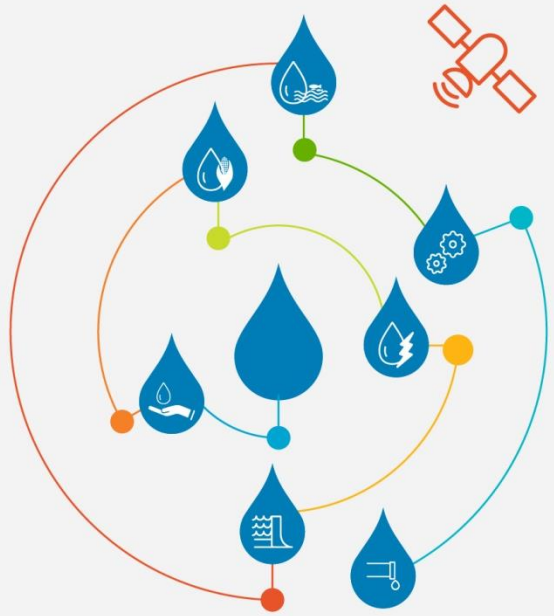
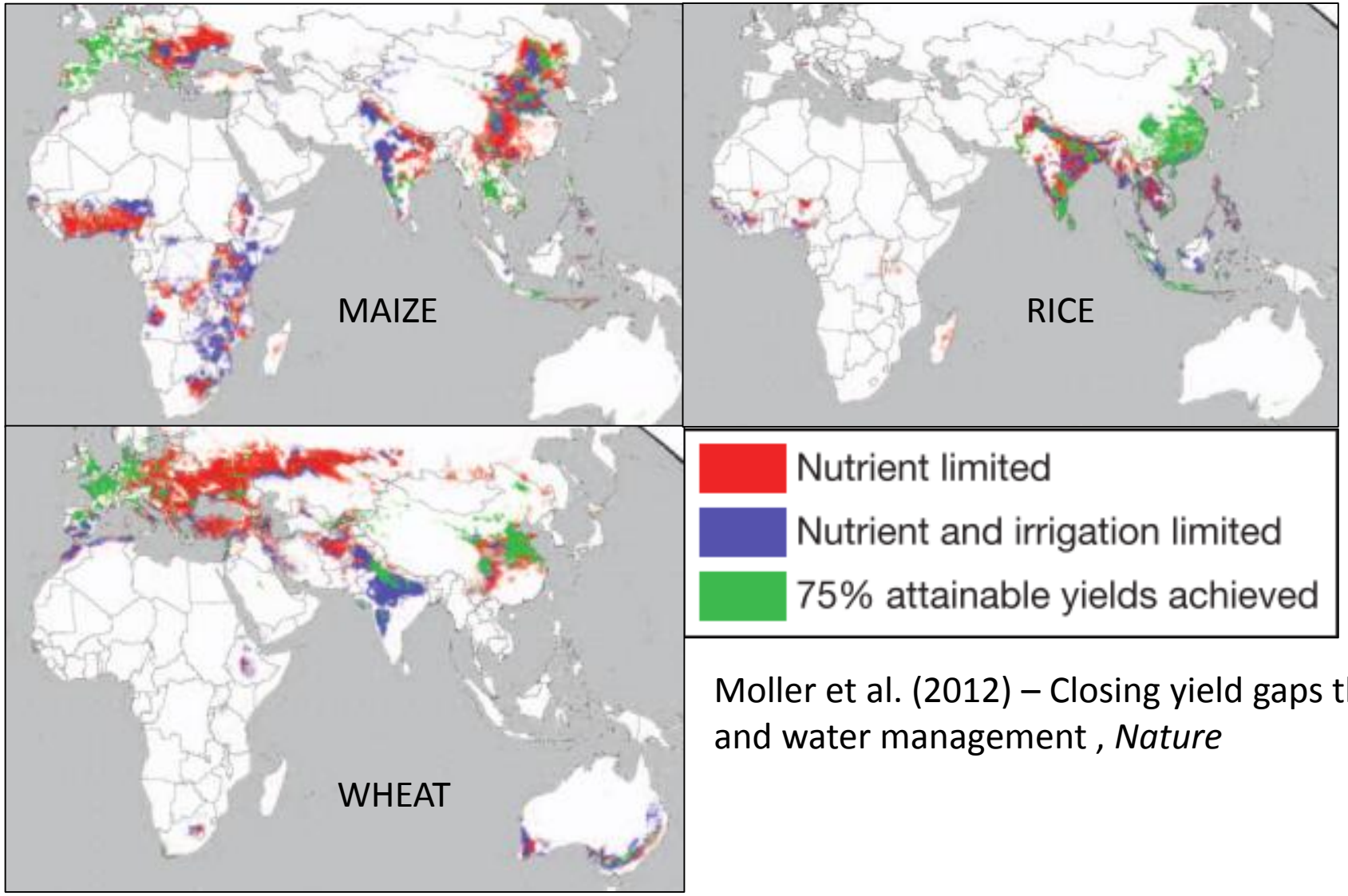
Mainstreaming Satellite Earth Observations and Smart Technology for Addressing Water-Food Security Challenges of Asia



