

NASA Science Mission Directorate Earth Science Division Applied Sciences Program



*Towards Operational Water Resources Management in South Asia
Exploiting Satellite Geodetic and Remote Sensing Technologies*

**Faisal Hossain (PI), Hyongki Lee , CK Shum,
Jason Brent Roberts, Franklin Robertson**
NASA Water Resources PI Meeting
June 26-28 2018



NASA Science Mission Directorate Earth Science Division Applied Sciences Program



*Improving Livelihoods Through Sustainable Application of NASA
Earth Observations for Increased Water Security*





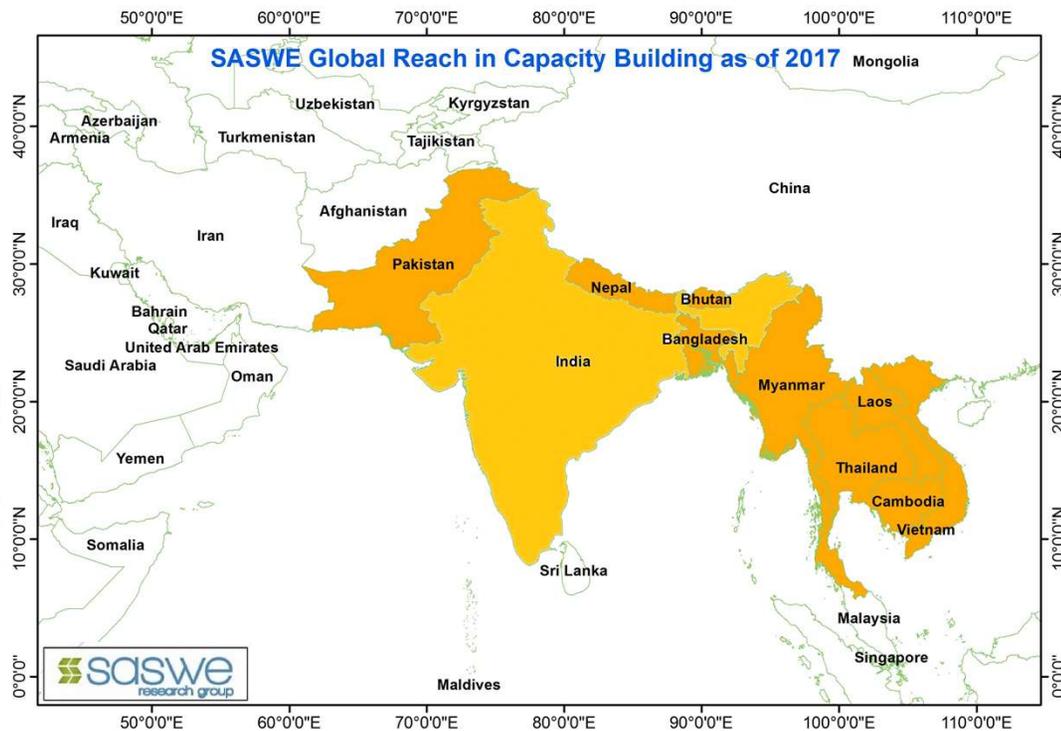
PROJECT IMPACTS ON IMPROVING LIVELIHOOD

- **Project-enabled Sustainable Applications**
- **Spin-off (Project leveraged) Sustainable Applications**

PRESS COVERAGE (Stories)

