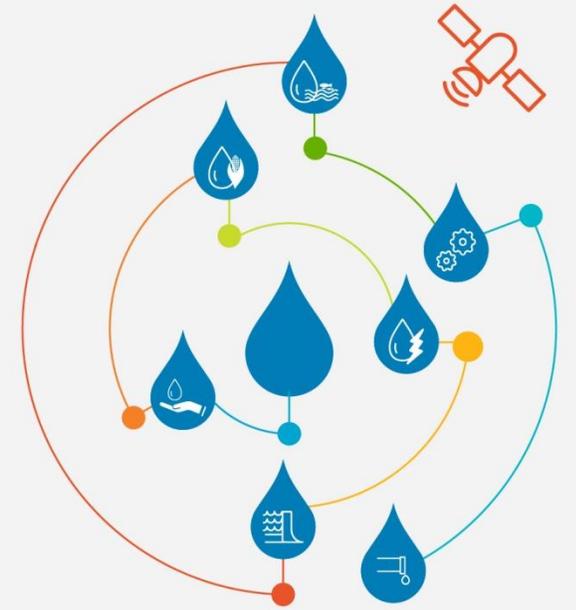


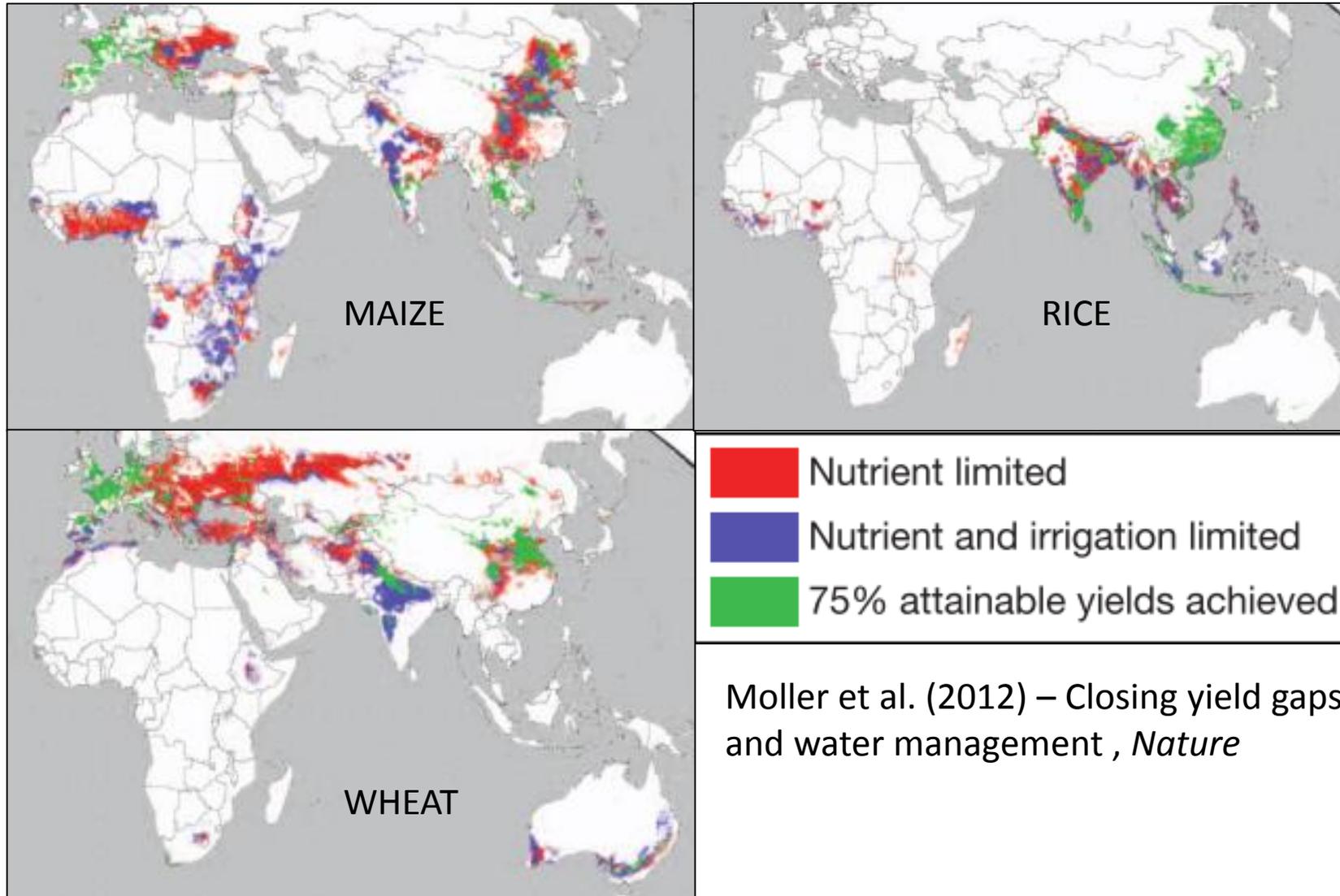
Mainstreaming Satellite Earth Observations and Smart Technology for Addressing Water-Food Security Challenges of Asia



