Solar Irrigation for Agriculture Resilience – Bangladesh
Year 1 Updates and Results

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Second Regional Forum

23rd February, 2021

Zoom Meeting

Innovative water solutions for sustainable development

Food · Climate · Growth

Snapshot of SoLAR in Bangladesh

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Snapshot of SoLAR in Bangladesh

Policy priority to replace diesel irrigation in off-grid areas ➔

Save foreign exchange, reduce subsidy burden, reduce GHG emissions

Grid solarisation in pilot phase

Broad Policy Questions:

- To what extent **diesel use is reduced?** -*(IE study)*
- Impact on **farmer level outcomes (who & what)–** yield, income, equity -*(IE study)*
- Pros and Cons of **different models of SIP promotion** in BD – *(Case studies)*
- **Grid integration** of SIPs – learnings from the pilot –*(Demo pilot)*
- How does it affect **GW sustainability**? -*(GW study)*

Partnership with IDCOL and NGO Forum

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Key achievements of Year 1 - Bangladesh

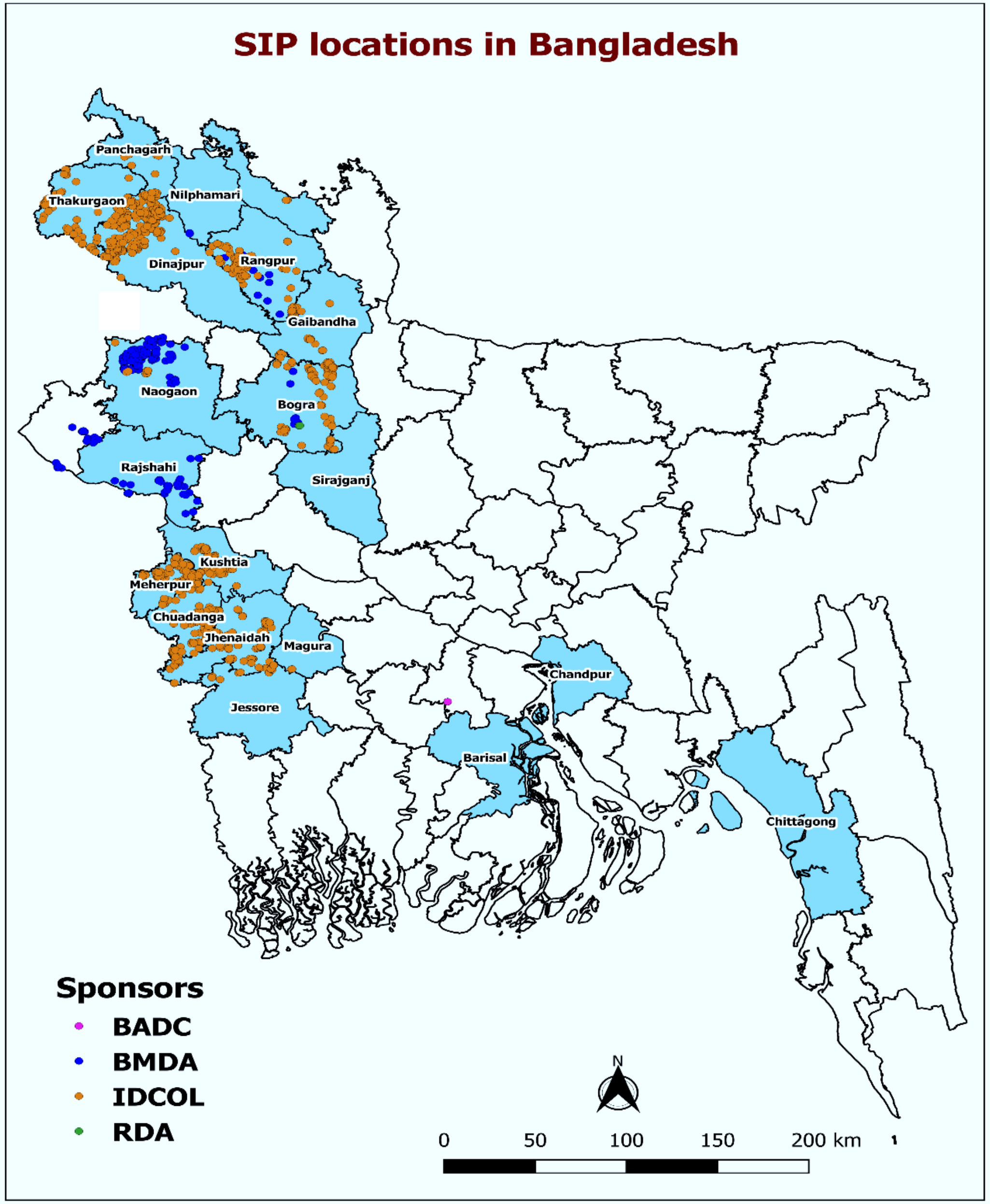
- **Situation analysis report** based on secondary data from IDCOL + literature review
- 1st round (kharif 2, 2020) of **SIP survey** - phone interviews
- **Sampling design for HH survey** completed, scoping visit before pandemic
- **Dialogue with BREB, BMDA, BADC** on their SIP models
- **Methodology and monitoring protocol for GW study** developed, **SIP site plans** in select locations
- 5 sponsors and sites selected for **grid connection pilot**
- **SIP policy analysis** through the lens of gender and social inclusion
- 1 **farmer training** completed
- CPMC meeting [1], Webinar

❖ *COVID delays in field based activities **HH survey, GW measurements** from 2020 to 2021*
❖ ***Close cooperation** from IDCOL and NGO forum*

Current scenario of solar irrigation

2293 Solar irrigation pumps (SIP), ~48 MW

- Infrastructure Development Company Limited (IDCOL)
  - 1515 SIPs, Target 10,000 by 2027
  - Development partners and Government of Bangladesh
- Bangladesh Rural Electrification Board (BREB)
  - ADB funded project for 2000 SIPs **(pipeline)**
- Barind Multipurpose Development Authority (BMDA)
  - 453 SIPs
  - Mostly surface water pumps
- Bangladesh Agricultural Development Corporation (BADC)
  - 249 SIPs, Target 1000 by 2023
- Department of Agricultural Extension (DAE)
  - 40 SIPs, Target 105 by 2022
- Rural Development Authority (RDA)
  - 35 SIPS