Faisal Hossain
University of Washington
October 2-4, 2018

ADB

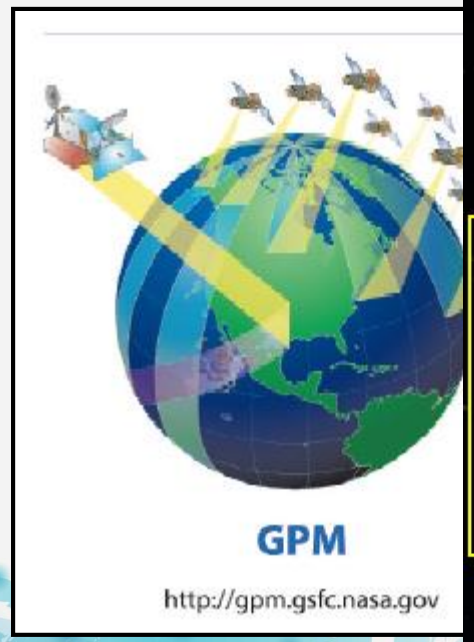
CURRENT STATE OF AFFAIRS

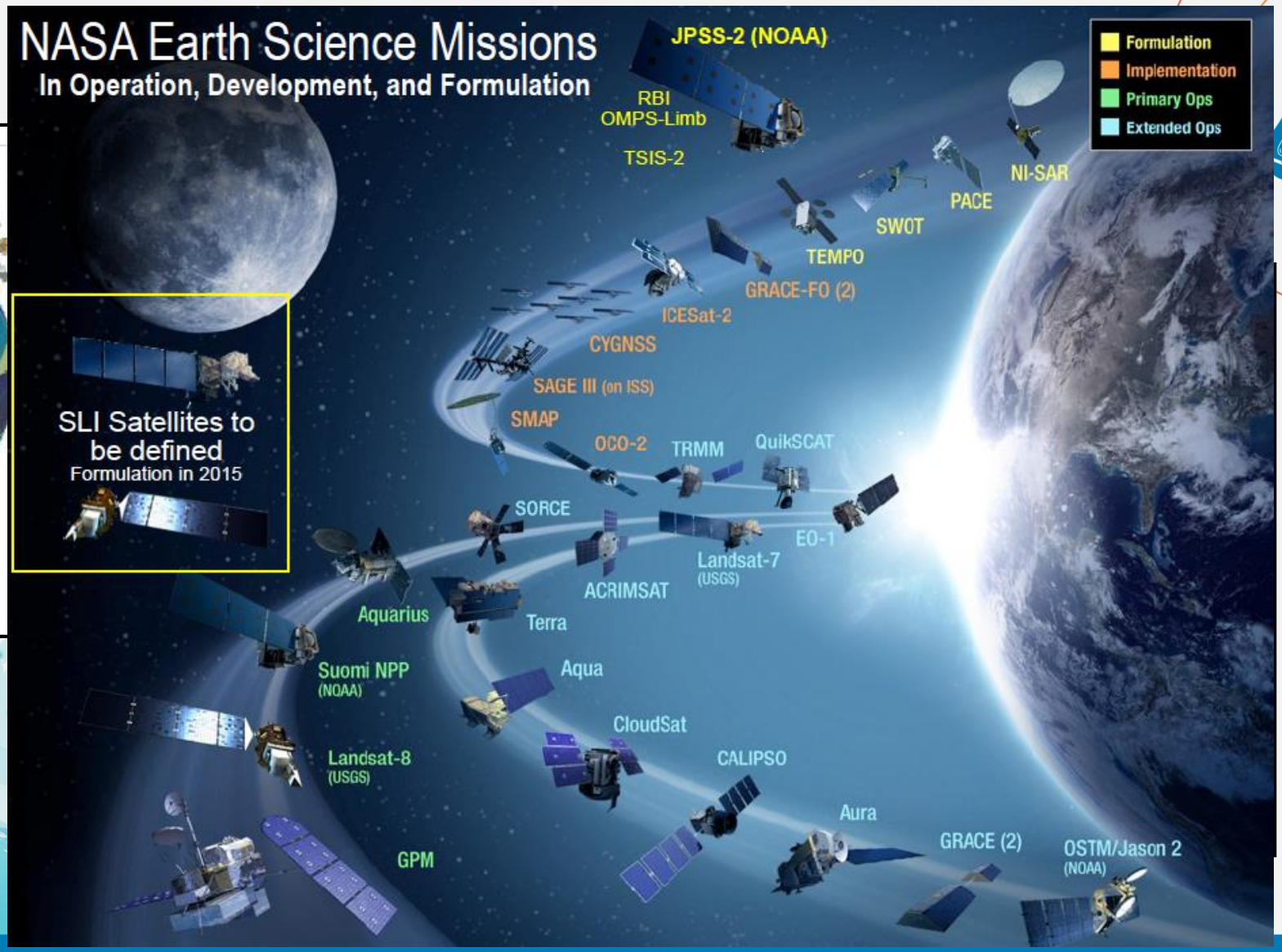


Moller et al. (2012) – Closing yield gaps through nutrient and water management , *Nature*