Faisal Hossain
University of Washington
October 2-4, 2018

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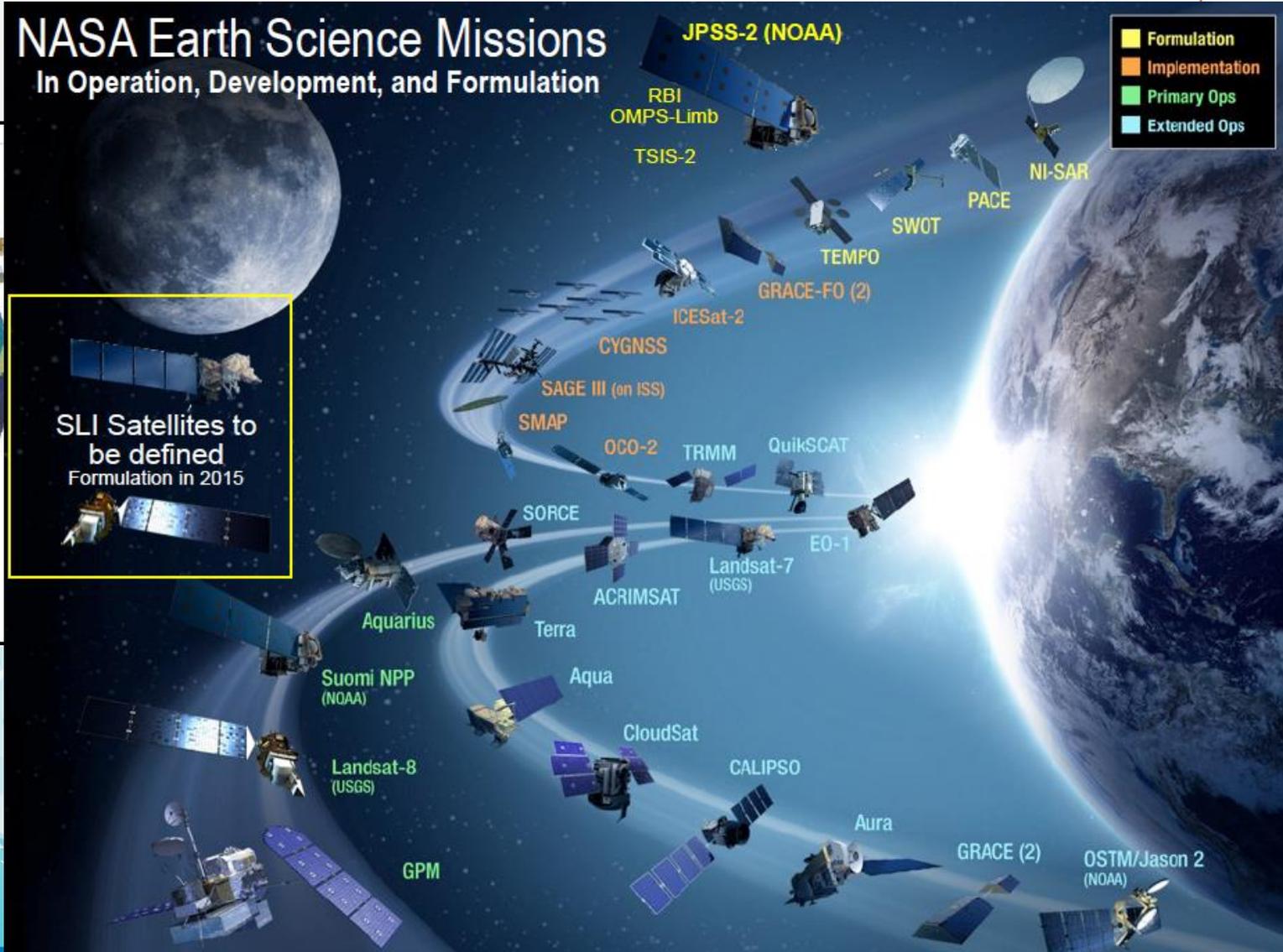
CURRENT STATE OF AFFAIRS



Moller et al. (2012) – Closing yield gaps through nutrient and water management , *Nature*