1.24 million diesel pumps irrigating ~ 3.0 million hectares &
0.34 million electric pumps covering ~2.3 million hectares

Financial & institutional models of SIP

	Fee for service model	Ownership model	Group ownership model
Organizations	IDCOL	BREB	BMDA, BADC, RDA
Grant: Loan: Down payment	50: 35:15	55: 35: 10 (not finalized)	100% grant, minimal equity
Repayment time	10 years	10 years	-
Number of units installed	1,515	~400 **target** in 2021	350
Average capacity per SIP (kW)	28 [2 – 46]	5 [2- 15]	6 [2 - 22]
Division covered	Kushtia, Rangpur, Thakurgaon	Rangpur, Rajshahi, Dhaka, Chattogram, Mymansingh, Khulna	Barisal, Rajshahi, Rangpur

“Comparative case studies” (Activity 2.1.1) to study these different models ***(FGDs and KIIs, secondary data)***

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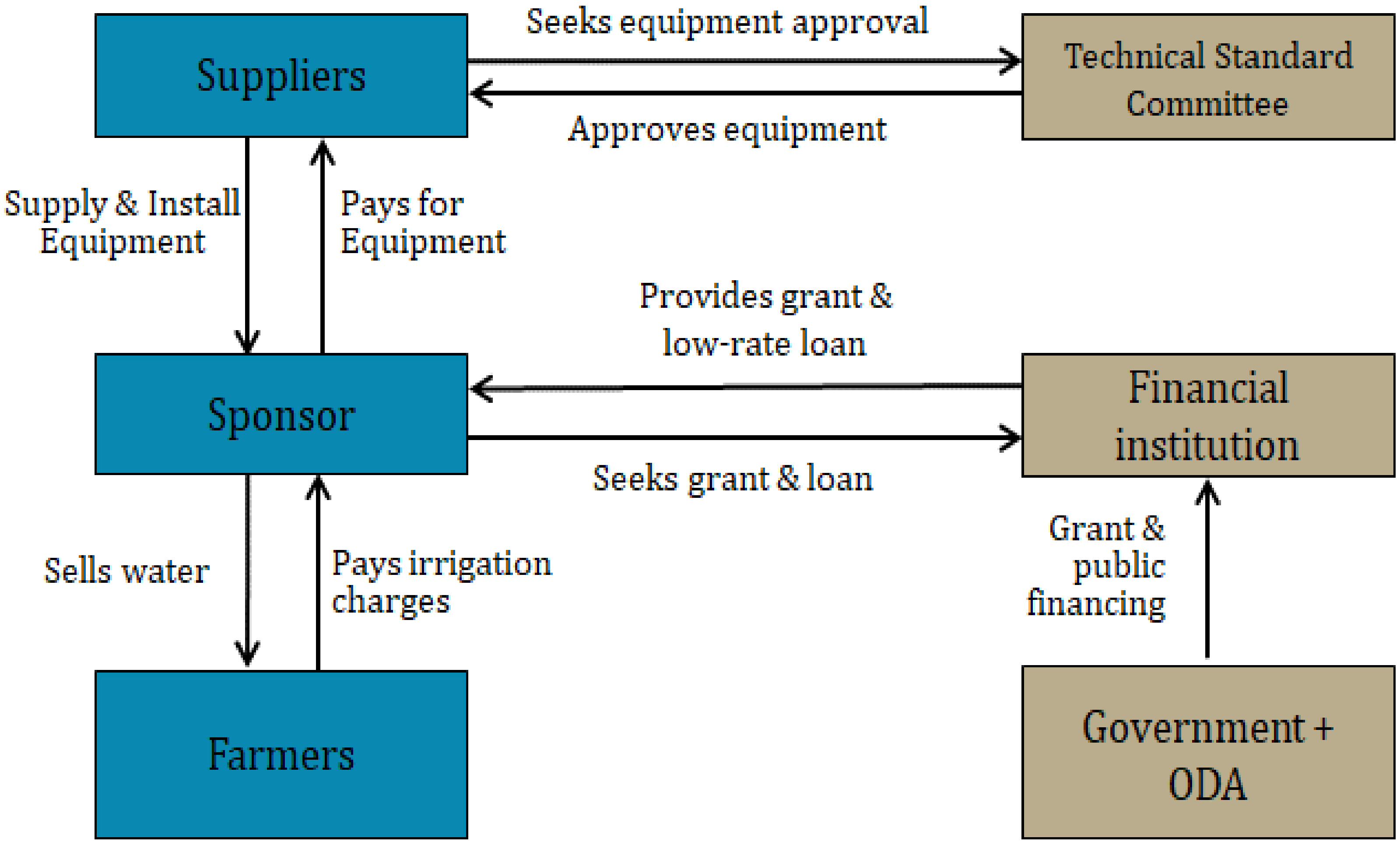
Fee-for-Service model of IDCOL



