td>6.716233</td>
<td>33.612049</td>
<td>5,014</td>
</tr>
<tr>
<td>Farm3</td>
<td>6.704607</td>
<td>33.578011</td>
<td>2,039</td>
</tr>
<tr>
<td>Farm4</td>
<td>6.683507</td>
<td>33.564448</td>
<td>1,579</td>
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<tr>
<td>Farm5</td>
<td>6.605908</td>
<td>33.552394</td>
<td>3,049</td>
</tr>
<tr>
<td>Farm6</td>
<td>6.717472</td>
<td>33.569803</td>
<td>2,703</td>
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<tr>
<td>Farm7</td>
<td>6.729286</td>
<td>33.573701</td>
<td>2,452</td>
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<tr>
<td>Farm8</td>
<td>6.690977</td>
<td>33.573454</td>
<td>4,057</td>
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<tr>
<td>Farm9</td>
<td>6.676971</td>
<td>33.599369</td>
<td>2,525</td>
</tr>
<tr>
<td>Farm10</td>
<td>6.666595</td>
<td>33.604833</td>
<td>2,195</td>
</tr>
<tr>
<td>Farm11</td>
<td>6.707888</td>
<td>33.595405</td>
<td>478</td>
</tr>
<tr>
<td>Farm12</td>
<td>6.703041</td>
<td>33.586931</td>
<td>1,233</td>
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<tr>
<td>Farm13</td>
<td>6.695853</td>
<td>33.572357</td>
<td>1,526</td>
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<td>Farm14</td>
<td>6.702122</td>
<td>33.562839</td>
<td>1,412</td>
</tr>
<tr>
<td>Farm15</td>
<td>6.68507</td>
<td>33.585016</td>
<td>4,026</td>
</tr>
</tbody>
</table>

Range b/w < 1 to 5 t/h

Median 2 t/h.
Quantification of Farming Systems @ multiple-scales

Smart Farming Platform
Resilient Agroecosystems
Sustainable

The Big Data

Geo-Tagging
Satellite data
Crop data
Climate data
Soil data
Water data
Topography
Demography
Ecological data...

Biggest drivers

Computation

Applications

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

Mapping

Geo-Tagging
Satellite data
Crop data
Climate data
Soil data
Water data
Topography
Demography
Ecological data...

Biggest drivers

Computation

Applications

Scalability
Geotagging and AgroTagging
Agroecosystems: scaling innovations and measuring impacts

1.3 ha
30 k ha
300 k ha

- Inputs/reuse
- Yield/Production
- Markets/income
- Functional flows

Irrigated systems
Rainfed systems
Agro-pastoral systems
Easily detectable (RS) evidences of potential yield gaps at farm level
Shift in paradigm for sustainable agri-food systems

Disaggregating yield gaps at farm/pixels scales to target appropriate interventions

Shift in the paradigm from commodity to functional productivity

Productivity (return)

Single commodity

Compound productivity
Integrated Observation Systems

Agro-ecosystems

Weather Station

PhenoCam

Spectroradiometer

CO₂, H₂O, CH₄, & N₂O
Eddy Flux Tower

FLIR Thermal Camera

COSMOS Soil Moisture

COSMOS Rover

Airborne & Space-borne RS

Solar Power
Changing Water Balance

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

Frequent deviation from long-term averages

Shift in growing season and pattern

- Climate variability and extreme events
- Dominance of mono-cropping / few commodity focus
- Depleted soil organic carbon
Build resilient agroecosystems

Sustainable intensification

Financial inclusion

Better livelihoods

Resilient cropping systems

better integration of crops, livestock, fish, trees & people

Optimizing agricultural water use by integrated approach

compound intensification in cereal based systems

Copy with water demand

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

Blockchain for ecological intensification

Incentivizing best agricultural practices through blockchain based WATER/CARBON CREDITS associated with improved agroecosystem health by adoption of the water saving agri-food systems (integrated agroecosystems)

3 days revisit

30m

10m

1.0m

0.3m

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

<Biggest drivers

Agreements

Open source
Integrated Agroecosystems combining Component Research & Systems Research

A multi-scale and multi-criteria R4D

Global
Country
Region
Landscape
Field

icarda.org

Climate (Variability and Change)
Nutrition Security and Sovereignty
Un-employment Poverty
NRMNs

