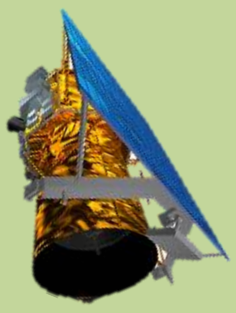
Global Water Security Conference
for Agriculture and Natural Resources
3-6 October 2018, Hyderabad, India | Taj Krishna Hotel



Pulses in rice-fallows for improved resource use efficiency

Raj Kumar Singh[1], Chandrashekhar Biradar[2*], Mukund Behera[3], Nigamananda Swain[1], Ashutosh Sarker[1], Apurba Dash[1] and Surajit Ghosh[1]

[1]International Center for Agricultural Research in Dry Areas (ICARDA), New Delhi, India
[2]International Center for Agricultural Research in Dry Areas (ICARDA), Cairo, Egypt
[3]Indian Institute of Technology, Kharagpur, India
*correspondences: c.biradar@cigar.org, a.sarker@cgiar.org

Abstract: Resource use efficiency, especially water resources have become a norm for sustainable and efficient agricultural production systems in the dry areas. While the productivity of few dominant crops has been a major driver than functional systems resulted in system inefficiency over the long term. The production follows function and functional agricultural systems are vastly more productive and sustainable than dysfunctional systems. Therefore, diversified agroecosystems are found to be more productive, resource-use efficient, and help bridging the yield as well nutritional gaps per acre while resilient to extreme climate events. Such diversification requires a paradigm shift in the crop rotation, sequence and intensification for better resource efficiency. One of the opportunities lies in the potential use of the rice-fallows rotation for growing pulses to improve water productivity. However, often lack of the adequate and updated information on the crop follow rations, its dynamics, soil type and moisture status, productivity dynamics, etc. led to poor intervention at the ground level. With recent advances in harnessing the power of big-data analytics couple with Geoinformatics and access to real-time remote sensing provided a unique capability for quantifying suitable matrix for intensification with pulse crops such as lentil, green gram, grasspea, pea and chickpea in the rice-fallows rotations. The dynamics of the rice fallows has been mapped using multi-source satellite data (MODIS, Landsat, Sentinel, WorldView, SMOS), UAVs/drones and in-situ observations. The hotspots (priority areas) were delineated with respect to multi-year crop fallow dynamics such a start and end dates, length of the fallows, biophysical parameters for specific pulse crops and varieties. The high-resolution farm typology was built along with soil moisture regimes and suitable points for rainwater harvesting have been drawn for providing supplemental irrigation during the dry season. Resultant analytics may able to provide a holistic perspective to fine tune decisions and actions for efficient use of water resources towards higher cropping intensity in mono-cropped areas. Such intervention contributes to human, animal and soil health improvement, and to overall resilient livelihoods of the people of dryland production systems.

INTRODUCTION

- Diversified agroecosystems are found to be more productive and resource-use efficient.
- Opportunities lies in the potential use of the rice-fallows for growing pulses to improve water productivity. However, often lack of the adequate and updated information on the crop follow ratios, its dynamics, soil type and moisture status, productivity dynamics, etc. led to poor intervention at the ground level.
- Real-time Geo-Big-data analytics can provide a unique solution to quantify suitable matrix for intensification with pulse crops in the rice-fallows.
- The dynamics of the rice fallows has been mapped using multiple satellite sensors, UAVs/drones and in-situ observations. The hotspots (priority areas) were delineated with respect to multi-year crop fallow dynamics such a start and end dates, length of the fallows, biophysical parameters for specific pulse crops and varieties.
- The high-resolution farm typology was built along with soil moisture regimes and suitable points for rainwater harvesting have been drawn for providing supplemental irrigation during dry season.

