Understanding the impact of upscaling solar irrigation on sustainability of groundwater

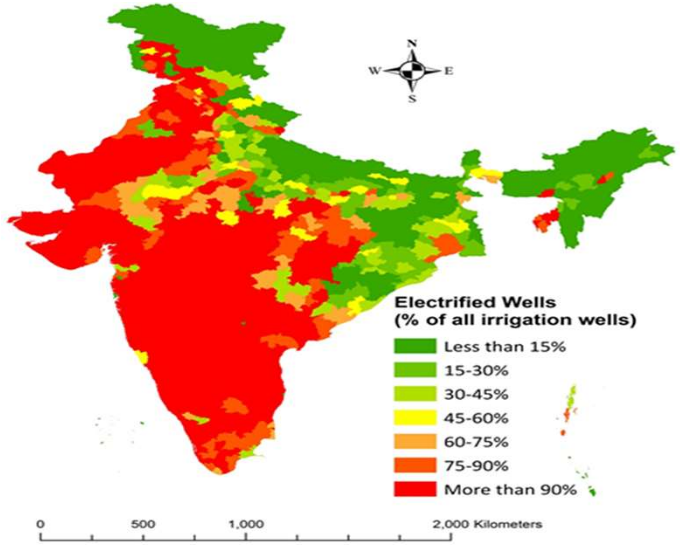
Sikka, A.K. [1], Alam, M.F. [1], Pavelic, P. [1], Krishnan, S [2].

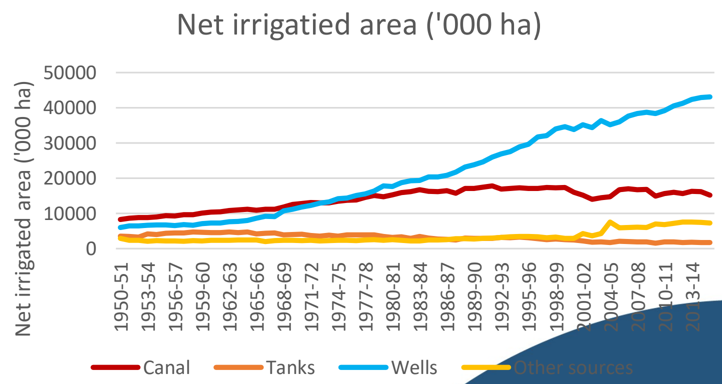
1) International Water Management Institute, India
2) Indian Natural Resource Economics and Management Foundation, Anand, India

Groundwater: Key to Indian Agriculture and SDGs

- Contribution of GW to irrigation up from 29% in 1950-51 to over **63% of the net** irrigated area (68.38 Mha)
- Number of wells and tube wells has increased from 11.4 million in 1986-87 to about **24 million**
- GW use propelled by access to subsidized or free energy
- About **20% of the energy** is used in agriculture (majorly in pumping water)
  - ~74% powered by grid-electricity, ~26% by diesel
  - 54 times increase in electricity use for agriculture from 1970-2016