PROPOSED OBJECTIVES – *for retrospective reflection*

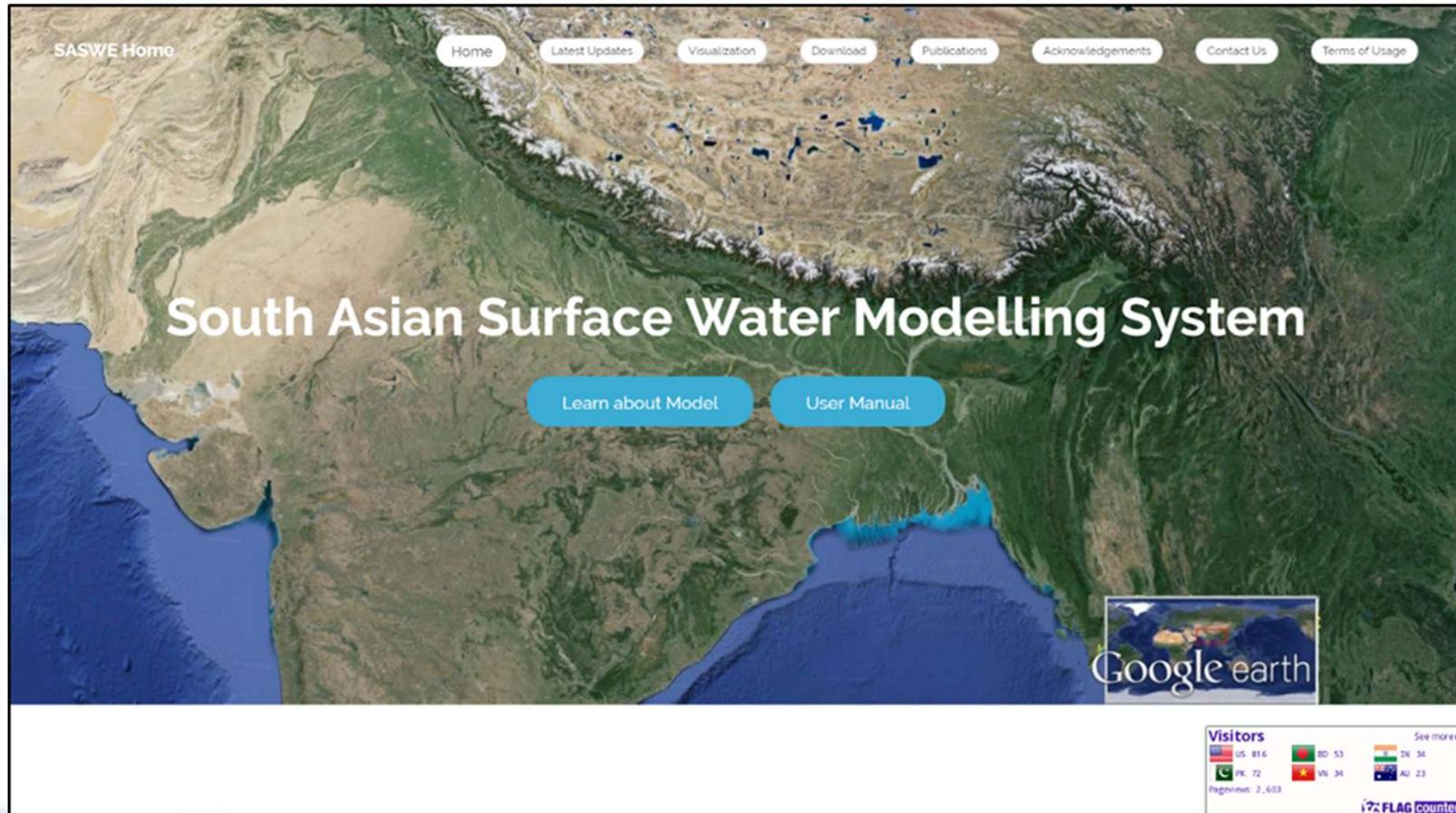
Geographic Scope Of The Project



Water Management Problems Managed with NASA Satellite Data/Models:

1. Transboundary & Hydro-politics issues
2. Water supply uncertainty
3. Increasing demand vs supply
4. Climate & Land cover change impact
5. Uncoordinated regulation
6. **Lack of timely/easy access**

Geographic Scope Of The Project



<http://www.depts.washington.edu/saswe/>

Countries Targeted by Project: Pakistan, Nepal, Bhutan & Bangladesh

Spin-off Impact Countries: India, Vietnam & Cambodia

PROJECT IMPACT – INDUS RIVER & PAKISTAN



Groundwater Stock Projection up to 60 Days by Pakistan Government serving Upper Indus Water Districts – ARL 9 (since 2016)

General
 To monitor the variations in groundwater storage, the USA under NASA-SEF established a satellite mission (GRACE) which started in early 2015.

Launching Satellite

As a result of this mission, the USA and Pakistan (USA) of GRACE). Now, PCRWR and derive maximum groundwater storage in the region.

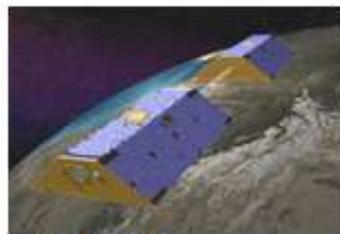
Remote Sensing

Every tower is a satellite in space

Satellite Based
 Current Synopsis (Detailed Background Info)

Satellite Based

Operationalization of GRACE and GPM for Seasonal Groundwater Management in Pakistan by PCRWR (<http://www.pcrwr.gov.pk/grace.html>)