Early Results from 1st SIP Survey

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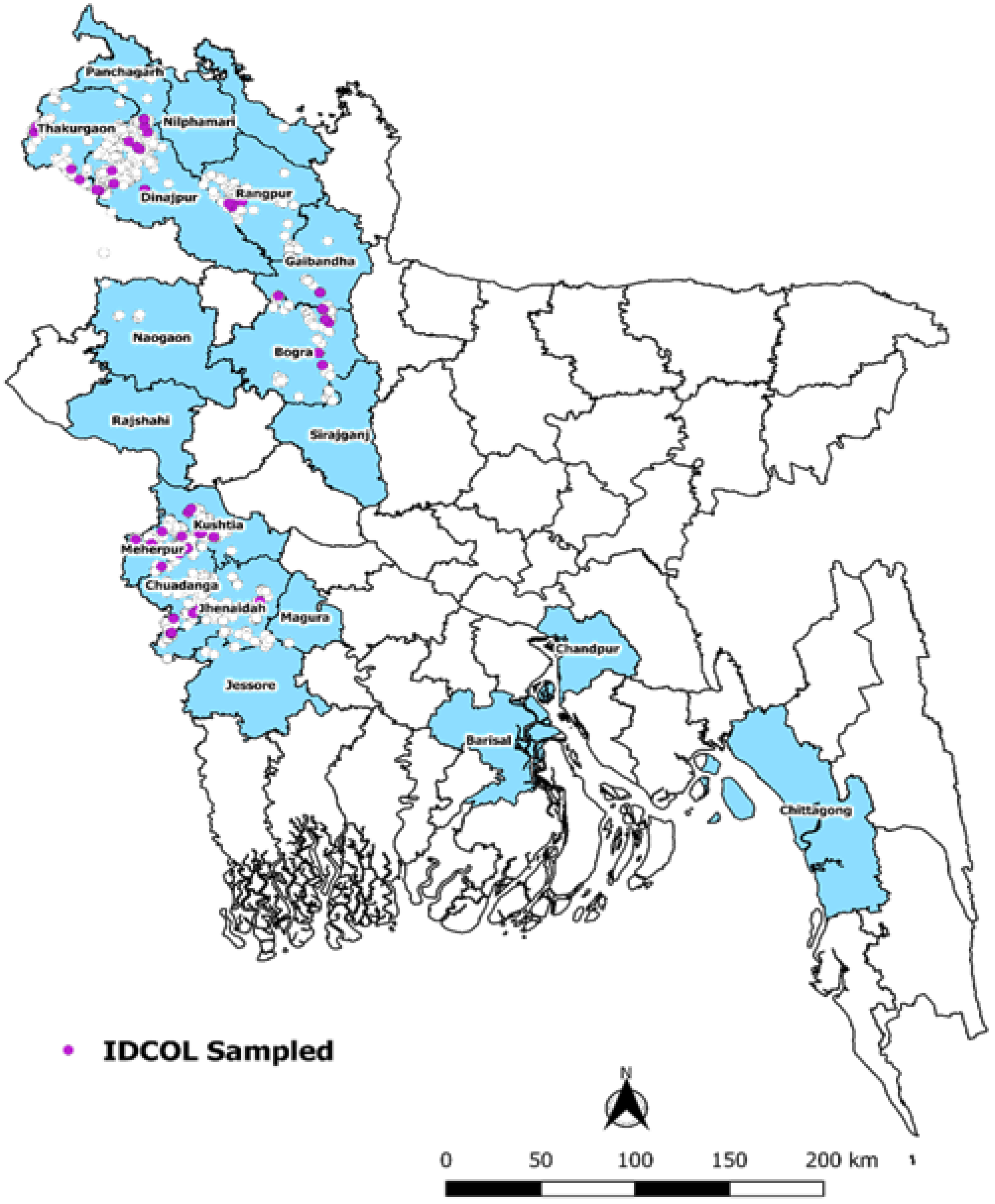
SIP survey in *kharif*-2 2020

- Sample of **82 IDCOL SIPs randomly selected and representative of locations, NGO/private sponsors, years of approval**

- 61 SIPs operational during the *kharif*-2, 2020 (June/July - Oct/Nov)

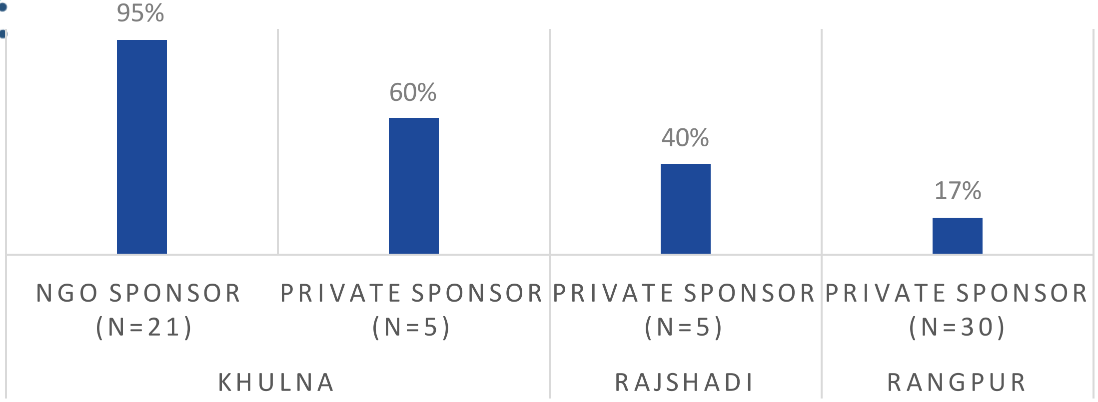
- **Phone surveys** with SIP operators in Oct-Nov 2020