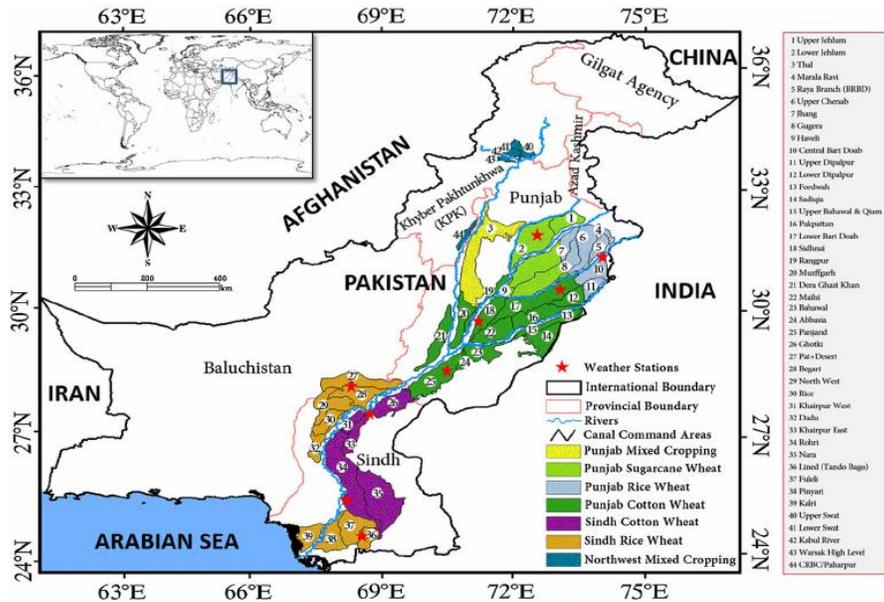
SATELLITE REMOTE SENSING AS A COST-EFFECTIVE PLATFORM



SLI Satellites to be defined
Formulation in 2015



CAN WE GROW MORE WITH LESS WITH EARTH OBSERVATIONS AND SMART TECHNOLOGY?



Indus Basin Irrigation System

Original design: One crop/year
Reality Today: 2.5 crops/year

Year-round farming = increased demand on Pakistan's water supply.



1951

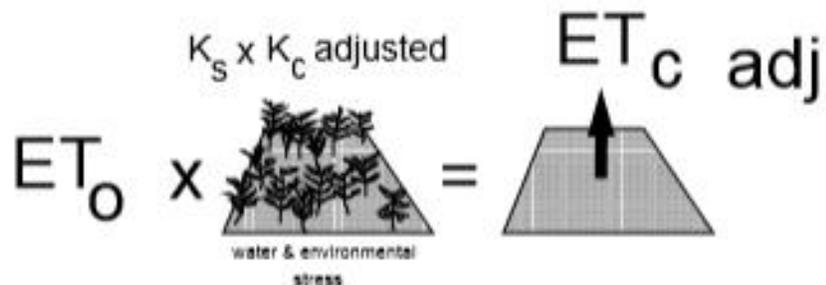
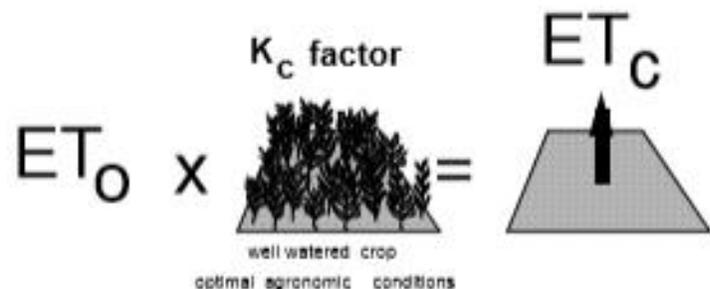
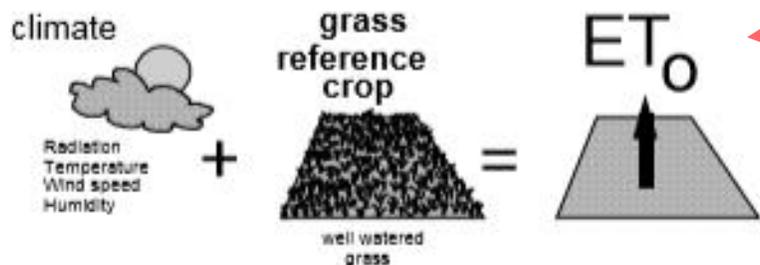
2017

CAN WE GROW MORE WITH LESS WITH EARTH OBSERVATIONS AND SMART TECHNOLOGY?

- Crop water requirements for rice > **60 percent** of irrigation water
 - **600 mm** in Punjab province **1,400 mm** in Sindh province
 - Farmers apply 2,200 mm – tremendous water loss, groundwater decline and costlier pumping
- How do we change farmers mindset (that they do not need to 'irrigate' that much) when there is enough from nature?*
- Water use efficiency of rice averages **0.45 kg of rice/m³** (world average **0.71 kg/m³**) – lowest - **0.08kg/m³**
 - Several indigenous water conservation-irrigation technology available