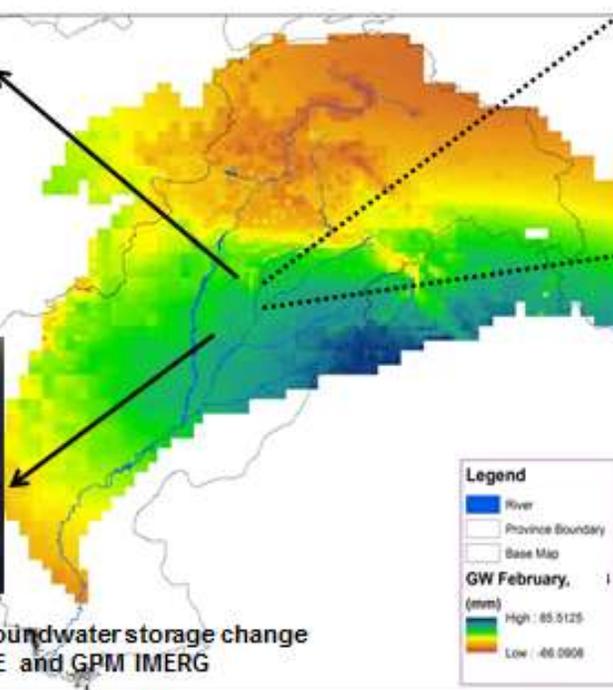


GRACE

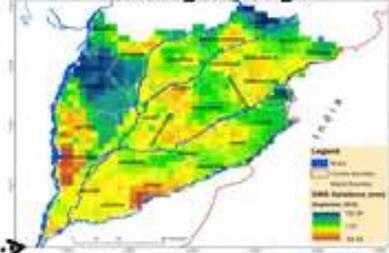


GPM

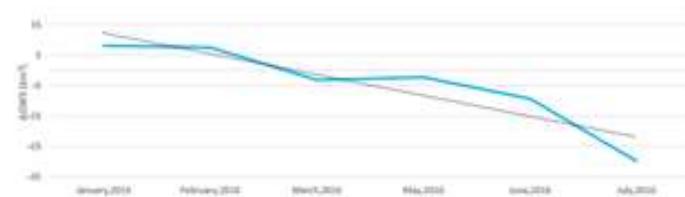
A map of groundwater storage change using GRACE and GPM IMERG



Actionable Map of Groundwater Storage Change



GRACE and GPM aiding costly and challenging in-situ piezo meter network management and field measurements



Groundwater storage change trends (60 day forward projections)

SPINOFF IMPACT – PAKISTAN

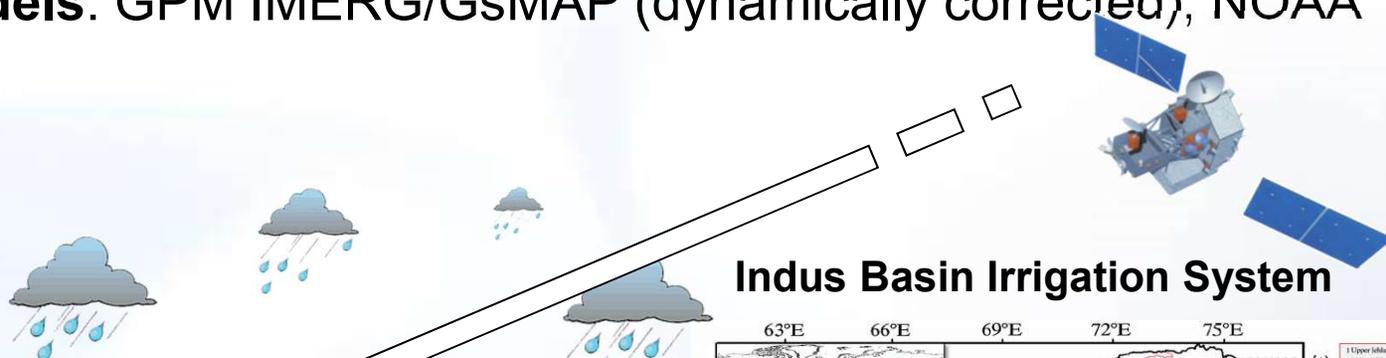


Satellite-based Irrigation Advisory System serving 20,000 Pakistan farmers (ARL 9 since 2017)

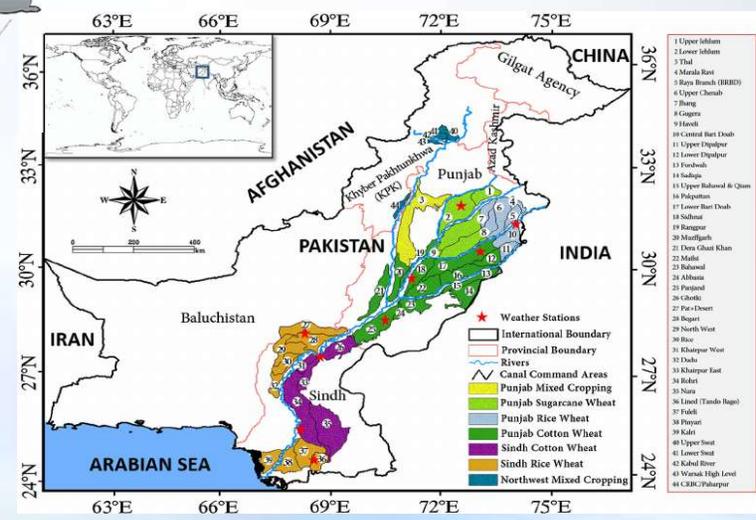
Goal: To minimize groundwater wastage and increase crop yield

(Decision: **How much to irrigate, where/when?**)

Satellites & Models: GPM IMERG/GsMAP (dynamically corrected), NOAA GFS



Indus Basin Irrigation System



SPINOFF IMPACT – PAKISTAN



On a permanent budget line of Pakistan Government (2018)



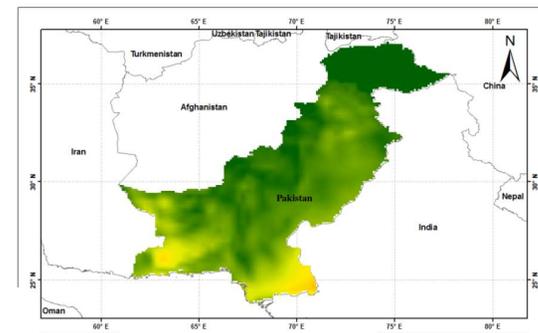
Server, Trained Personnel and User Interface developed locally