- **9 seasons data to be collected** till Boro 2023

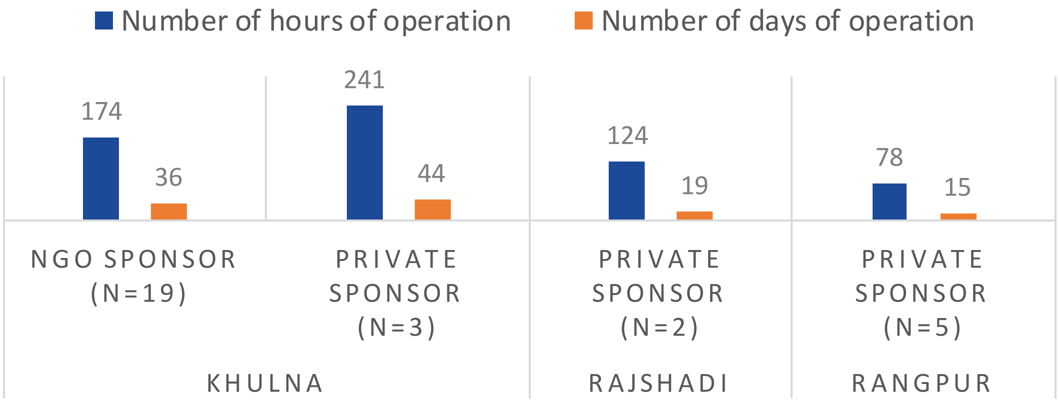


EARLY RESULTS | Low irrigation need in *kharif-2 season*

Percentage of SIPs operated in Kharif 2-2020



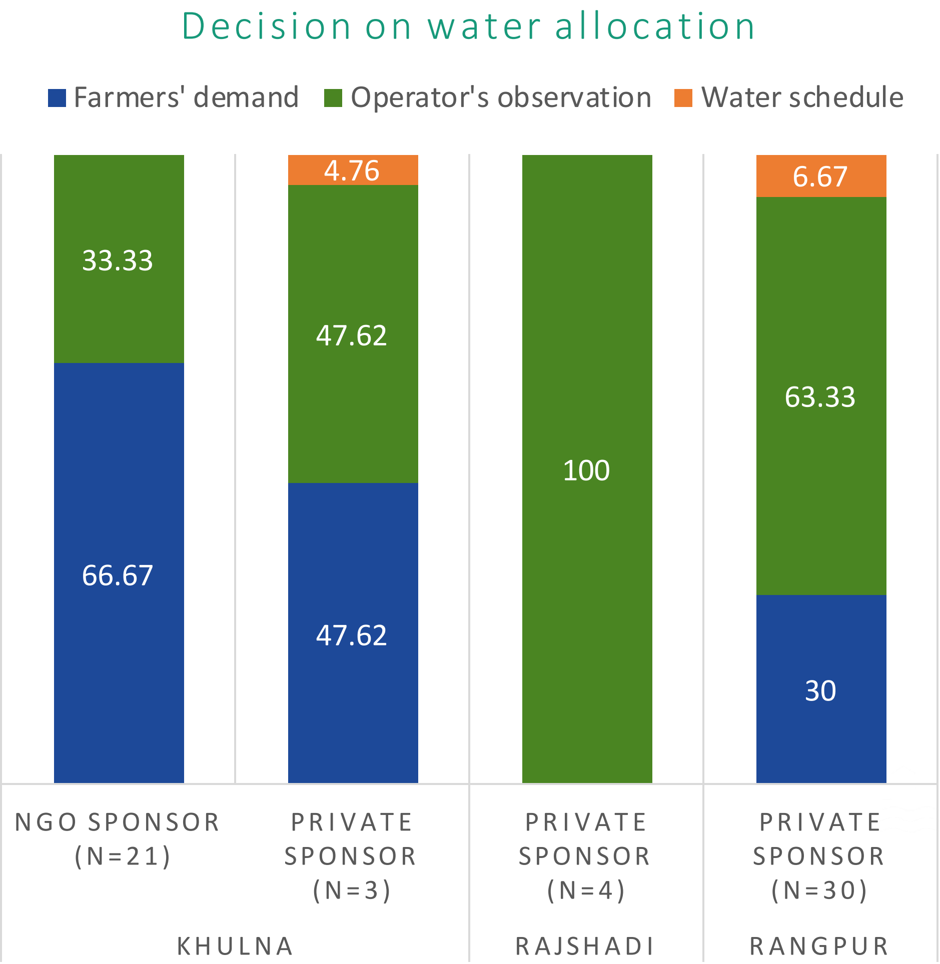
Hrs and days of operation in Kharif 2-2020



- **49% SIPs provided irrigation** in *kharif-2*, 2020
- For SIPs providing irrigation, only 35% of the command area required irrigation
- **Aman is the primary crop** during *kharif-2*
- Only 4 SIPs in our sample provided **other services** (husker, grinder) during this season

Irrigation need during kharif-2 (monsoon) very low

EARLY RESULTS | SIP irrigation services, more convenient?



- 58% SIP operators decided the allocation of water based on his own observation of the plots
- 65% **don't require the presence of farmer** during irrigation ➔ **Convenience**
- **Anecdotal mentions of convenience** (*to be probed further in HH survey*) – no need to buy diesel (beneficial financially + labour), no maintenance cost, reliable + quality irrigation

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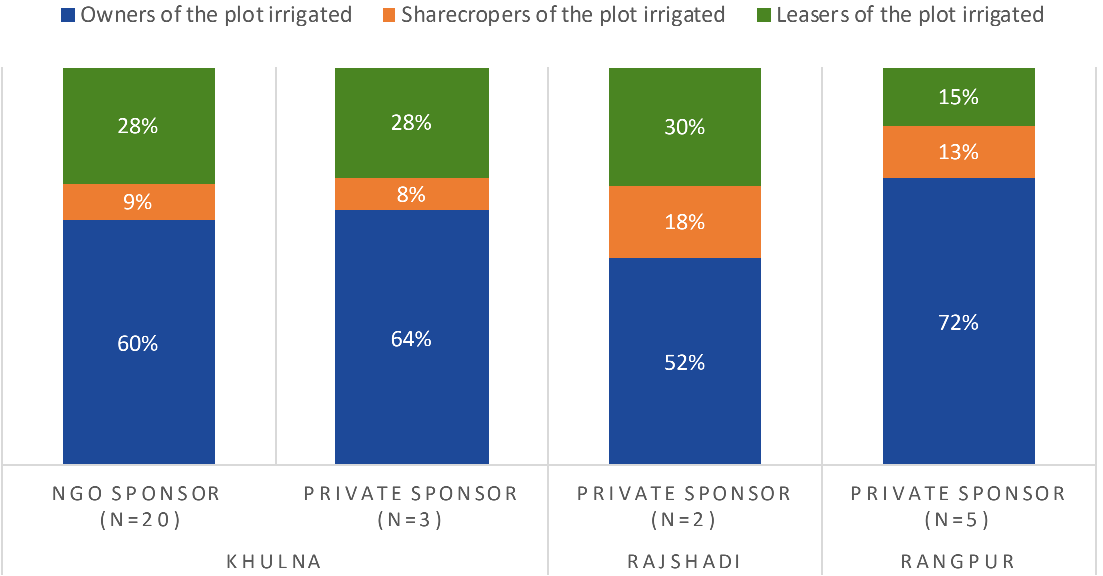
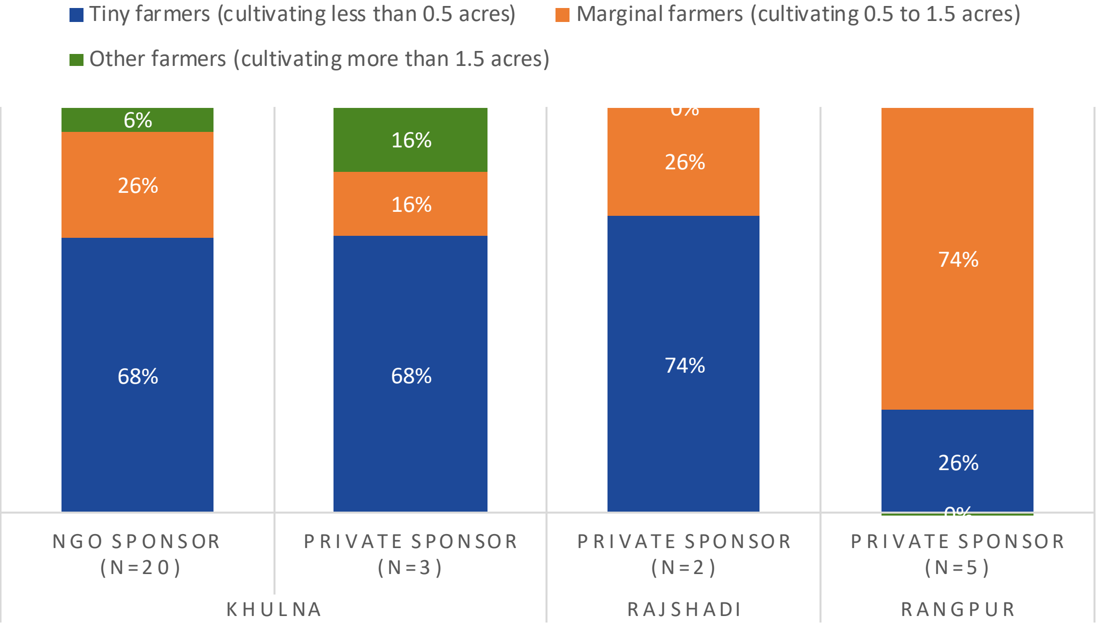
EARLY RESULTS | Beneficiaries in *kharif*-2 2020