Managing GW – Energy nexus key to sustainable GW development and SDGs





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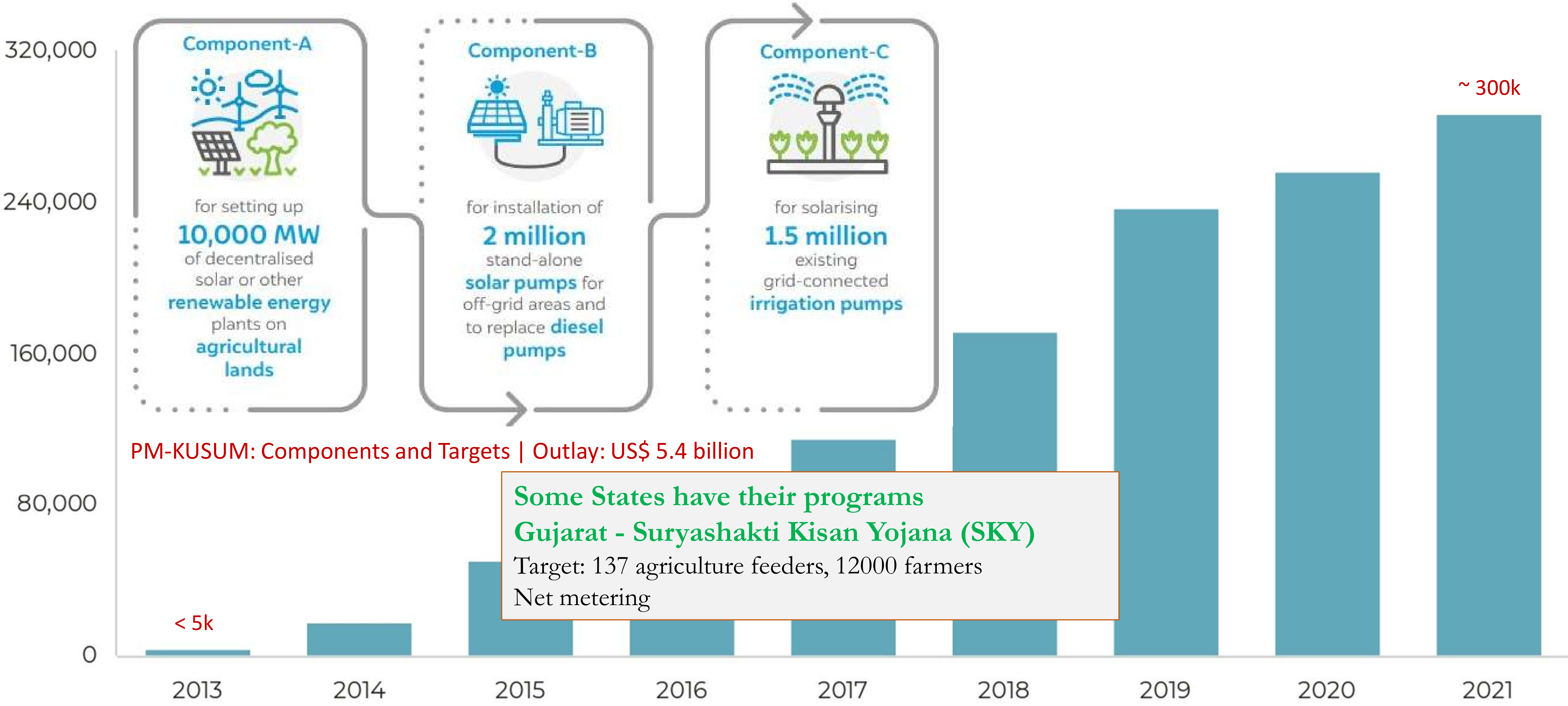
Solar Irrigation Pumps in India

Exponential growth - but still a small share of India's massive Minor Irrigation Economy



Some States have their programs

Gujarat - Suryashakti Kisan Yojana (SKY)

Target: 137 agriculture feeders, 12000 farmers

Net metering

Solar irrigation: A boon or bane for groundwater?

Farmers incomes
Cut down diesel costs for farmers
Free, uninterrupted day-time power instead of poor grid availability and frequent interruptions

Climate change mitigation
Reduce GHG and black carbon emissions
Contribute to NDC commitments
15 million tones of carbon emission from agriculture

Energy sector
Agricultural sector consumer 23% of electricity generated
Reduce burden of farm power subsidy (70000 crore Rs)

Risk of groundwater depletion
Free/highly subsidized energy created unsustainable GW use
Near zero marginal cost of SIPs - water a formidable GW governance challenge