Raster Gridded Visualization

Forecast ETo (mm) 4 Days 02/03/2018 Download Dataset

Selected Dataset-eto forecast. Lead Time-L4. Date-20180203



<http://58.65.129.81/index.html>



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 Data](#)

Campaign Management Tool

[Login](#)

<http://www.pcrwr.gov.pk/advisory.php>

LIVELIHOOD IMPACT - PAKISTAN



25 billion cubic meter savings per million farmers

[25 km³; Grand Coulee Dam: 6 km³]

40% saving in groundwater irrigation water

80% usage rate among farmers

Doubling of farmer income through yield increase

SPINOFF IMPACT – INDIA

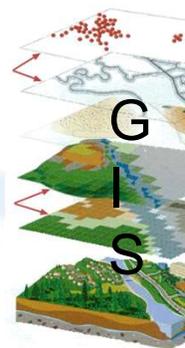
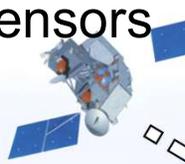


Irrigation Advisory for Marginal Farmers (**P**rovision for **A**dvisory on **N**ecessary Irrigation **PANI**) [World Bank – launched **April 2018**]

Goal – Irrigation Advisory for 50 million marginal farmers (2024)

(**Decision: How much to irrigate, where/when?**)

Satellites and Models – GPM, GsMAP, GFS, IoT, Low Powered WAN, ground sensors



IoT

IoT

farmer friend, we would
o inform you that your
at crop does not need
tion due to sufficient
all during the past week.

farmer fri
o inform yo
tion need
was 2 inch
week.



PILOT SITE: [HTTP://DEPTS.WASHINGTON.EDU/SASWE](http://depts.washington.edu/saswe)

PROJECT IMPACT - BANGLADESH

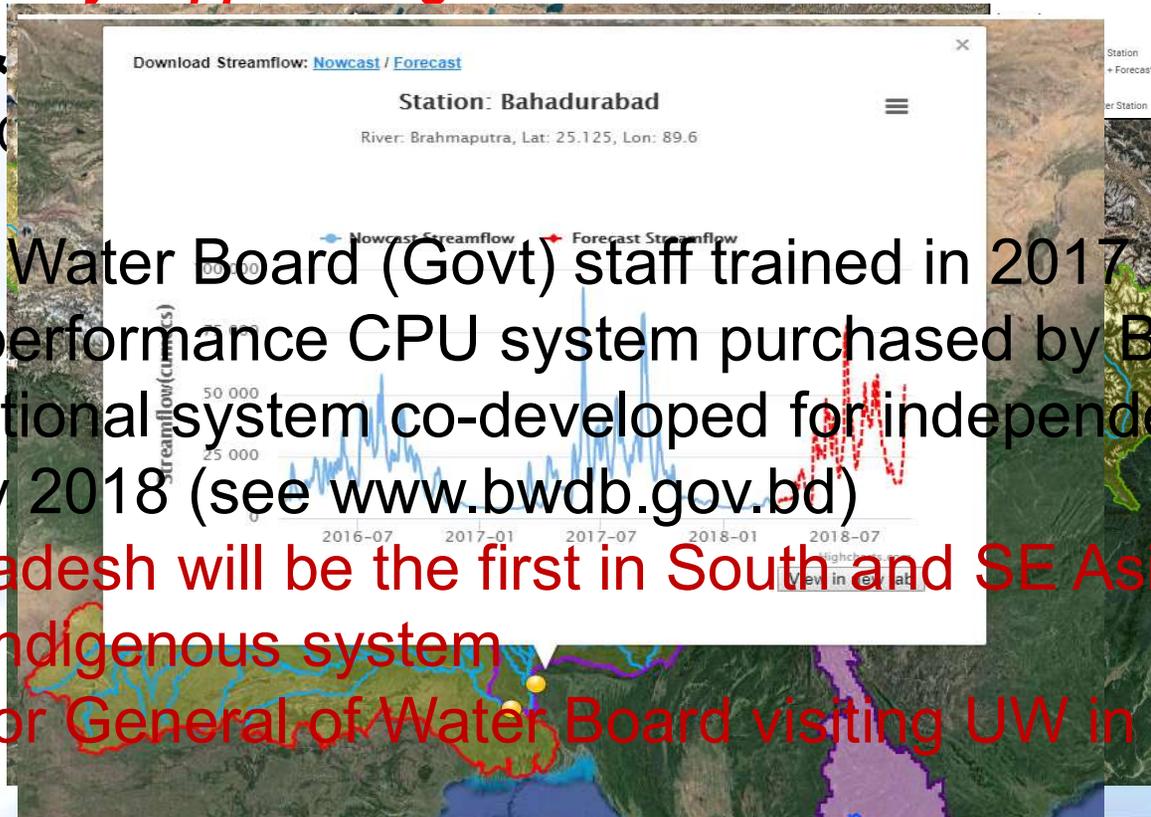


Seasonal and Weather-scale Flow Forecasting in Ganges and Brahmaputra river up to 6 months (ARL 6-7 since 2017)

Goal: To improve dry season water and wet season flood management for Bangladesh Government (Water Development Board)