SATELLITE REMOTE SENSING AS A COST-EFFECTIVE PLATFORM

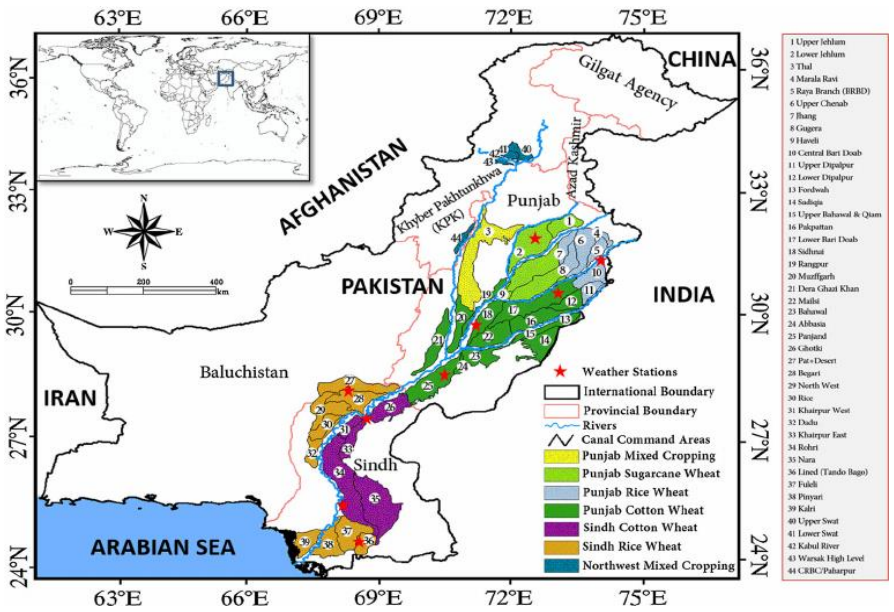
GPM





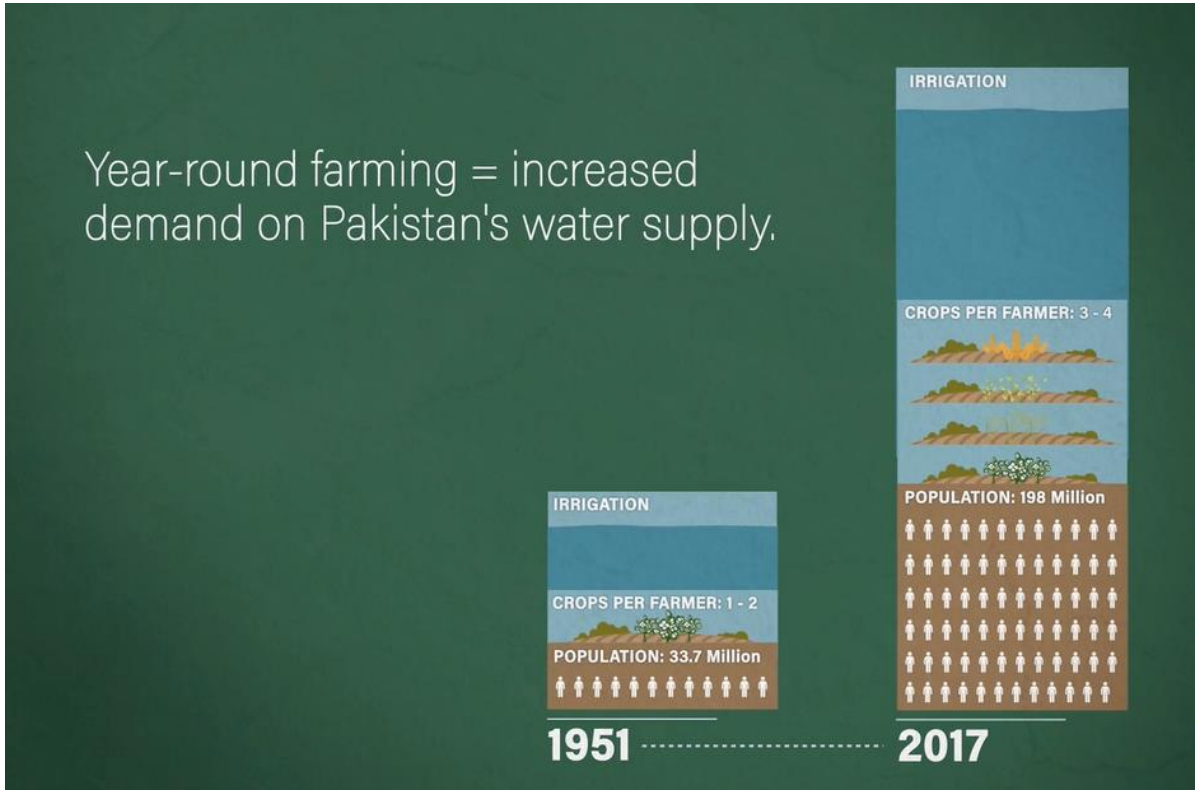
ADB

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



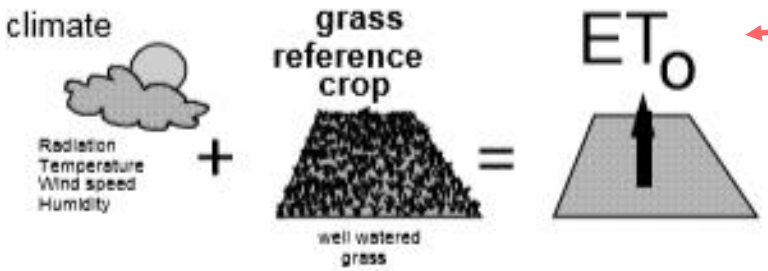
CAN WE GROW MORE WITH LESS WITH EARTH OBSERVATIONS AND SMART TECHNOLOGY?