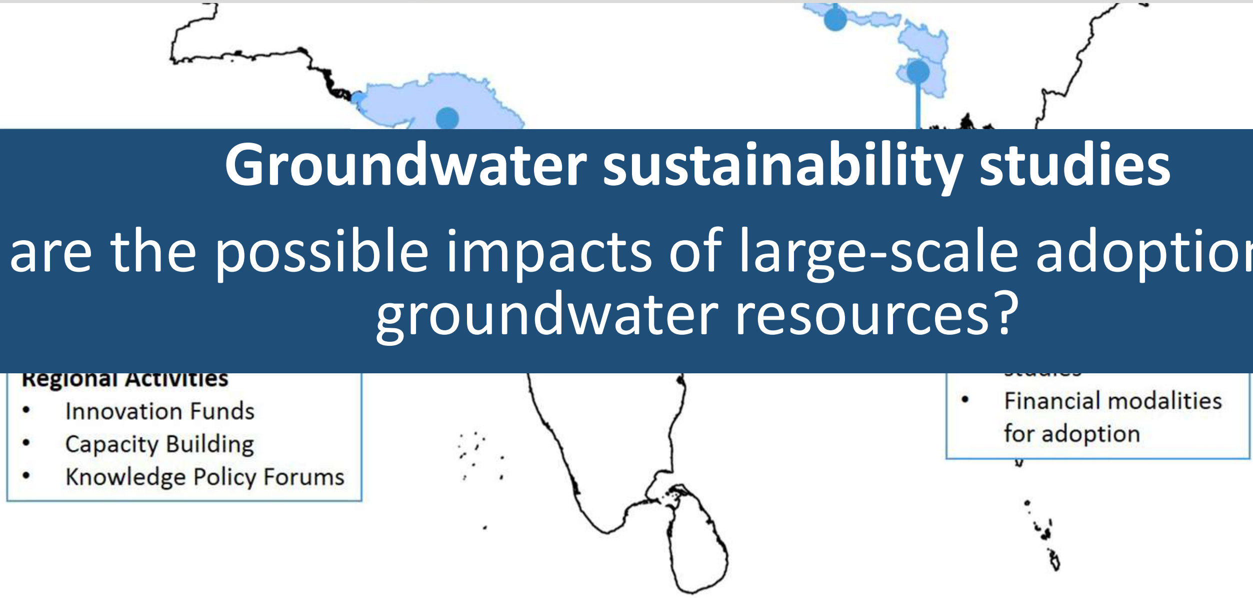
Solar Irrigation for Agricultural Resilience (SoLAR) in South Asia

Goal:

Climate resilient, gender and socially inclusive agrarian livelihoods in Bangladesh, India, Nepal and Pakistan by supporting national government efforts to promote solar irrigation

Groundwater sustainability studies

What are the possible impacts of large-scale adoption of SIPs on groundwater resources?



Surya Shakti Kisan Yojna(SKY): A distributed ultra-mega solar initiative

GENERAL

- Scheme is for farmers already connected to the grid.
- Desirable to include as many farmers as possible (at least 75%) on a given AG feeder.
- SKY feeders get 12 hrs of electricity, but non-SKY armers controlled for 8 hrs

PV SYSTEM

- Farmer will be provided with a grid-connected solar PV system.
- 1.25 kW PV system to be provided per hp.
- E.g. 10 hp →12.5 kW PV system

FINANCE

5% Minimum upfront investment from farmer

oan on behalf of farmer (supported by govt. body)

ubsidy from Govt. of India

REVENUE

- Rs. 3.50 / kWh, feed-in tariff by DISCOM, +Rs. 3.50 /kWh, evacuation-based incentive (subsidy for first 7 years) by Govt. of Gujarat up to maximum of 1,000 kWh /hp/year