Decision: *Advise Ag & Disaster Agency how much food (rice) import and emergency supplies might be needed*

Satellites &
Sentinel, VI



DIS, JASON3,

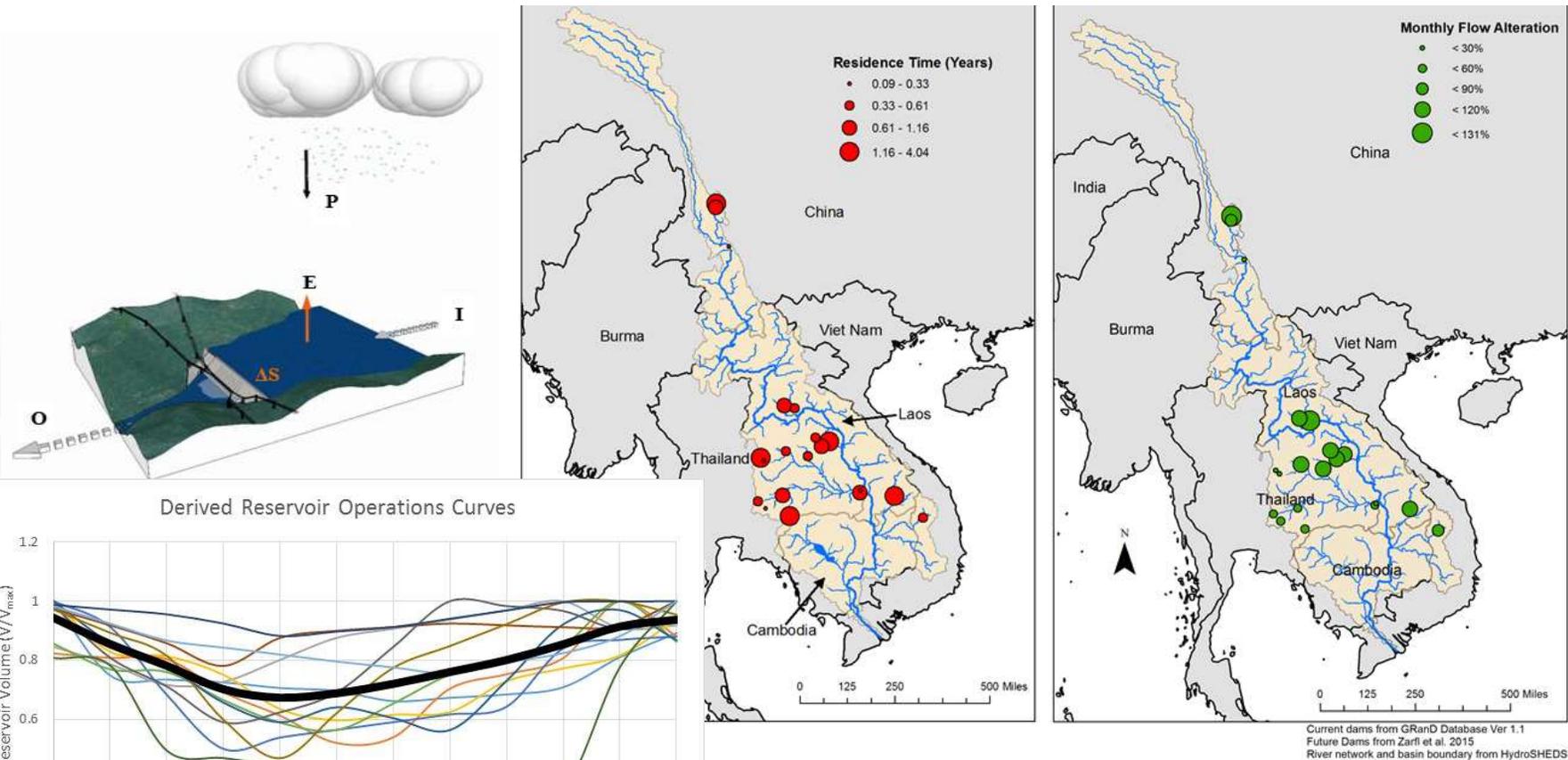
- ❑ Three Water Board (Govt) staff trained in 2017 (DIME based 6 months forecasting up to monthly flow with 30 days lead time forecasting)
- ❑ High performance CPU system purchased by Bangladesh
- ❑ Operational system co-developed for independent operations in May 2018 (see www.bwdb.gov.bd)
- ❑ Bangladesh will be the first in South and SE Asia to boast of such indigenous system
- ❑ Director General of Water Board visiting UW in Oct 2018

GIS-based fast forecasting up to monthly flow with 30 days lead time forecasting

SPINOFF IMPACT – VIETNAM & CAMBODIA



Seasonal and Weather-scale Flow Forecasting & Transboundary Reservoir Outflow Prediction in Red and Mekong Rivers (ARL 9 from July 2018)



- ❑ PI's group to set up co-designed operational system in Vietnam July 2018 for 2 Agencies (USAID/PEER)
- ❑ Shoreline/depth forecasting model for Tonle Sap (Cambodia) fisheries and rice production community (ARL-4/5 – via NSF)