CROP WATER DEMAND

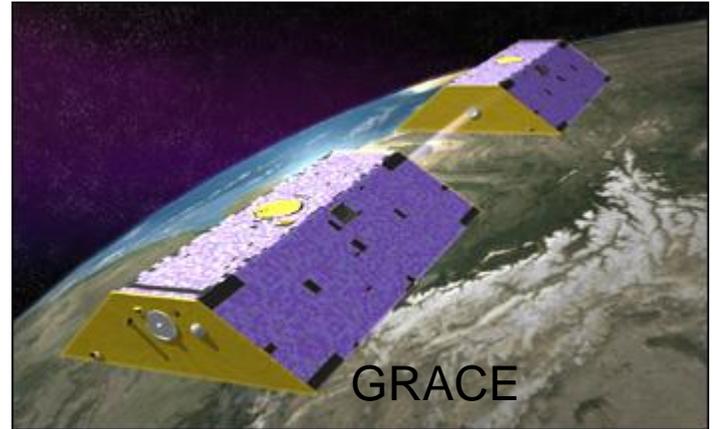
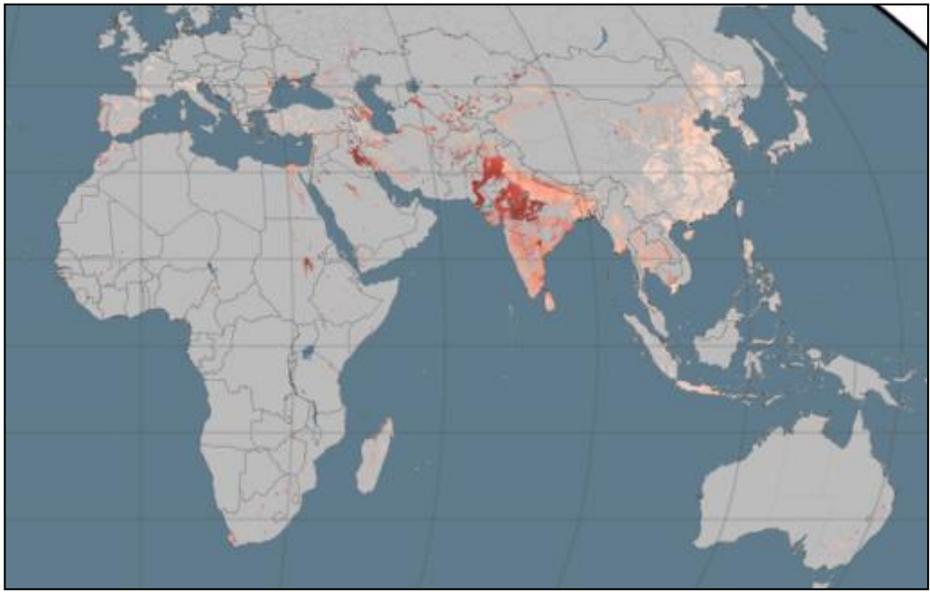
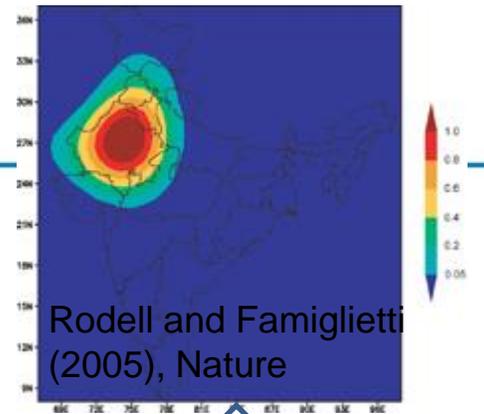
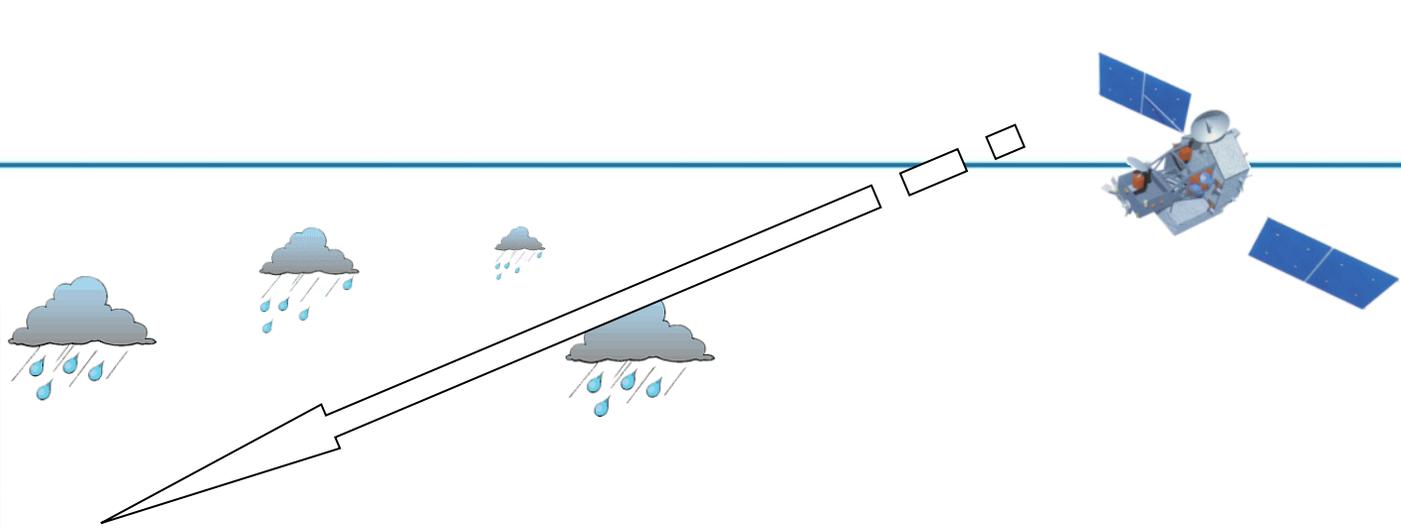


