DryArc Interface
R4D framework for collaboration between CGIAR and FAO on Dryland Agriculture

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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
Paradigm shift from monocropping to resources efficient integrated Agri Foods Systems with more crops, trees, livestock, rotation, nutrition >> “more wealth per acre”
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
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.
Biodiverse agroecosystems for plant based diets

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

Changing diet pattern >> cropping systems
>> Sustainable living

Sustainable alternatives for future food systems

There is a need for paradigm shift from more calories per acre to more nutrition (health) per acre.
“Family farms produces 80% of the food in the world.”

- FAO Family farming decade
Support towards rebuilding the resilience

through sustainable intensification

building healthy food systems and rebuilding living soils

“Family Smart Agriculture”

- 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

<<<more health per acre>>>
New era of Geo Bigdata analytics in farming systems

- **Tabulating Systems Era**
- **Programmable Systems Era**
- **Cognitive Systems Era**
- **Conscious Systems Era**

Data driven multi-layer farming with crops, trees, and animals.
Digital Augmentation for Revitalizing Agriculture

Data driven decision for sustainable intensification

- Geotagging
- Agrotagging
- Expert and Existing Knowledge base
- RS/ML algorithms
- sFarm typologies
- MVPs
- Site-specific in-season indicators
- geoWeb Analytics
- Demand driven decisions
- Dissemination
- Digital Extension

- Evidence based Farming systems dynamics
- Diversification of Wheat systems
- Quantify yield/RUE potential and bridge gaps
- Anticipated Advices and Result based management
- Technology Scaling and Accessibility

Resilient Agroecosystems for sustainable future

Extension Advisors
Farmers Unions
Scientists Agents
Supply chains
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

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

1000m
500m
30m
10m
Daily
Monthly
Seasonal
Annual

Region to Farm Scale

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

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.
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.
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

(1) Tools, Databases, Services

- **DryArc Interface**
- **WOCAT**
- **WAPOR**
- **FAOStat**

(2) R4D and D Projects

- **Global Drylands/DryArc region**
  - **Hand-in-Hand Initiative**

- **MENA/NENA Region**
  - **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

3 billion ha

3 million ha

300 k ha

30 k ha

Irrigated systems

Rainfed systems

Agrosilvopastoral systems

Desert farming Potential
Dynamics of Cropping Systems

- Integrated Agro-Ecosystems
- Sustainable Intensification
- Pulses as a crop catalyst
- Building diet and Water Climate Resilience

Agricultural Intensification: 72% Increase in Arable Land

Cropping Intensity
- Kharif fallow
- Rabi fallow

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

(Biradar et al., 2015)
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
Land use and systems level yield gaps

2000 to 2018

Tracing changes to target interventions
The DryArc, Egypt

National level

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

Agricultural development began here in the 1960s using ground water from the Nubian Sandstone Aquifer predominantly center pivot irrigation systems.

Operational Land Imagery (OLI) on landsat 8 captured these natural color images of East Oasis, one of Egypt’s land reclamation projects aimed at making desert areas suitable for agriculture.
Scaling domains for specific varieties and breeds

Biradar et al., 2015. Mapping scaling domain for wheat varieties, SARC SC hub countries. ICARDA.
Machine Learning Intelligence & Applications (MILA)

- e.g. assess cropping system dynamics
Harvesting Progress
2019 vs 2020
Data and Info Integration and Interoperability

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

AI
ML

Big Data

Meta Analytics

- deep learning
- predictive analytics
- translation
- classification & clustering
- information extraction
- natural language processing (NLP)
- Demand driven
- Sustainable options
- expert systems
- planning, scheduling & optimization
- robotics
- vision

- machine learning
- contexts
- options
- location
typology

Inclusive Agroecosystems
Multi-domain integrations
Project specific outputs and integration into interface
Multi-domain integrations
Project specific outputs and integration into interface

4000+ metadata and 1300+ data series
1,000,000+ geodata layers and thousands of statistics series
Dynamics of cropping systems and rotations

**Fallows in Double cropped area**

**Fallows in Single cropped area**
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


Dry Moist Wet Water

High Medium Low NS

Real-time rice crop extent

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

Biradar et al., 2019
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

Length of rice fallows in 2018/2019

Corresponding soil moisture

Rice varieties:
- Short
- Mid
- Long

duration rice varieties

Real-time rice crop extent

Oct 2018  Nov 2018  Dec 2018

Dry  Moist  Wet  Water

<30 days  31-60  61-90  91-120
Sustainable intensification of the cereal-based systems with legumes

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

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

<table>
<thead>
<tr>
<th>Rice Acreage by MoAFW, Govt of India (2017-18)</th>
<th>Rice Acreage by Sentinel-1 SAR image</th>
<th>All crop Fallows</th>
<th>Rice crop fallows</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.716 Million Ha</td>
<td>2.775 Million Ha</td>
<td>4.25 Million Ha</td>
<td>0.99 Million Ha</td>
</tr>
</tbody>
</table>

# 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

Impact on
- Productivity
- Production
- Quality
- Trade

Informed decisions in advance
- Predicted risks
- Early warning
- Mitigation measures

Climate change impacts and scenarios
Potential climate risk for current and future

May 2020 - Jul 2020 Precipitation Anomaly Forecast

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

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ACCELERATE co-design with Farmers Communities

ENABLE Policies and Institutions for Systemic Innovation

INTEGRATE Innovations and Methods

Commodity-based and Component-based innovations (eg. New varieties, new equipment....)

Existing Platforms (national, regional, international)
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

Nearly 11m ha left fallows each year
Dryland Family Farming

Planting multiple crops for monthly income while main crop continue to grow. Example 1: Growing monthly harvestable crops, like salad greens (arugula), red radish, leafy amaranth, coriander, dill, spinach in the 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

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