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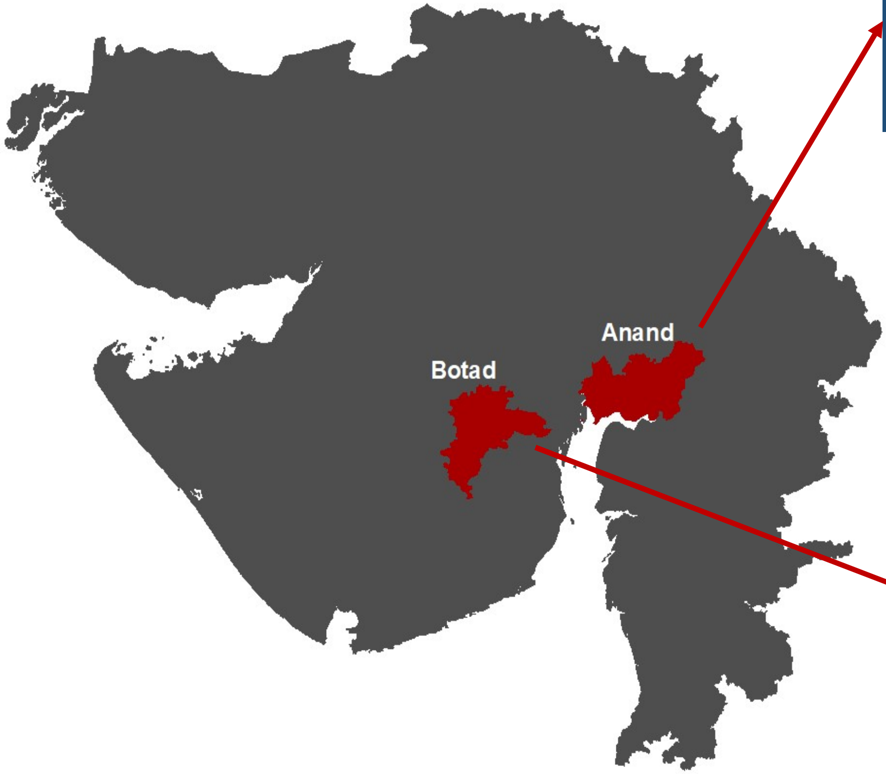
Assessing groundwater pumping behaviour

4 Feeder selected in Alluvial and Hard rock regions



Highly productive Alluvial aquifers with high cropping intensity and 15-20 HP pumps

Low storage weathered hard rock aquifer with low cropping intensity and 5-7.5 HP pumps

Methodology

- Measuring the quantity of water pumped by thousands of farmers is a herculean task
- Project uses an innovative way to do the same, i.e., converting farmers energy consumption data to water abstraction

Monitoring and instrumentation

GW-Energy relationship and validation

$$V = \frac{E \times \alpha \times 3.6 \times 10^6}{H \times g \times \rho}$$

$\alpha_r = f(HP, age, H..)$

Volume (flow rate), energy consumption and depth to gw table being measured regularly

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Conversion factor
(m3 per unit electricity consumed)