$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma \left(1 + \frac{r_s}{r_a}\right)}$$

K_c = from lysimeter crop studies (published in manuals)
Function of crop type, growth stage, climatic zone,
breed

K_s = from soil moisture conditions (because a site will
not always be 'well-watered' (or always irrigated))





Source: Foley et al. (2011), Nature, "Solutions for a Cultivated Planet"



THE MESSAGES TO FARMERS

Dear farmer friend, we would like to inform you that your wheat crop does not need irrigation due to sufficient rainfall during the past week.

Dear farmer friend, we would like to inform you that the irrigation need for your banana crop was 2 inches during the past week.

Forecast-based Advisory also provided

With Telenor Pakistan

700 farmers

10,000 farmers

100,000 farmers

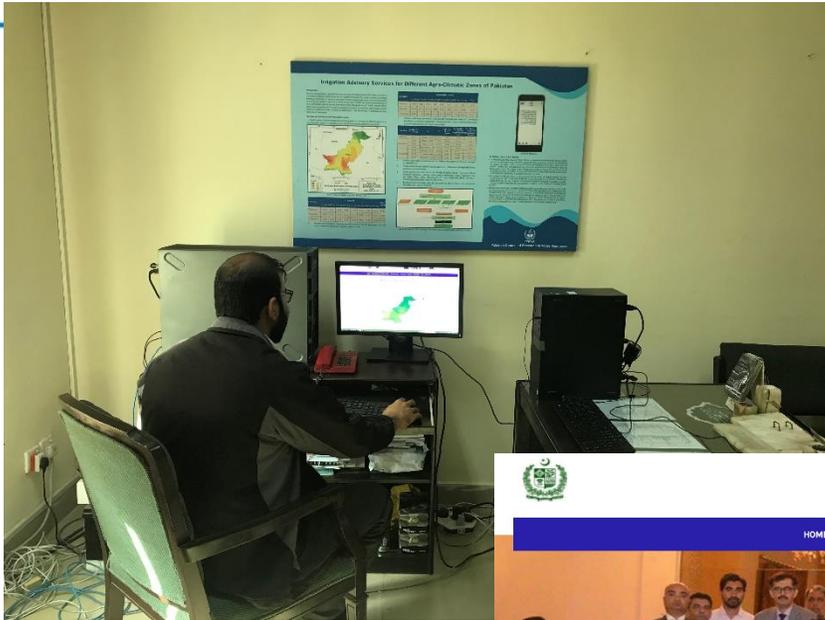
2016

2017

2018



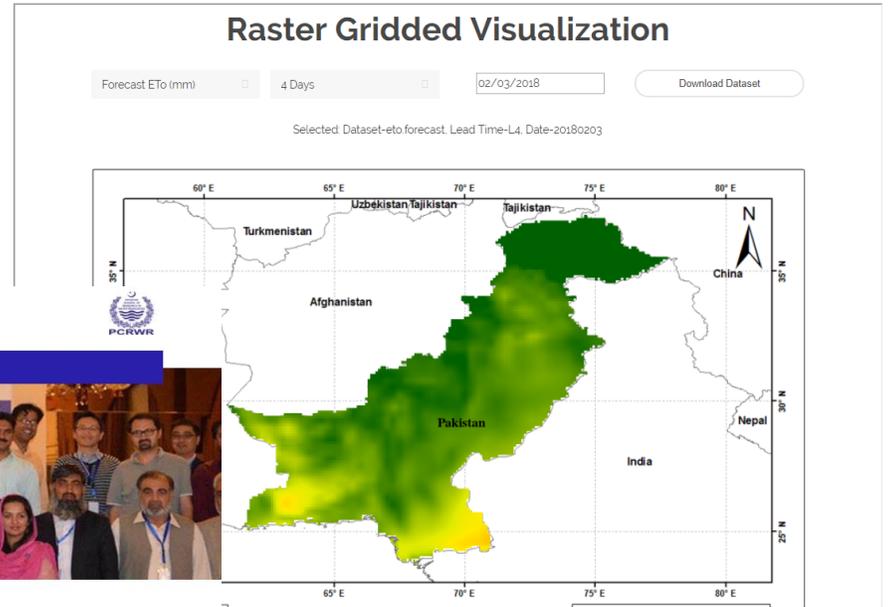
CAPACITY BUILDING AND TECHNOLOGY TRANSFER



<http://58.65.129.81/index.html>


Government of Pakistan
Ministry of Science and Technology
PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES (PCRWR)


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Government of Pakistan
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Water Research for Changing World

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Irrigation Advisory Services

PCRWR Launched Weekly Irrigation Advisory SMS Service for the Farmers

PCRWR launched the service on April 18, 2016, which is an outcome of international collaboration extended by the University of Washington (UW) and NASA. The UW is providing real time daily Potential Evapotranspiration (ET) and precipitation for entire Pakistan using NASA's remotely sensed data. PCRWR determined crop coefficients (Kc) for different crops in different agro-climatic zones of Pakistan. The service informs the farmers about their net weekly irrigation requirements, considering ET and precipitation. In the long run, PCRWR envisions extending the service to all farmers of irrigated areas, through international and national coordination.