PROJECT IMPACT - NEPAL



Seasonal snow cover and total water storage anomaly analysis in Himalayas for Nepal (ARI 5-6 since 2016)

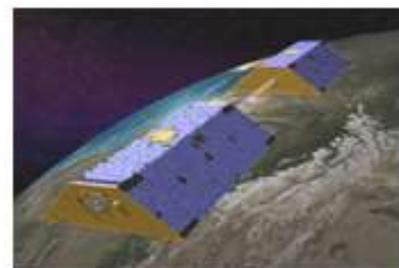
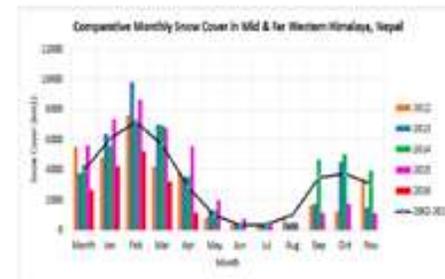
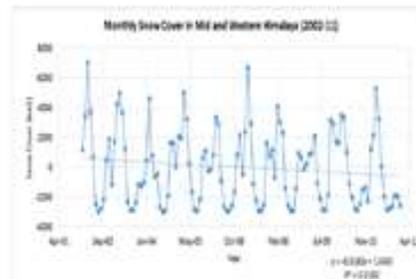
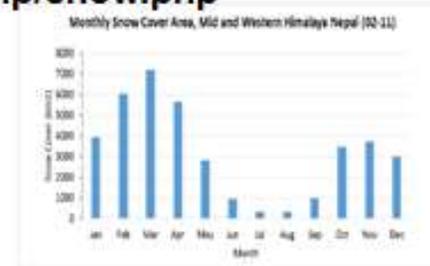
Goal: To
agricultu
Satellite

Joint application of GRACE and MODIS for projecting (operational) spring/summer water availability at basins by Nepal Department of Hydrology and Meteorology (<http://www.dhm.gov.np/snow.php>)

for

All earth observation data processing and modeling conducted independently by Nepal DHM (via training)

Mid and Far Western Himalaya Nepal (Shadow Portion)



GRACE



MODIS SENSOR

PRESS COVERAGE (& Stories)



SILICON VALLEY & TECHNOLOGY

June 26, 2017 8:15 PM
Ben Thompson

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Print

Pakistani I



fe



e helping countries

English नेपाली हिन्दी বাংলা اردو

Maps & Data > Share a map

Search here...

farmers with smart

sending rain forecasts to 10,000 farmers,
r crop yields

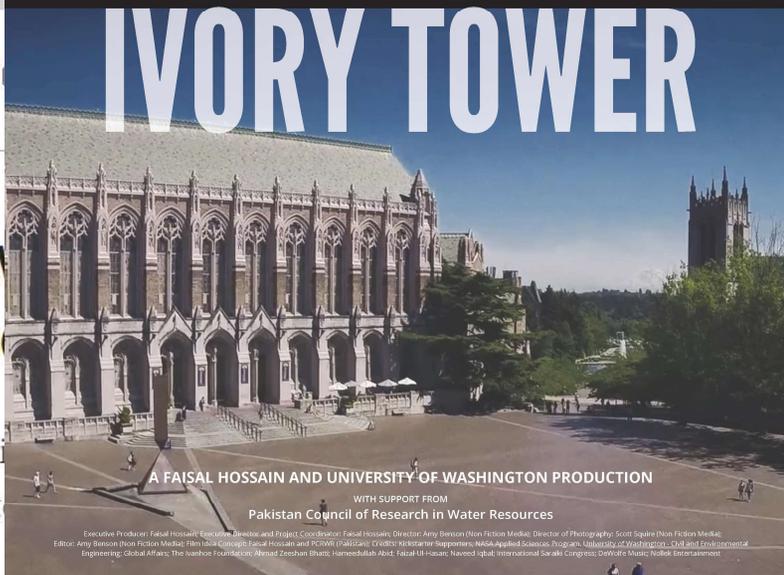


HYDROLOGY, CRYOSPHERE & EARTH SURFACE



Growing More v and Satellite D

Researchers from the Un
21st century technology t
the Indus Valley.



Executive Producer: Faisal Hossain, Executive Director and Project Coordinator: Faisal Hossain, Director: Amy Benson (Non-Fiction Media), Director of Photography: Scott Squire (Non-Fiction Media), Editor: Amy Benson (Non-Fiction Media), Film Tech Credits: Faisal Hossain and PCWRW (Pakistan), Credits: Faisal Hossain, Supporting: Non-Fiction Media, Applied Sciences Program, University of Washington, God and Professional Engineering, Social Affairs, The Notebook Connection, Ahmed Zeebullah, Islamabad, Faisal Hossain, Naved, Iqbal, International Social Congress, D-Watch, Naved, Naved, Islamabad

PROJECT OBJECTIVES (Retrospective Reflection)



To reach ARL>7 for operational water management in South Asia for the following [**proposed in 2013**]:

- 1) Monthly-to-seasonal GRACE-based monitoring and projection of ground water storage anomalies (**Pakistan**) **ARL 9**
- 2) Satellite (GPM/TRMM) Precipitation and Model-based seasonal forecasting of water availability (**Regional**) **ARL 9**
- 3) Satellite-based Mountain snowcover & water budget monitoring (**Nepal/Bhutan**) **ARL 5-6**
- 4) Multi-Satellite Altimetry based monthly-to-3 monthly monitoring and projection of reservoir storage changes (**Bangladesh and Pakistan**) (**Vietnam**) **ARL 7 (avg)**
- 5) Satellite Altimetry/Model-based long-range river flow forecasting during non-Monsoon (dry) periods (**Bangladesh**) (**Vietnam**) **ARL 9**

ACKNOWLEDGEMENTS



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- Stakeholder agencies of South Asia – PCRWR, IWM, BWDB, PARC/NARC, DHM, DHMS, IRSA, FFWC, BARI, NUCE, NAWAPI**

- UW Global Affairs Program, UW Civil Engineering, University of Houston**

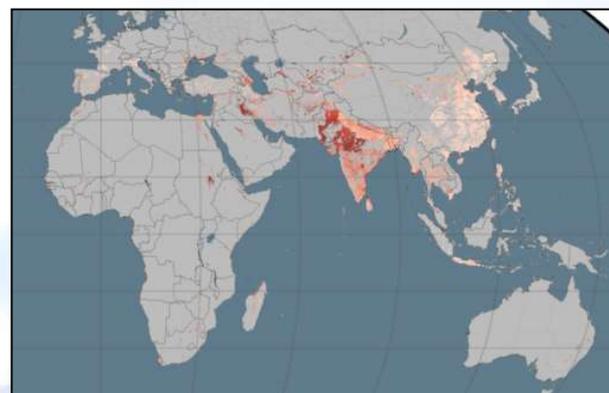
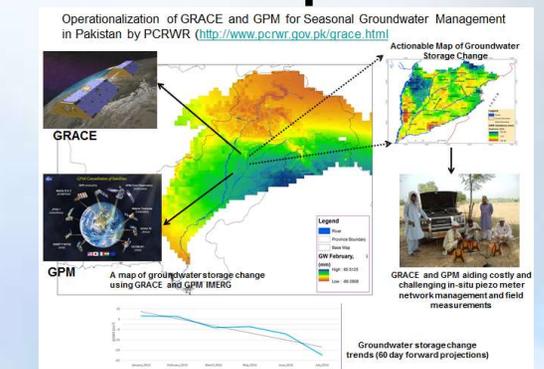
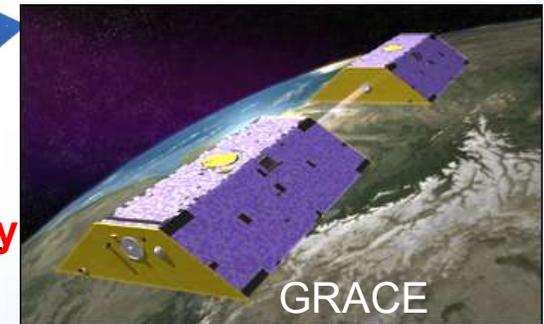
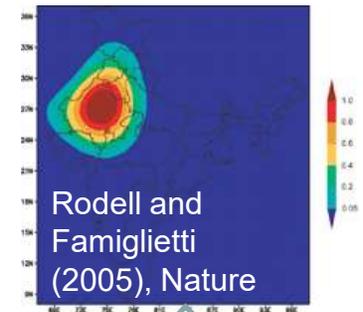
- The Ivanhoe Foundation, USAID, Asian Development Bank, World Bank, IITK, University of Melbourne, Crowdfunders, Volunteer work of Students**

POST-PROJECT SYNERGY – PAKISTAN



Integration of Project GRACE-GPM groundwater information system with Spinoff Satellite irrigation advisory system

Goal: To provide water services 100,000 farmers in 2019
Satellites and Models: GPM, GRACE, GFS, MODIS, VIC