$$\frac{V}{E} = \frac{\alpha \times 367}{H}$$

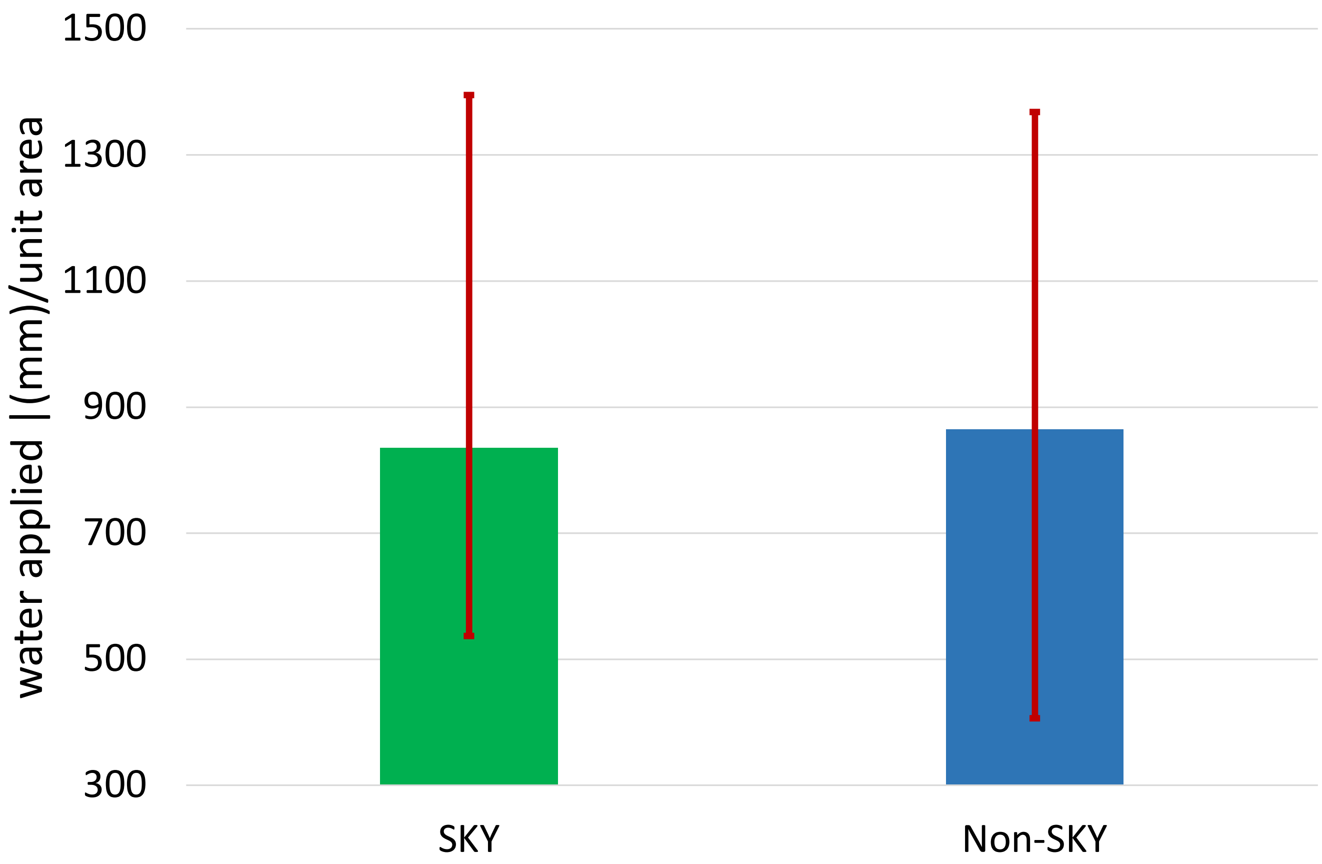
Anand CF = 14.03 – 0.38* HP – 0.20*GW_depth

Botad CF = 8.95 – 0.35* HP – 0.14*GW_depth

Test continuing work in progress <> equations to be updated. Currently explains ~ 60 %.

Water use/unit area of farmers

- No statistically significant difference
- Large range and variance
- Data gaps and errors
  - Only small subset of farmers can be compared
- Inconclusive evidence at this stage to make any significant statement



Early Impressions

- Initial results indicate no change in cropping systems/pattern and additional area under agriculture

- In terms of water use, very early impressions are not suggestive of changes in water use and pumping behaviour
  - Looking to modified and improved considering improved energy-water relationship, cropping pattern and biophysical factors (e.g., soil type)
  - Extended to pre and post SKY with collection of past electricity data

- In another impact assessment study, no statistically significant change was found in increase in area cultivated, GW selling and micro irrigation adoption among enrolled SKY farmers compared to control farmers.
- Innovative on grid solar irrigation system provides the incentive for efficient use of groundwater

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Thank you
Dr. Alok K Sikka
A.sikka@cgiar.org