- 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

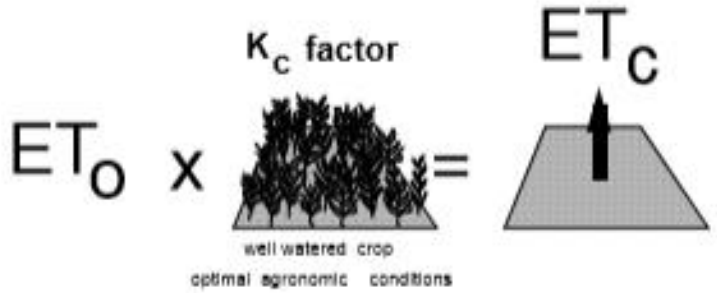
How do we change farmers mindset (that they do not need to 'irrigate' that much) when there is enough from nature?

- 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

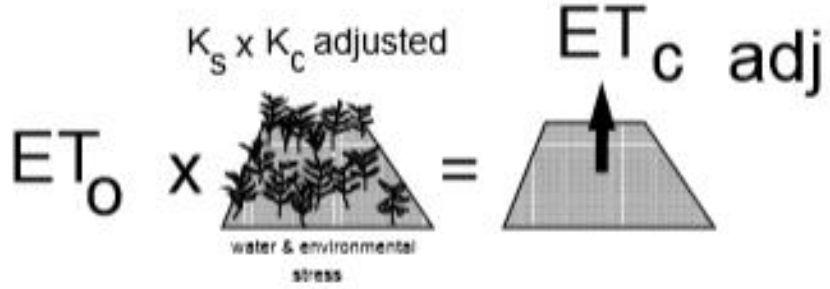
CROP WATER DEMAND



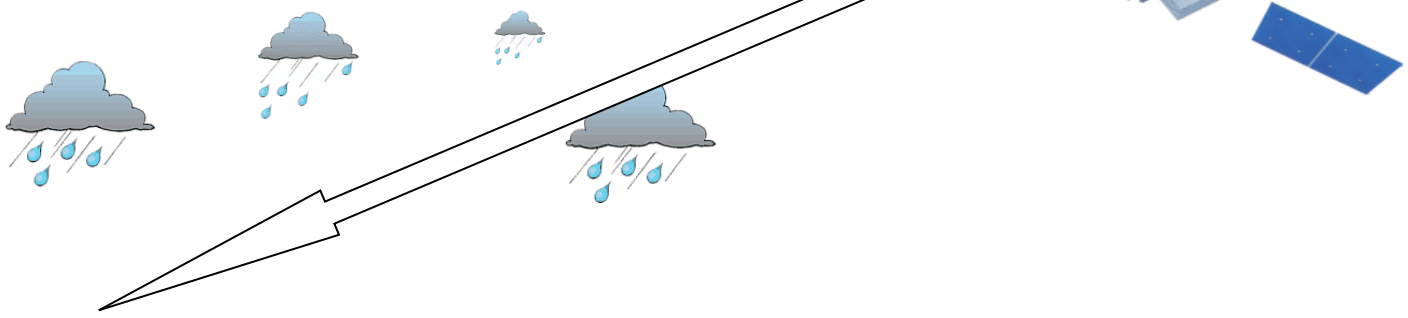
$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)}$$

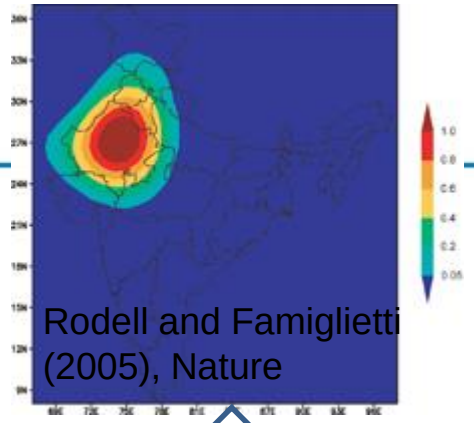


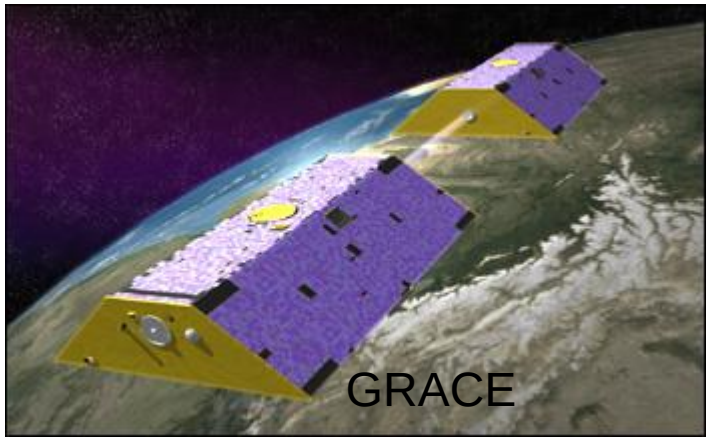
Kc = from lysimeter crop studies (published in manuals)
Function of crop type, growth stage, climatic zone, breed