Land tenure of the SIPs' irrigated plots



Land tenure of the SIPs' farmers



- 36% of the farmer beneficiaries were either sharecropper (10%) or leaser (26%)
- 10.9% of tenant only farmers in Khulna division, 16.9% in Rajshahi.
- 62% farmer beneficiaries in *kharif-2* were tiny farmers (cultivating <0.5 acres of land)

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Situation Analysis : SIP as “fee-for-service” model

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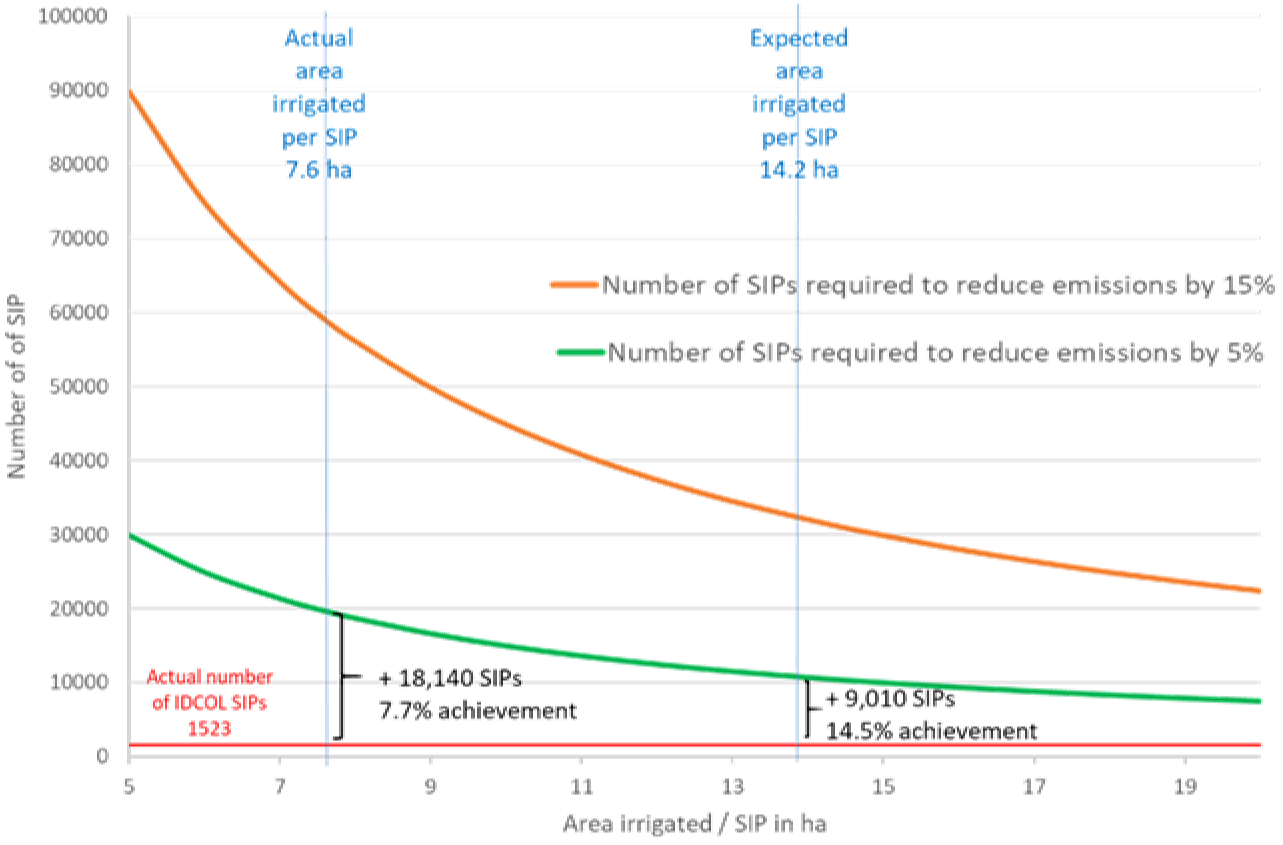
Solar irrigation and climate change mitigation

- 3.5 million MT/year of CO_2 emission from diesel irrigation (4.4% of national emissions)
- NDC under UNFCCC➔ GHG emissions reduction unconditionally by 5% and conditionally up to 15% by 2030
- 5% reduction in irrigation emissions may be **achievable and in line with IDCOL target of 10,000 SIPs** *(Under certain assumptions + command area achieves full potential)*

Do SIPs replace diesel pumps? Or just enable the expansion of energy access from renewables?