District-Wise Weekly Advisory Messages
[View File](#)

Campaign Management Tool
[Login](#)



QUANTITATIVE IMPACT EVALUATION

25 billion cubic meter can be saved per year per million farmers

[25 km³; Grand Coulee Dam: 6 km³]

40% saving in irrigation water

80% usage rate among farmers

Evidence of doubling of farmer income through yield increase



FUTURE DIRECTIONS

1. Skill improvement issues for Crop water demand and Precipitation supply:
net radiation/cloud cover, land cover heterogeneity, in-situ/AWS data for dynamic correction – *ON GOING* (Pakistan)

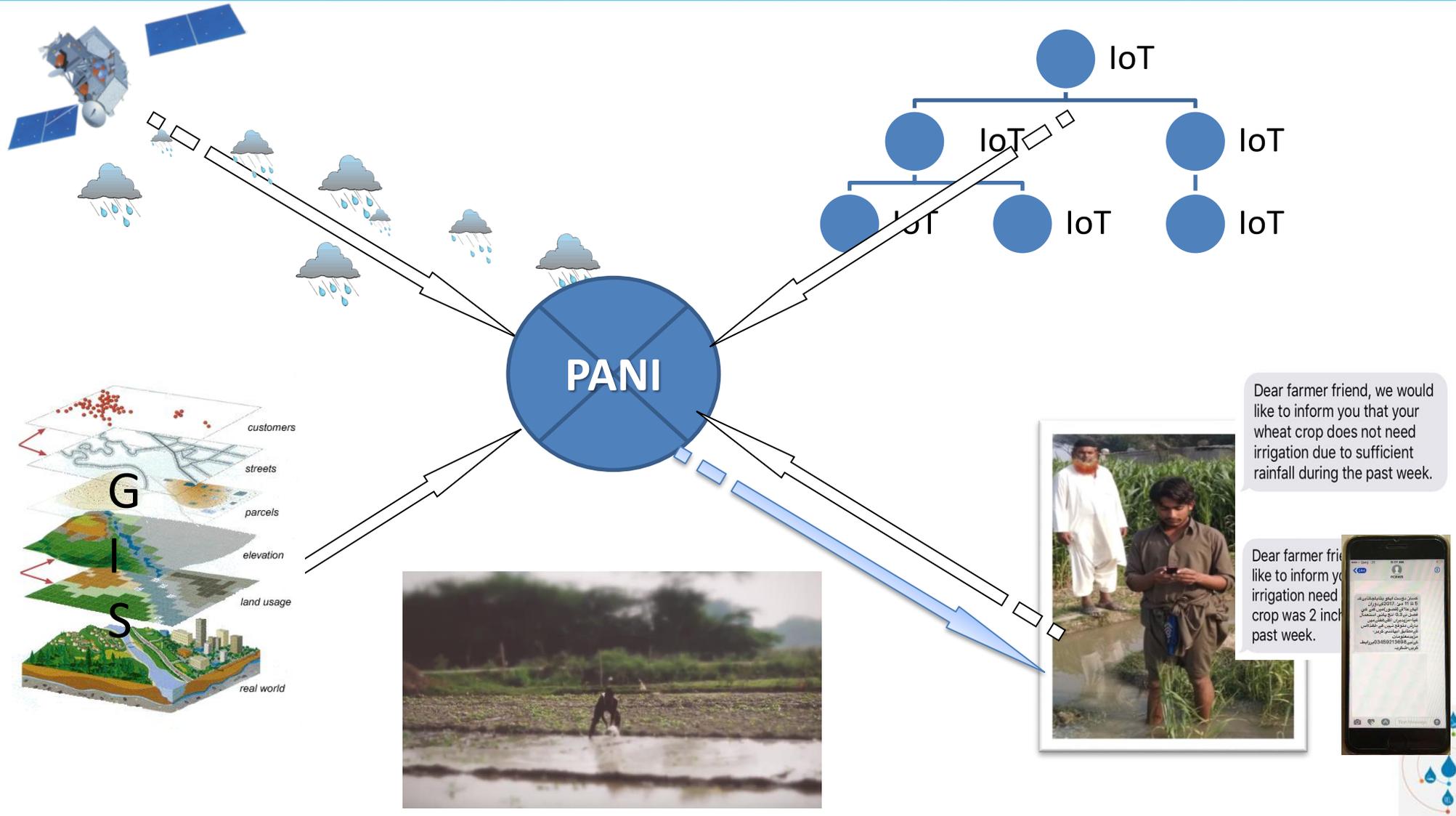
2. Marginal farmer needs who grow 3/4th of total food:
higher spatial resolution (plot scale), IoT and Cloud-based computing (Google earth engine) – *ON GOING* (India)

3. Comprehensive use of (FREE) Satellite and Model-based Earth Observations:
Additional satellite sensors/weather models to add value and keep costs down



IoT BASED PANI IS BEING BORN...