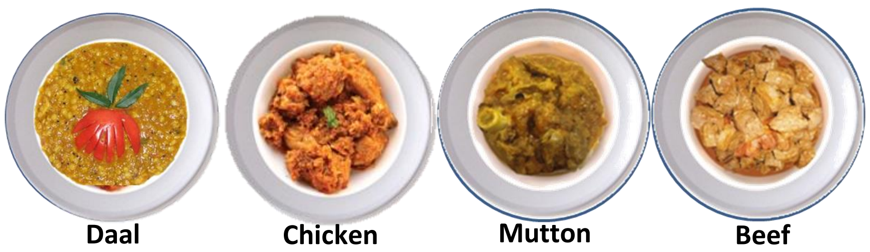
Three fold benefits of legumes in rice-fallow rotation

1. Livestock fodder: Lentil: **2.0-2.5 t/ha;** Chickpea: **2.8-3.0 t/ha**
Grasspea: Green fodder **12.0 t/ha**and residue **3.0 t/ha**
2. Soil health: Fertilizer Savings: **40-70 kg/ha**
3. Income: Average net income from pulses as additional crop in rice fallows: **USD 350-400/ha**

DATA USED

- **Remotely Sensed Data:** MODIS, Landsat, Sentinel, WorldView, SMOS, AMSR-E and UAVs/drones.
- **Fallow Dynamics:** Start date of fallow, End date of fallow, length of the fallow (Duration).
- **Climate Data:** Temperature (Min and Max), Rainfall and Net radiation.
- **Topographic Data:** Elevation, Slope, Drainage density.
- **Soil Data:** Texture, Depth, Moisture, pH, OC, CEC and Salinity.

Water productivity of dietary protein (liters used to produce 1 kg)



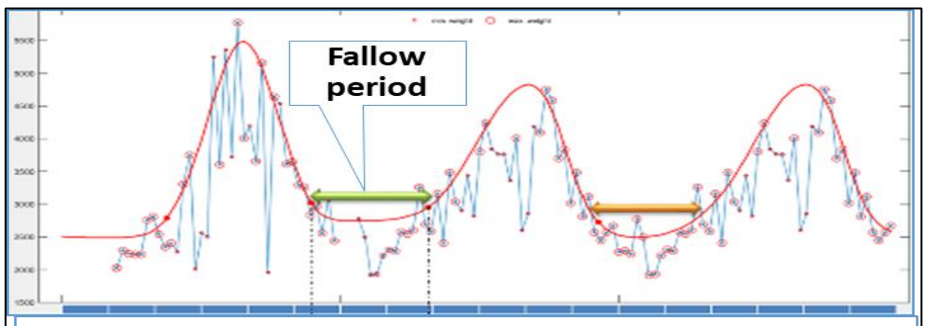
Daal	Chicken	Mutton	Beef
1,250	4,325	5,520	13,000

RESULTS AND DISSCUSSION

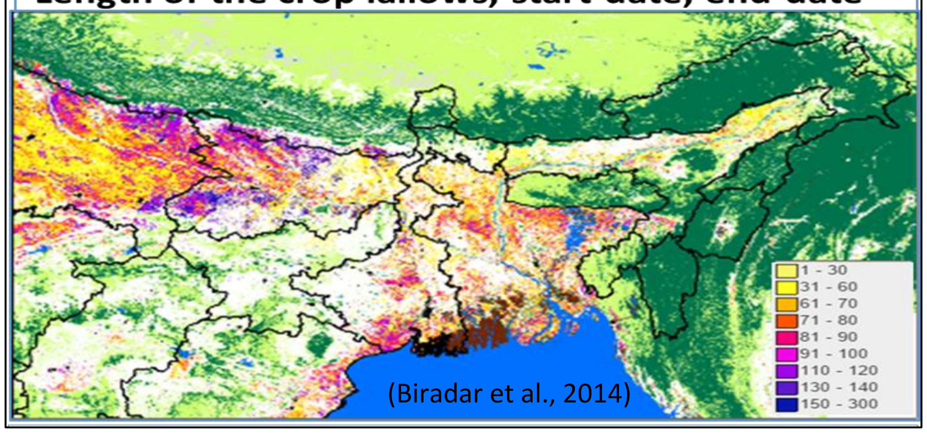
Cropping Intensification and diversification of the Rice-fallow systems