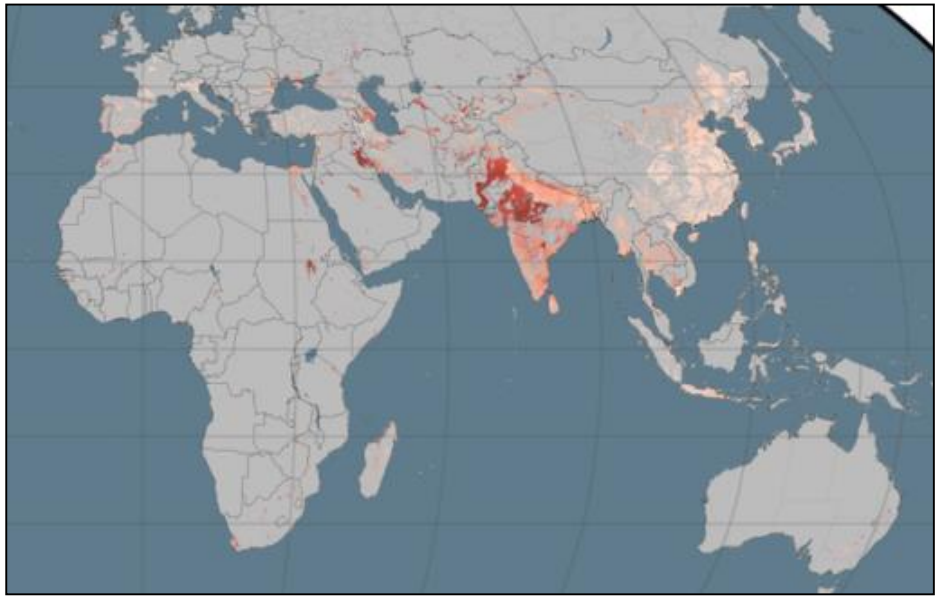


Ks = from soil moisture conditions (because a site will not always be ‘well-watered’ (or always irrigated)









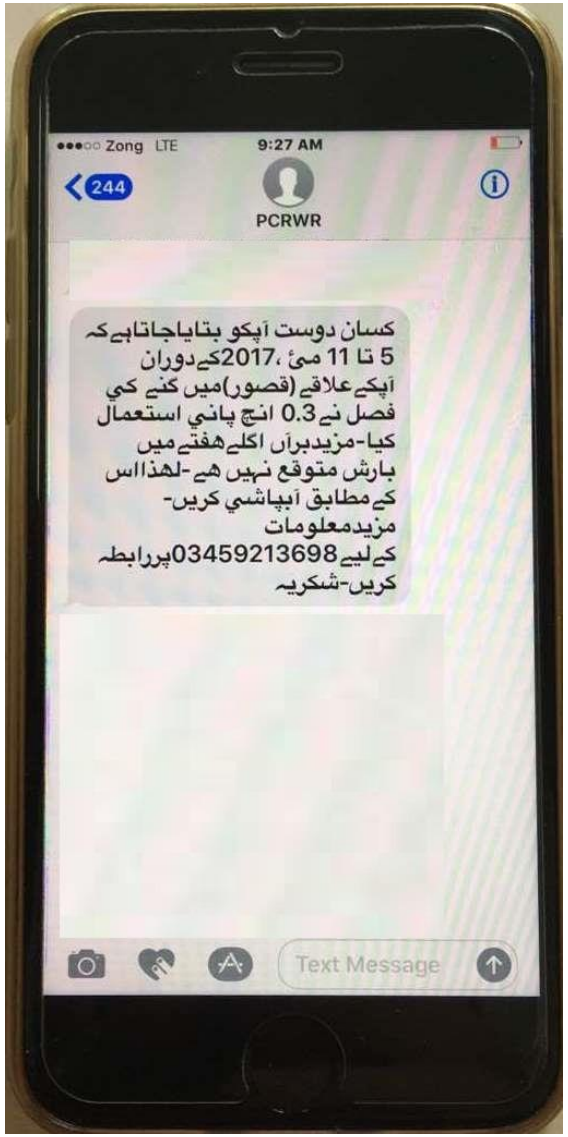
Source: Foley et al. (2011), Nature, “Solutions for a Cultivated Planet”

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.