Provision for Advisory on Necessary Irrigation



TAKE HOME MESSAGES

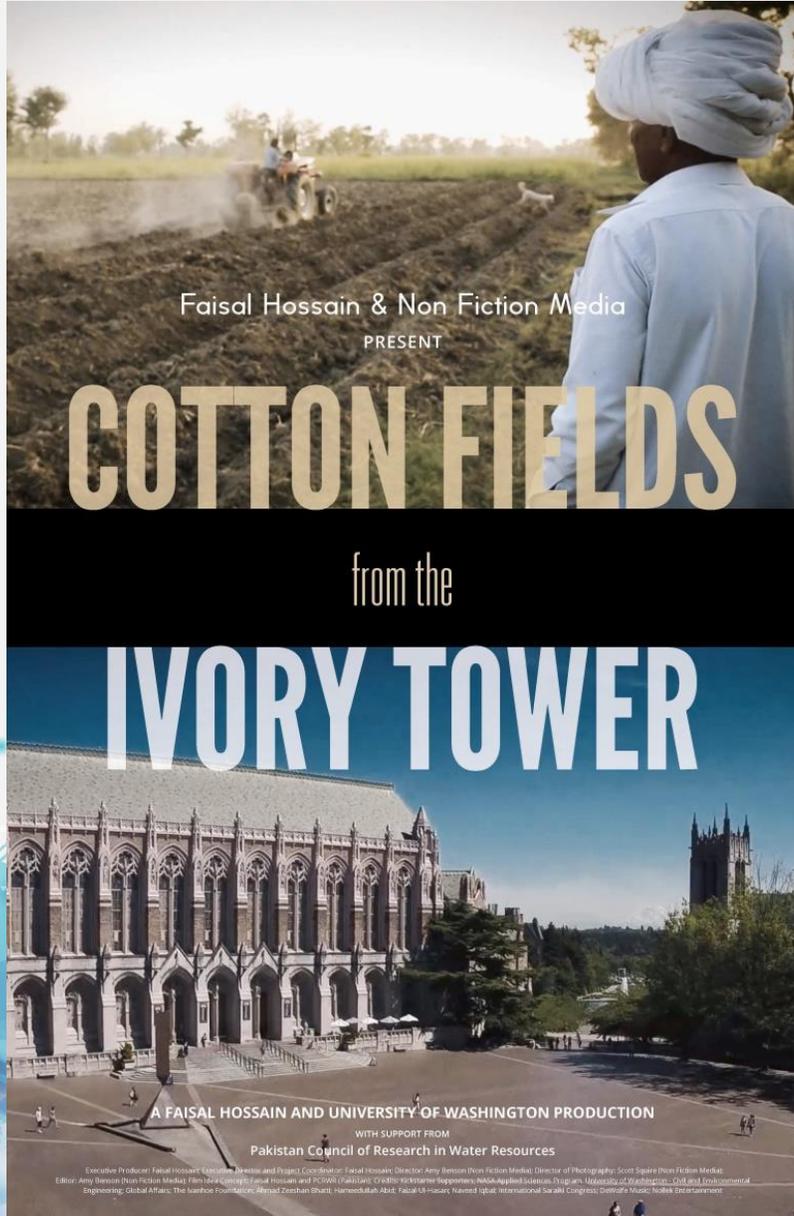
- EARTH OBSERVATIONS AND NUMERICAL WEATHER MODELS ARE LOW HANGING SOLUTIONS FOR ADDRESSING WATER-FOOD SECURITY CHALLENGES
- TWO-WAY ENGAGEMENT, CO-DESIGN AND BUSINESS MODELS NEEDED FOR RESEARCH-GRADE SOLUTIONS TO THRIVE IN SUSTAINABLE OPERATIONAL SETTINGS
- TECHNOLOGY THAT HAS PRECISION AND IS SMART DOES NOT HAVE TO BE EXPENSIVE
- FUTURE DIRECTIONS SHOULD ADDRESS MARGINAL FARMERS (WHO GROW 2/3rd OF FOOD) USING IoT, CLOUD-BASED COMPUTING AND FREELY AVAILABLE DATA