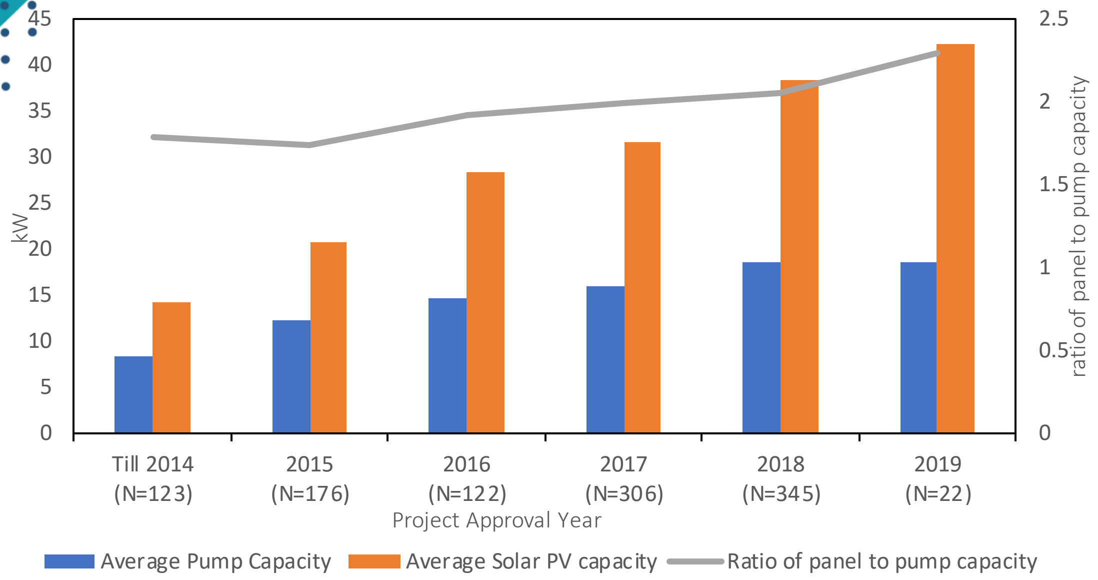


Number of SIPs required to meet INDC targets

Hypothesis / Caveats

- No shifting/complimentary use of diesel
- Only IDCOL SIPs
- Emission factor=3.186 kg of CO2 (WRI, 2015)
- Diesel sold to agriculture assumed diesel used for irrigation

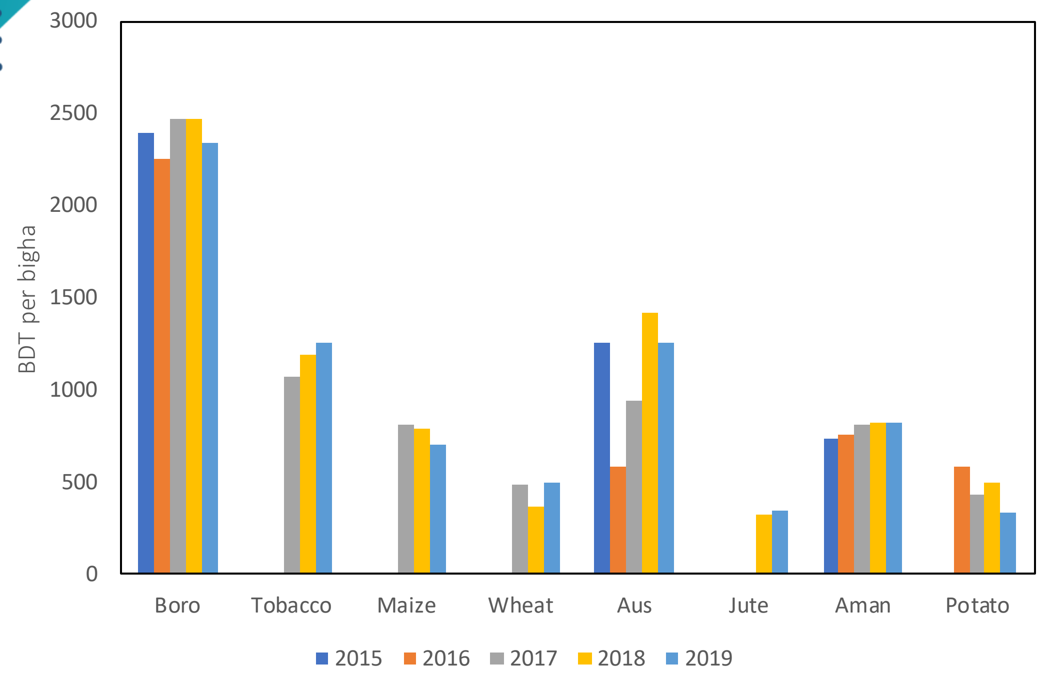
Excess solar energy during non-peak season

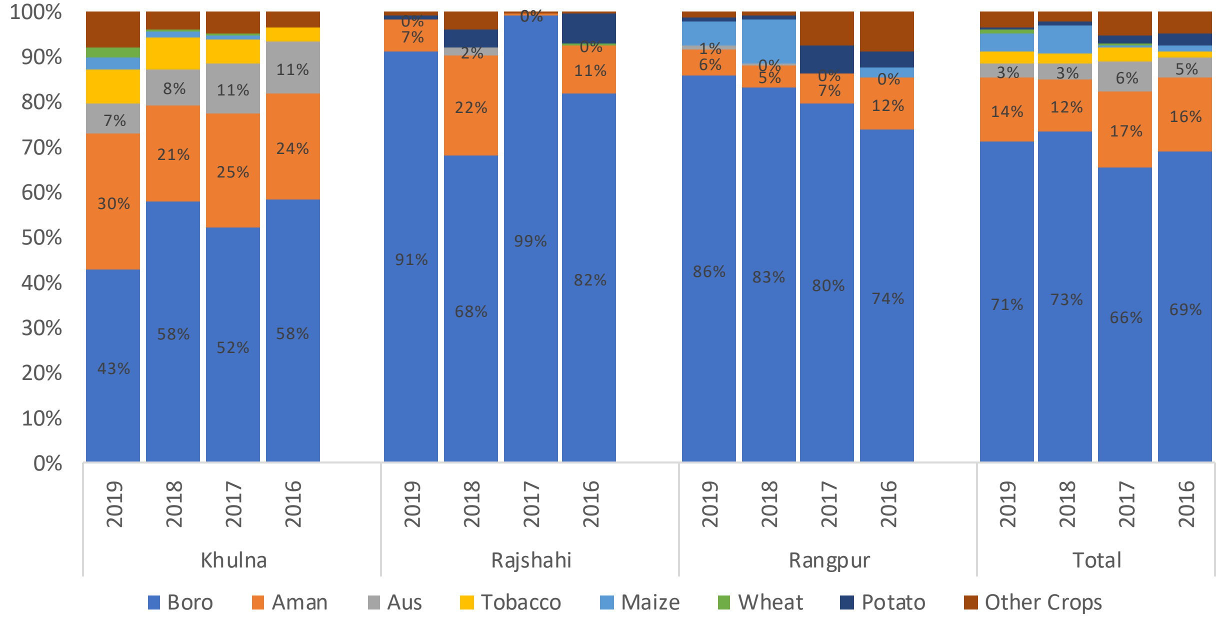


Division	Average Pump Capacity (Kw)	Average Solar PV capacity (kWp)	Ratio of panel to pump capacity	Discharge (Kilolitre/day)
Khulna *(N=358)*	15.54	29.02	1.84	1607417
Rajshahi *(N=88)*	16.07	30.47	1.81	1652682
Rangpur *(N=687)*	15.43	30.98	2.02	1713295
Total *(N=1134)*	15.51	30.30	1.95	1673924