Forecast-based Advisory also provided

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



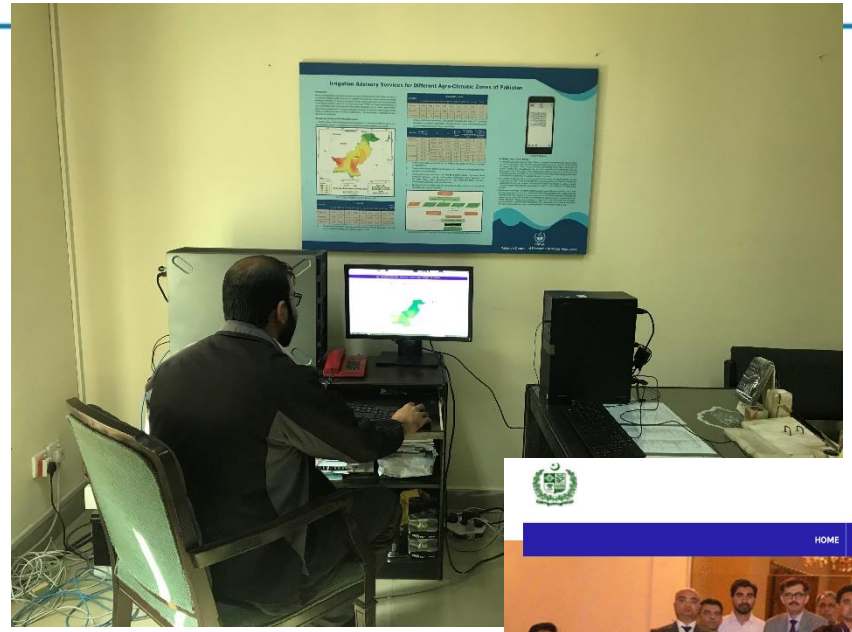
With Telenor Pakistan

700 farmers — **2016**

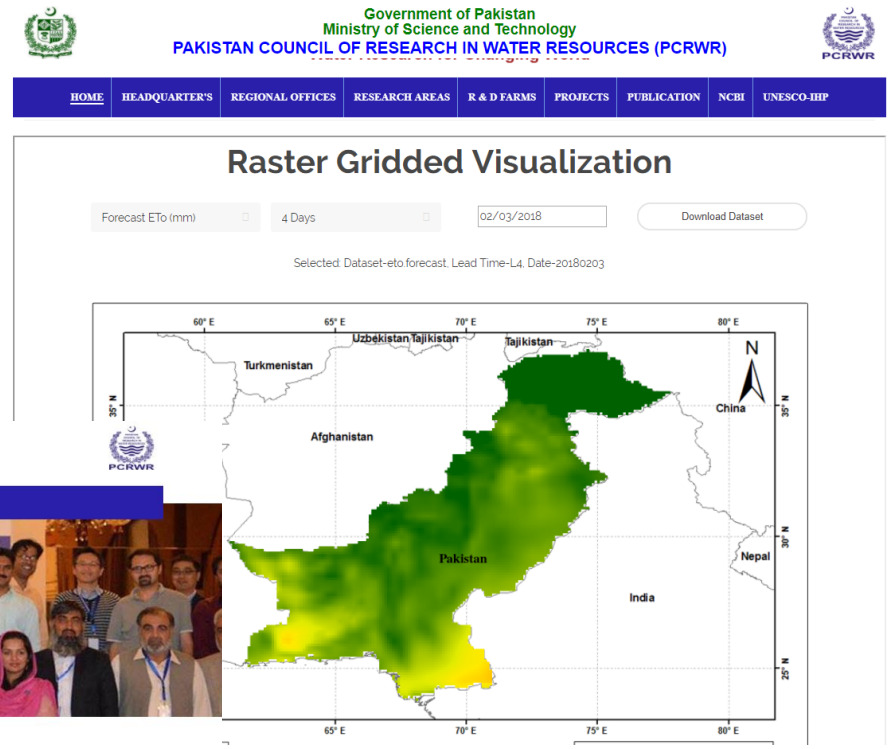
10,000 farmers — **2017**

100,000 farmers — **2018**

CAPACITY BUILDING AND TECHNOLOGY TRANSFER



http://58.65.129.81/index.html



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

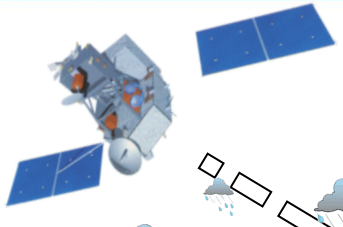
FUTURE DIRECTIONS

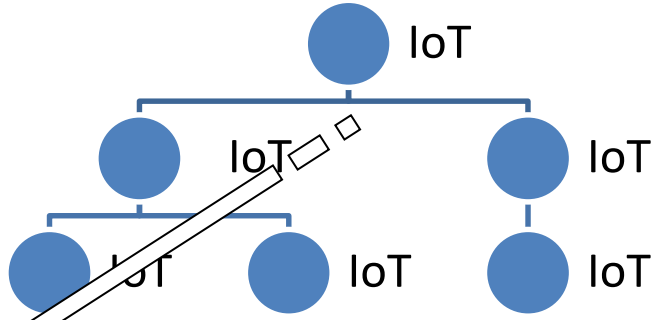
1. Skill improvement issues for Crop water demand and Precipitation supply:
net radiation/cloud cover, land cover heterogeneity, in-situ/AWS data for dynamic correction – *ON GOING* (Pakistan)

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)

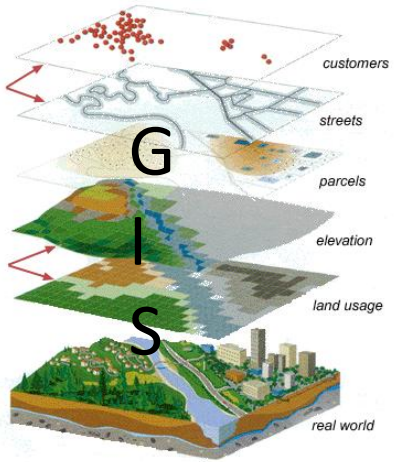
3.Comprehensive use of (FREE) Satellite and Model-based Earth Observations:
Additional satellite sensors/weather models to add value and keep costs down

IoT BASED PANI IS BEING BORN…
Provision for Advisory on Necessary Irrigation





PANI



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 fri
like to inform y
irrigation need
crop was 2 inch
past week.