ACKNOWLEDGEMENTS

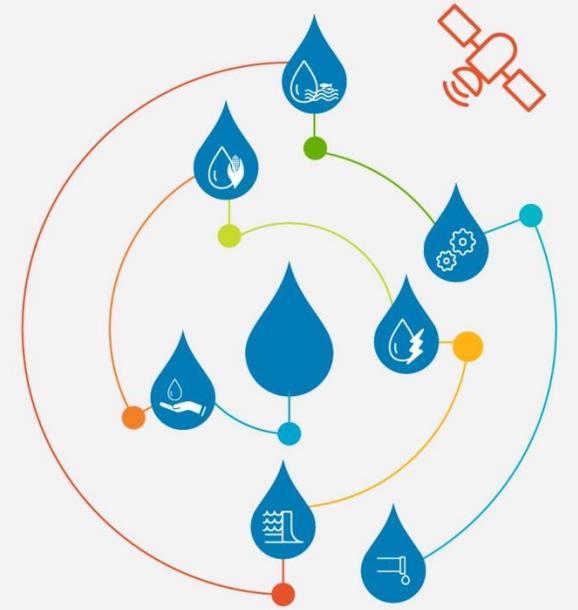
- Asian Development Bank & PCRWR
- University of Washington – Global Affairs Program
- Sponsors (federal, non-federal, banks, foundations)
- Collaborators (research and stakeholder agencies) - PCRWR, IITK, Geokno, Kritsnam
- Friends/Colleagues: Nishan Biswas, Shahryar Ahmad, Asif Mahmood, Safat Sikder, Ahmed Zeeshan, Naveed Iqbal, Bharat Lohani, Shivam Tripathi, Harsha Karumanchi,





THANK YOU!
QUESTIONS?

www.saswe.net/cinematography



ET_o MEASUREMENT – CROP WATER DEMAND

Different methods are available however, most common is:

FAO-56 (Penman-Monteith)

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma \left(1 + \frac{r_s}{r_a}\right)}$$

R_n: net radiation

Necessary inputs (from satellites/models) to apply this method:

G : soil heat flux

(e_s - e_a) : air vapor pressure deficit

1. Daily maximum temperature (°C)

r_a : mean air density at constant pressure

2. Daily minimum temperature (°C)

c_p : air specific heat

3. Daily maximum relative humidity

Δ : saturated vapor pressure-temperature relationship slope

4. Daily minimum relative humidity

γ : psychrometric constant

5. Latitude of the location

r_s and r_a : elevation above sea level of the location

6. Elevation above sea level of the location

Challenge: Daily manual calculations not practical for an entire country



Land Records on GIS

← → ↻ nlrmp.nic.in/faces/rptPhysicalHome/rptStateGenericDetail.xhtml?id=../master/physical.xhtml ☆



Digital India Land Records Modernization Programme - MIS 2.0

Department of Land Resources (भूमि ससाधन विभाग)
Ministry of Rural Development, Government of India (ग्रामीण विकास मंत्रालय, भारत सरकार)



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▼ **Sanction and Release**

- Project Wise
- Component wise
- Model Districts
- Model Districts -Component wise
- Financial Year wise
- Duration wise (From – To)
- Activity wise
- State / District wise

▼ **Physical progress**

- Land Records State Generic Details

Land Records State/UT Generic Details

Sl.No	State/UT Name	Entry of ROR	Whether Hand Written Records Discontinued	Whether Legal Sanctity given to Computerized ROR	Whether ROR Available On Web	Website Address		Dashboard Link		Whether Maps Available On Web	Establishment of Project Management Unit (PMU) for NLRMP at the State/UT level	Integration with Banks	Integratio with Courts
						ROR	Bhunaksha	LR	PR				
1	2	3	4	5	6	7a	7b	8a	8b	9	10	11	12
1	ANDAMAN & NICOBAR	Ownership	Yes	Yes	Yes	Dweep bhoomi	Not Available	Not Available	Not Available	No	Yes	No	No
2	ANDHRA PRADESH	Ownership	Yes	Yes	Yes	Mee Bhoomi	Bhunaksha_AP	Not Available	Not Available	Yes	No	Yes	No
3	ARUNACHAL PRADESH	Ownership	No	No	No	Not Available	Not Available	Not Available	Not Available	No	Yes	No	No
4	ASSAM	Ownership	Yes	Yes	No	Not Available	Not Available	Not Available	Not Available	No	No	Yes	No



Soil health card (SHC) by Govt. of India

- Being produced every 3rd year
- For all 140 Million farmers
- Contains 12 soil parameters (namely N,P,K (Macro-nutrients) ; S (Secondary- nutrient) ; Zn, Fe, Cu, Mn, Bo (Micro - nutrients) ; and pH, EC, OC (Physical parameters)
- For fertilizer and crop type recommendations

A study conducted by National Productivity Council (NPC) in 2016 reported that around 84 per cent of farmers said the information on soil status and nutrients recommendations helped them in reducing the cost of cultivation and improving productivity of crops.



LOW COST SENSORS & LOW POWERED WIDE AREA NETWORK (LPWAN)



INTEGRATION ON THE CLOUD FOR PANI



HOW AFFORDABLE IS PANI?

- LPWAN gateway = (with solar panels and cloud connectivity)
- LPWAN communication node=
- Multi-sensor module (temperature, humidity, rainfall, pressure and windspeed) =

- Good quality soil moisture sensor (capacitance based) =
- ONE LPWAN tower covers at least 100 km² with 100 environmental sensors
- If 100 farmers live 1 km² (average farmer density in India), setup cost per farmer=
(estimate by Indian partners)