- **SIP systems size increasing (**9.53 to 15.8 hectares); **Ratio of Panel to pump capacity** increasing (kWp /kW - 1.79 to 2.28); **Cost per panel capacity decreasing (**2.4 lakhs/KW to 1.4 lakhs per kW)
- Panel capacity required for higher discharge
- **Some using excess solar energy to run other machineries** like husking machines, grinders, etc.

Boro crucial for SIP business sustainability



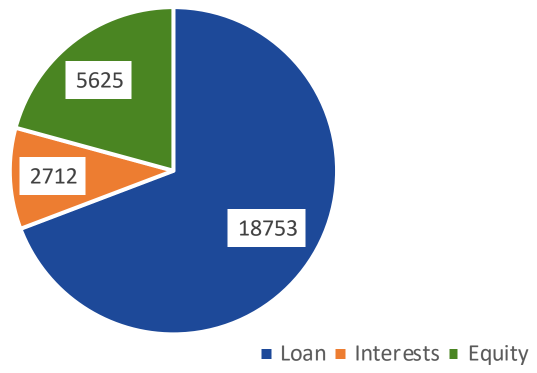


- Average irrigation charges for Boro higher than other crops (still less than diesel 3000 - 4000)
- Overall 65-70% of the revenue share is from Boro. Even higher in Northern region (i.e. Rangpur and Rajshahi) - above 80%.

Increasing Revenue for SIP business

- Average capital cost of SIP for the sponsor: 27,089 USD
- Average annual revenue from water charges in 2019: 1,450 USD
- Revenue not sufficient just from selling water, less than the base estimates (sort of maximum achievable)
- Increasing trend in revenue and further scope for gain through different mechanisms

Capital cost for the sponsor



OPPORTUNITIES AND WAY FORWARD

- **Other sources of revenue:** agricultural services, selling excess power to the grid
- Development of **market support**
- **Co-benefits** on poverty alleviation, food security, equity, climate change mitigation

IE study will capture these co-benefits, identify the dynamics of SIP business and where support should be prioritized

3.1.1 Farmers' training

30 participants at Panchagarh, 20th October 2020 – training needs identified by IDCOL

Resource persons from DAE and IDCOL

Objective:

- ❑ Educate farmers on solar pump and operational process
- ❑ Spread knowledge about water saving techniques and crop schedule
- ❑ Awareness on improved agricultural practices
- ❑ Platform for farmers to share their problems
- ❑ Develop interlinkage between farmers and local government agri. officials

2.2.1 Grid connection of SIPs

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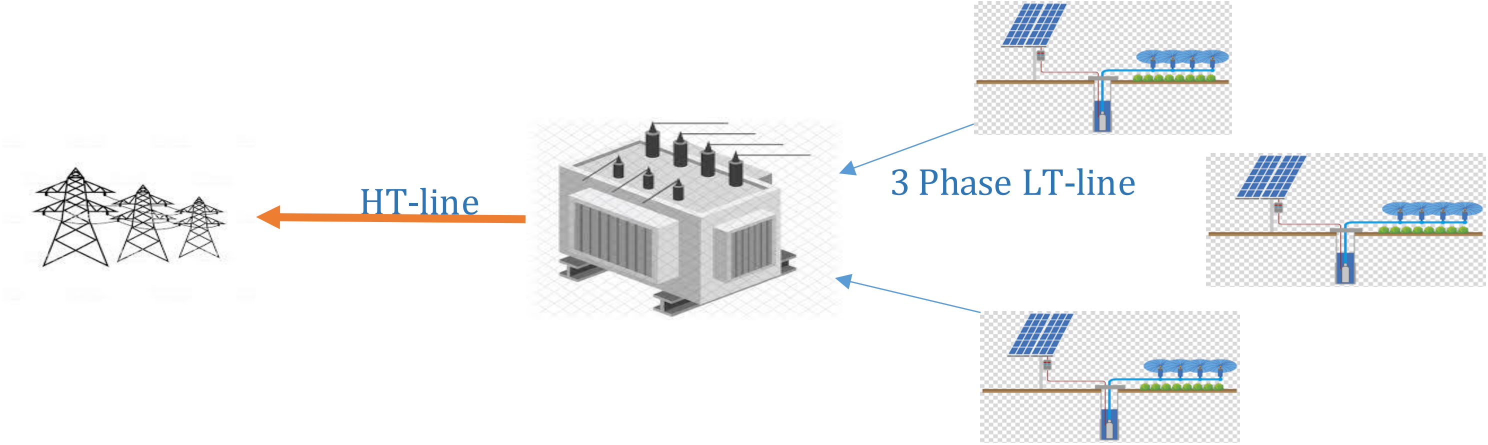
Grid Integration Topology

Possible topologies of Grid Integration:

- Topology 1: Integration of individual SIP site to the Grid via LT line (no transformer)
- Topology 2: Integration of clustered SIP sites to the Grid via HT (11kV) line (1 common Step up Transformer for all the clustered sites)
- Topology 3: Combination of Topology 1 & 2.