Functional Productivity

Down
Out
Up

Supply Chain

People
Crops
Livestock
Trees

Agricultural Systems
Irrigated
Rainfed
Agro-Pastoral

Cairo

Integrated Agroecosystems combining Component Research & Systems Research

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Irrigated
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Agro-Pastoral

Cairo
Machine Learning and AI in GeoAgro analytics

- 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 to landscape scales
- Enormous power of cloud computing, open access, algorithms, analytics to process data on time
- Smart phone enabled apps and cloud web-GIS for decision making at point, farm and administrative units
Technological Innovations
(integrated systems approach for reducing risks)

1. Biodiversity & Crop Improvement Program
   >> research plots, > farm trials / demonstrations, > international nurseries > germplasms, > NARS partners feedbacks, > etc.

2. Resilient Agricultural Livelihood Systems Program
   >> research plots, > agronomy, > CA/Zero tillage > livestock, > rangelands, > household surveys, > value chains, > etc.

3. Water, Land Management & Ecosystems Program
   >> field data, > raised beds, > Field ETs, > AWPs, > soils, > hydrology, > land degradation, > erosion, > hydrology, > etc.

4. Cross Cutting Themes
   Big Data and ICTs
   >> big-data, > open access resources, > cloud computing, > gender data, > scaling > capacity dev., > modelling, > etc.
Machine Learning and AI in GeoAgro analytics

**Crop types, rotation/sequence, health, productivity, trade**

**What do we assess?**

A: Crop types, rotation and health mapping

B: Crop Yield estimation and forecasting

C: Systems analytics and resource use tradeoffs

**At which temporal and spatial scales?**

**Temporal**

Mode 1: Archives and end-of-year
- Land use intensity
- Yield gaps
- Land degradation

Mode 2: Within-season monitoring
- Early crop acreage estimation
- Crop stress
- Early water demand estimation

**Spatial**

Mode 1: Pixel-level

Mode 2: Object-level

---

*GBDX* *Amazon Web Services* *esri* *Google Earth Engine*
Agroecosystems: scaling innovations and measuring impacts

- Inputs/reuse
- Yield/Production
- Markets/income
- Functional flows

1.3 ha
30 k ha
300 k ha

3 billion ha
3 million ha
3 billion ha

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Rainfed systems
Agro-pastoral systems
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Shift in the paradigm from commodity to functional productivity

Shift in paradigm for sustainable agri-food systems

Disaggregating yield gaps at farm/pixels scales to target appropriate interventions

Shift in the paradigm from commodity to functional productivity
Agricultural Monitoring in Yemen

Please select a product line:

- Croplands
- Fallowed Areas
- Productivity
- Changes

[Graph showing crop yield over time]

[Map showing agricultural land use and productivity]

Go back to the portal
Big-data, Machine Learning and AI algorithms
Big-data, Machine Learning and AI algorithms

AI-ML-BigData @ genetics, chemistry, weather, agronomies, trade…

Meta Analytics

Deep learning
Predictive analytics
Translation
Classification & clustering
Information extraction
Machine learning
Natural language processing (NLP)

Demand driven
Sustainable options

Inclusive Agroecosystems

People
Crops
Livestock
Trees
Multi-year mapping of the crops, intensity and rotation

Quantification of the decadal dynamics of the land use, crop types, cropping intensity and rotation at the field level.
Land use and systems level yield gaps

2000 to 2018
Productivity dynamics, pattern and yield gaps

Inter and Intra field variability

System efficiency at farm/field/pixel level
Crop diversification in the cereal systems - pulses in rice fallows
Smart Farming Systems Platform

Digital Augmentation for accelerating sustainable intensification

Location Specific Interventions

Crowdsource, OA, Cloud Computing at Farm Scale

Cadastral, Object & Pixel based

Biophysical and socio-ecological

Machine Learning
Crop types, crop intensity, rotation, fallows, crop stress, AET-I8, soil moisture-SMAP

Citizen-Science Cellphone feedback

Direct Access and Markets/Business

Precision-Decision

On the fly demand driven query and cluster analysis

Precision decision delivery at farm scales and feedback

Right Time Right Place
Production follows functions
Building functional feedback system through integration of crops, trees and animals

avoid the unmanageable and manage the unavoidable

- IPCC Confronting Climate Change:

Thank You

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Head-Geoinformatics Unit
Principal Scientist (Agro-Ecosystems)