ADB

TAKE HOME MESSAGES

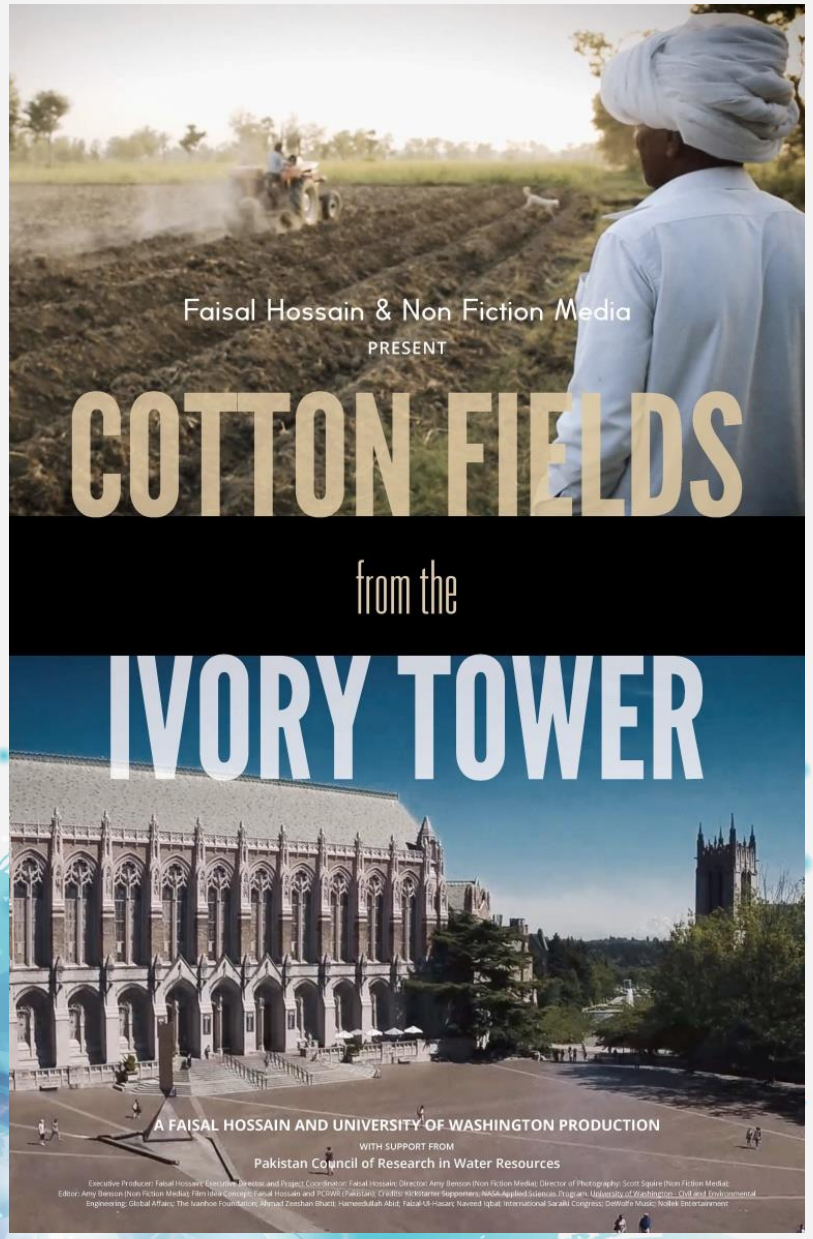
- EARTH OBSERVATIONS AND NUMERICAL WEATHER MODELS ARE LOW HANGING SOLUTIONS FOR ADDRESSING WATER-FOOD SECURITY CHALLENGES
- TWO-WAY ENGAGEMENT, CO-DESIGN AND BUSINESS MODELS NEEDED FOR RESEARCH-GRADE SOLUTIONS TO THRIVE IN SUSTAINABLE OPERATIONAL SETTINGS
- TECHNOLOGY THAT HAS PRECISION AND IS SMART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

ACKNOWLEDGEMENTS

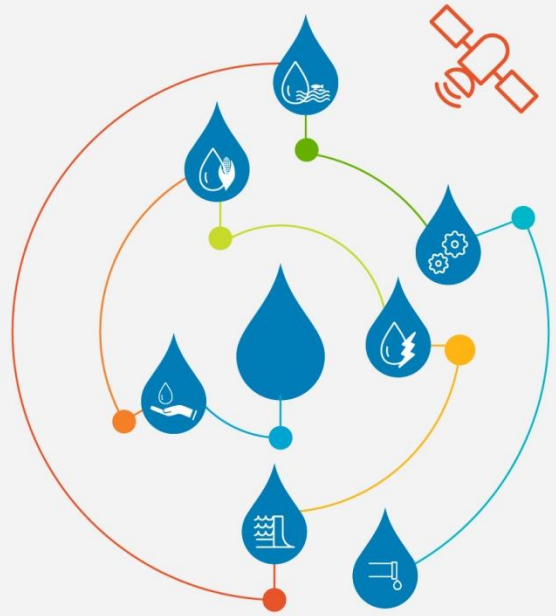
- Asian Development Bank & PCRWR
- University of Washington – Global Affairs Program
- Sponsors (federal, non-federal, banks, foundations)
- Collaborators (research and stakeholder agencies) - PCRWR, IITK, Geokno, Kritsnam
- Friends/Colleagues: Nishan Biswas, Shahryar Ahmad, Asif Mahmood, Safat Sikder,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