- Food legumes
- Forages/grazing
- Oil seeds/cash crops

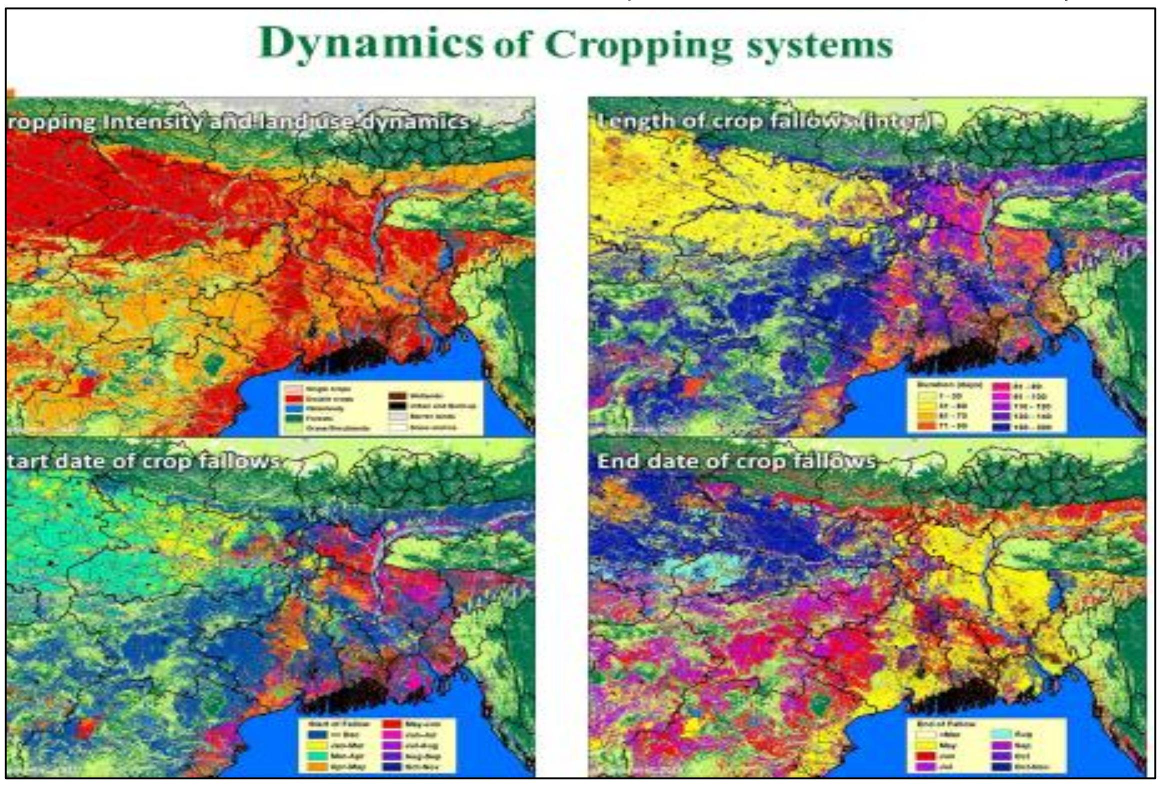
1. Increased land and water productivity/unit area
2. Sustainable income throughout the year
3. Improved crop rotation
4. Use of residual moisture
5. Improved soil health



Length of the crop fallows, start-date, end-date

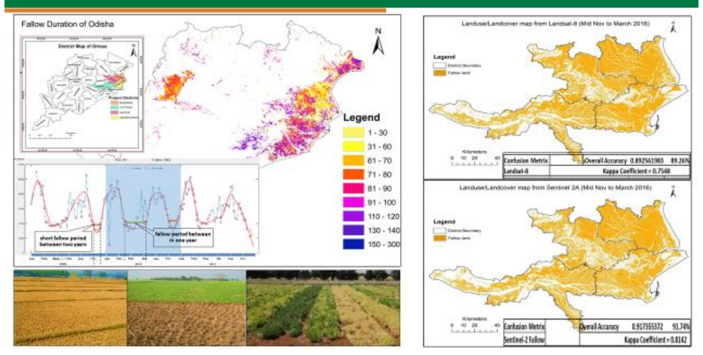


(Biradar et al., 2014)