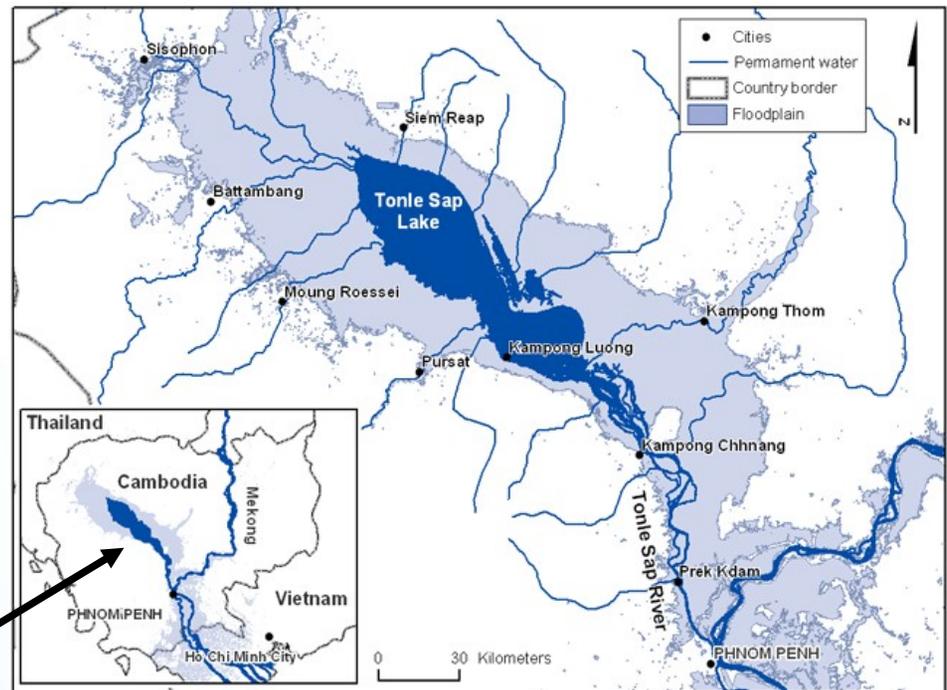
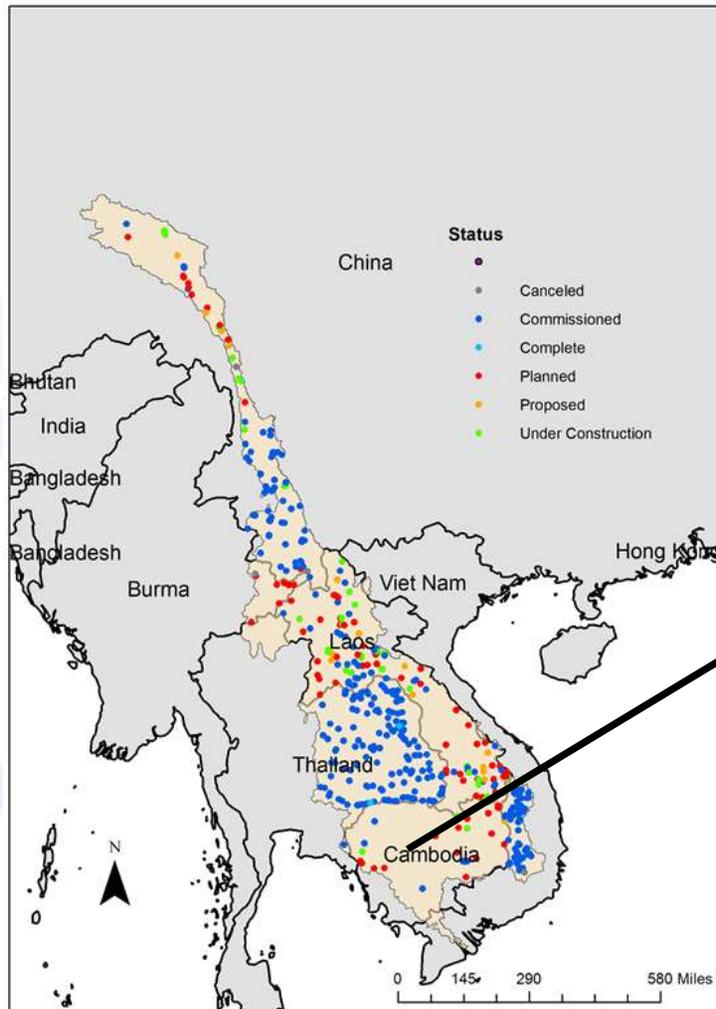


Source: Foley et al. (2011), Nature, "Solutions for a Cultivated Planet"

SPINOFF IMPACT – CAMBODIA



Tonle Sap Lake area and depth modeling as a function of upstream forcings
– Land cover change, Hydropower dam building and climate change



- Framework developed for lake shoreline and depth impacted by water management decisions, land cover change and climate
- This framework to be used by Fish and Rice community

BEHIND THE SCENES: Training & Capacity



PAKISTAN March 2015 – in Pakistan (**HIGH IMPACT** – *Project funded*)

NEPAL April 14- May 18, 2016 – at UW (**MODERATE IMPACT**; *Project funded & Volunteer*)

IT Training for Nepal and Pakistan January 2017 – at UW (**NO IMPACT** – *Volunteer*)

BANGLADESH July 2016; July 2017 in Bangladesh (USAID support) (**LOW-MODERATE IMPACT** – *Volunteer*)

VIETNAM April 2017, at UW (**MODERATE to HIGH IMPACT** – *Volunteer+USAID*)

BHUTAN –April 1- May 18, 2017 – (**NO IMPACT** – *FAILED*; *Project funded*)

BANGLADESH April 1-14 & November 14-27, 2017 – at UW (**HIGH IMPACT** - *Volunteer*)

PAKISTAN, INDIA, AUSTRALIA & ASIAN DEVELOPMENT BANK, November 7-8, 2017 – at UW (**HIGH IMPACT** – *Volunteer*) – Smart Water-Ag Technology- UW

BEHIND THE SCENES: Training & Capacity



ASIAN DISASTER PREPAREDNESS CENTER Feb 11-21, 2018 – at
UW (**IMPACT UNKNOWN** -100% UW supported)

Former Minister of Water and Irrigation - EGYPT September 3-8, 2018
– at UW (100% UW Supported)

Director General of Water Board – BANGLADESH October, 2018 – at
UW (100% UW Supported)