G : soil heat flux

$(e_s - e_a)$: air vapor pressure deficit

r_a : mean air density at constant pressure

c_p : air specific heat

Δ : saturated vapor pressure-temperature relationship slope

γ : psychrometric constant, and

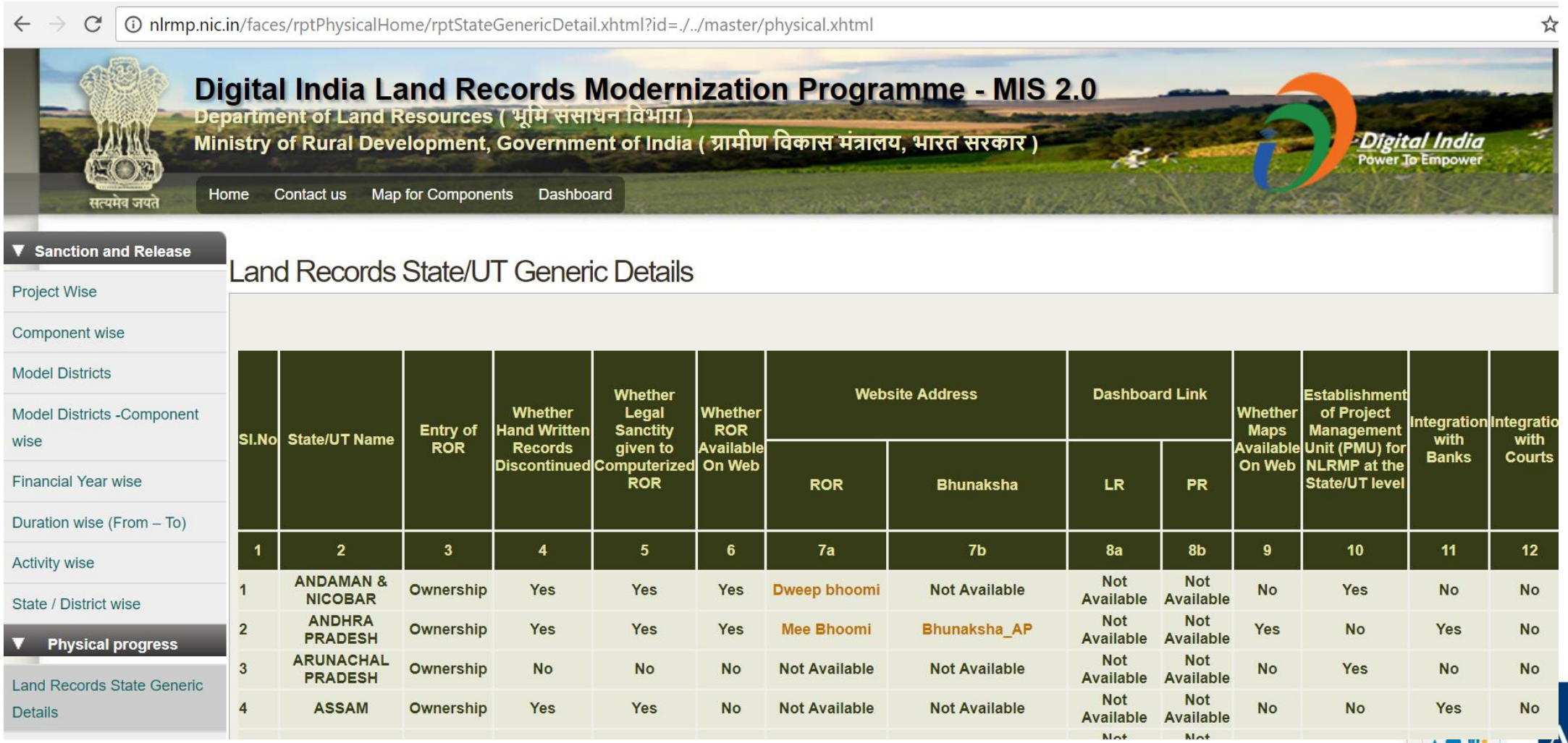
r_s and r_a : evaluation surface and aerodynamical resistances.

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

1. Daily maximum temperature (˚C)
2. Daily minimum temperature (˚C)
3. Daily maximum relative humidity
4. Daily minimum relative humidity
5. Daily mean windspeed in m/s
6. Latitude of the location
7. Elevation above sea level of the location in m
8. Julian day of the year

Challenge! Daily manual calculations not practical for an entire country

Land Records on GIS



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	Integration 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 km^2 (average farmer density in India), setup cost per farmer=

(estimate by Indian partners)