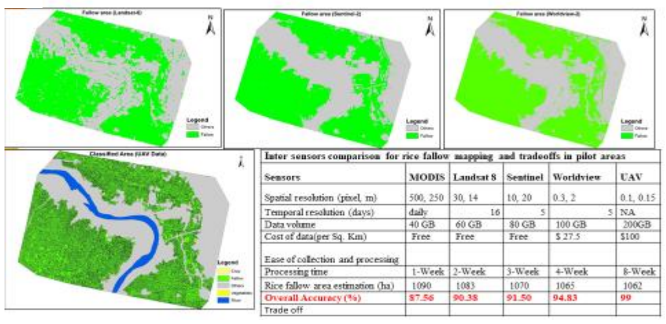


- Improved algorithms for mapping crop fallows and cropping intensity and crop calendar using earth observation data from 2000-2015
- Historical to current land use and land cover dynamics
- Crop fallows, length of the crop fallows, start date and end date of the crop fallows and crop intensification from last 15 years

Mapping Rice fallow Dynamics at different scales

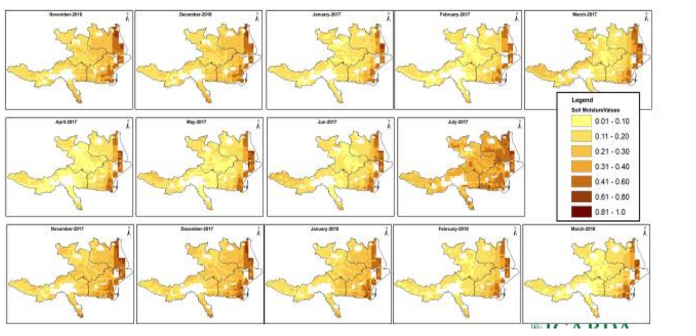


Inter sensors comparison for rice fallow mapping and tradeoffs in pilot areas



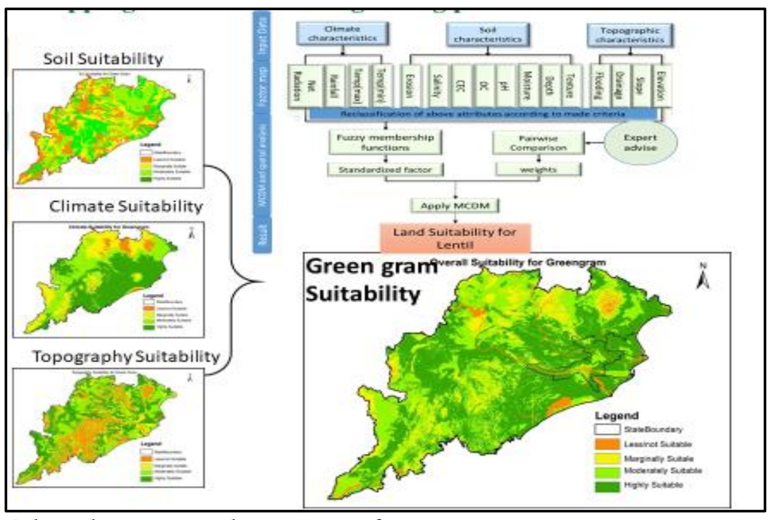
Inter sensors comparison for rice fallow mapping and tradeoffs in pilot areas					
Sensors	MODIS	Landsat 8	Sentinel	Worldview	UAV
Spatial resolution (pixel, m)	500, 250	30, 14	10, 20	0.3, 2	0.1, 0.15
Temporal resolution (days)	daily	16	5	5	NA
Data volume	40 GB	60 GB	80 GB	100 GB	200GB
Cost of data(per Sq. Km)	Free	Free	Free	$ 27.5	$100
Ease of collection and processing					
Processing time	1-Week	2-Week	3-Week	4-Week	8-Week
Rice fallow area estimation (ha)	1090	1083	1070	1065	1062
Overall Accuracy (%)	87.56	90.38	91.50	94.83	99
Trade off					

Soil Moisture regime from Nov 2016-18 (SMAP radiometer, Sentinel-1A & -1B)

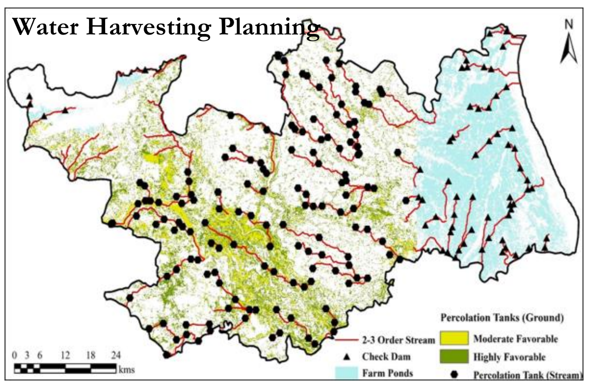


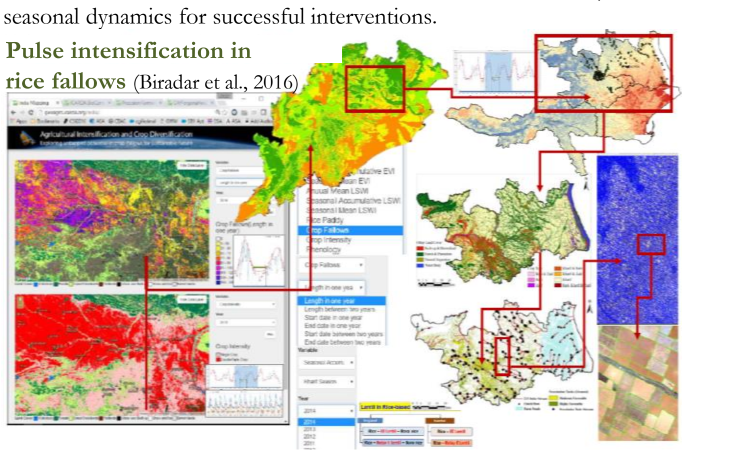
Building farm typologies using multisource data (MODIS, Landsat, Sentinel, WV2/3, UAV/Drones, In-situ observations)for achieving highest accuracy and better understand inter and intra seasonal dynamics for successful interventions.

Mapping suitable areas for growing pulses in fallow areas



Pulses have tremendous scope for area expansion in rice-fallow areas, considering the food and nutritional security. Residual soil moisture needs to be conserved to accommodate the pulses in rice-fallows for higher productivity and profitability





Pulse intensification in rice fallows (Biradar et al., 2016)

CONCLUSIONS

- Multi-sensors satellite provide options to map rice fallow dynamics across the scales
- Resultant analytics helps to make decisions for better pulse intensification with improved resource use efficiency
- Such intervention contributes to economic growth, soil fertility improvement, optimum usage of resources and to overall resilient to extreme climate events for the people of dryland production systems.

References:

http://geoagro.icarda.org/intensification/

Biradar, C. 2016. Powering up Nutritious Food Production in India with Spatial Solutions. Blog, CRP on Dryland Systems

Biradar, C., Singh, R., Behera, M., Sarkar, A., et al., 2018. Spatial big data analytics for sustainable intensification of pulse crops in South Asia. VII International Food Legumes Research Conference

Biradar, C. and Xiao, X. 2010. Quantifying the area and spatial distribution of double- and triple-cropping croplands in India with multi-temporal MODIS imagery in 2005. IJRS 32(2), 367-386.

Biradar, C., Zhang, G., et al. 2016. Spatial big-data analytics for agricultural intensification and crop diversification in rice fallows. D-SPACE: https://mel.cgiar.org/repo/20.500.11766/6309