Topology proposed by IDCOL:

- Considering the available SIP sites and based on initial study of probable cost of grid integration, IDCOL proposed to implement grid integration of clustered SIP sites via HT line

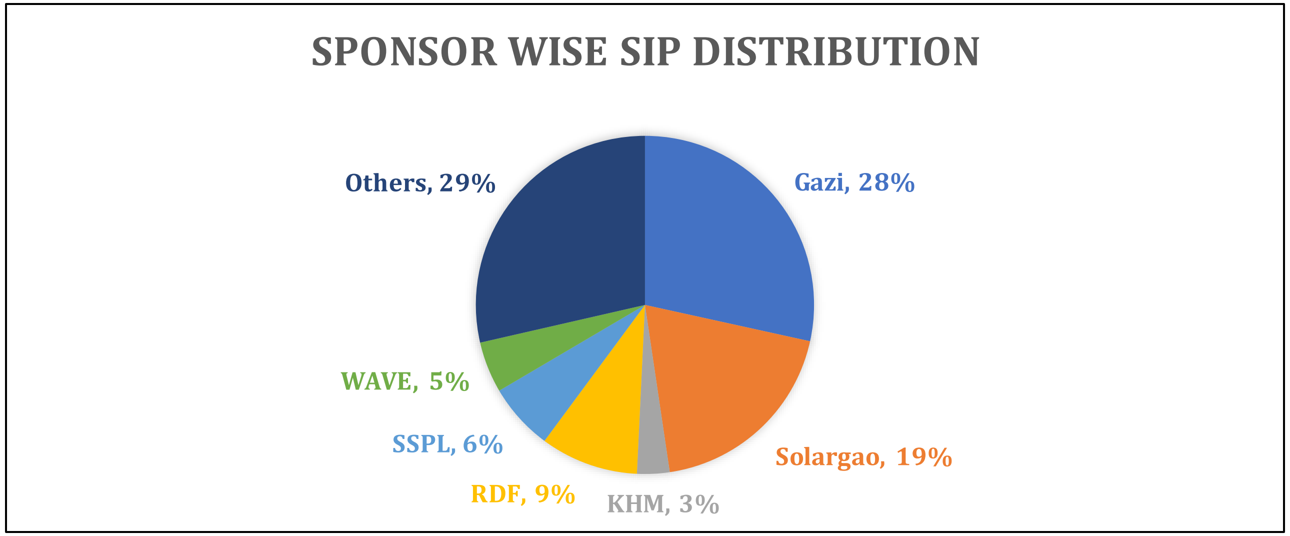


Site Selection Criteria

- SIP sites approved under IDCOL where clustering is possible;
- Connection of SIP sites to a common Transformer via LT Line (Star Connection);
- 11kV line from the transformer to the nearest utility pole;
- Maximum output of the clustered SIP systems must not be greater than 10MW;
- Power of Grid integration output must not be greater than 70% of the transformer rating;
- Maximum distance of the common transformer from each SIP site within 2km for allowable voltage drop
- Common Transformer should be within 300m of the nearest utility pole;
- Cabling can be either overhead or underground- depending on the cost, site location and preference by local farmers

Sponsor Selection Criteria

- Currently, 27 sponsors are operating under SIP program and have 1515 SIP sites installed so far.
- From the data of total installed SIP sites so far and location of clustered SIP sites, GAZI, SOLARGAO, KHM, RDF, SSPL, WAVE found to have the most potential sites.
- These sponsors were approached to submit site details (PV capacity, pump capacity, site-to-site distance, distance of nearest utility pole and distance of common transformer from each site) as per the site selection criteria.
- Potentially both Grid integration & Net metering of SIP sites will be selected



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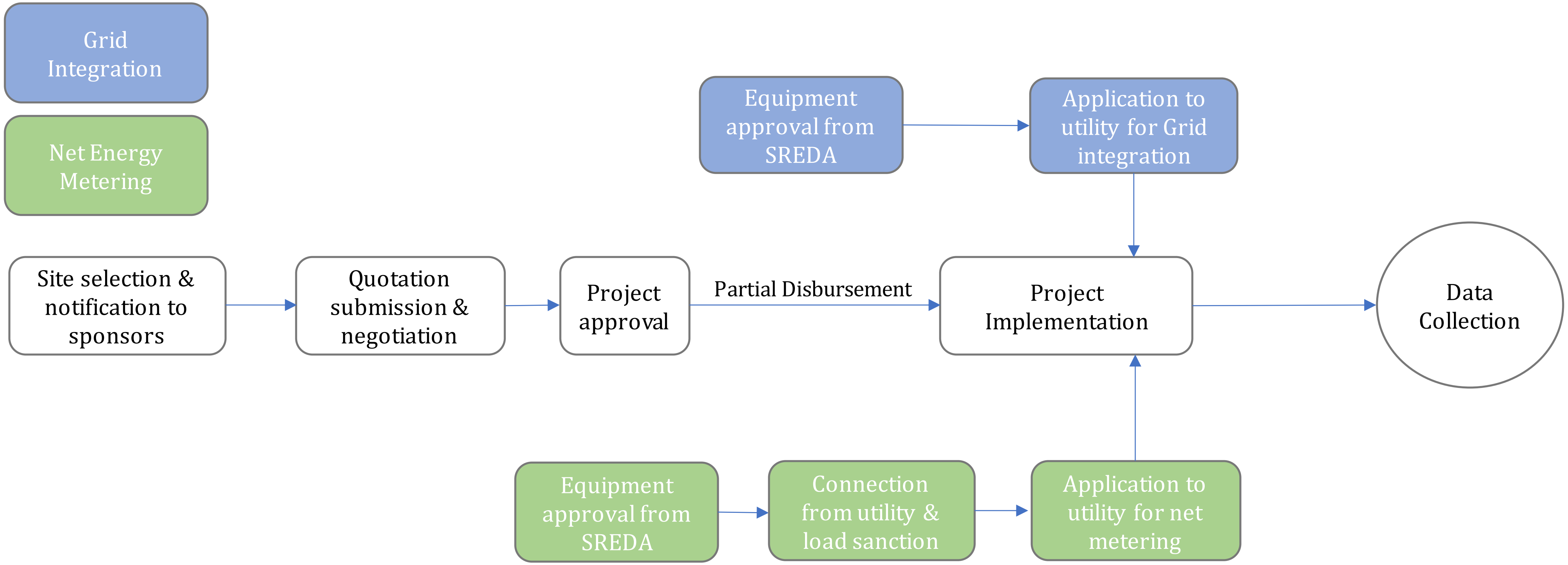
Implementation Process



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Groundwater situation in Bangladesh

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Groundwater recharge sufficient in BD (mostly)

- Intensive GW abstraction in BD (32 km^3 /year). 90% for irrigation; most extensively in North-central and North-west divisions. Mostly diesel shallow tubewells
- Plenty of Surface water (~ 20% of irrigated area) –but restricted use -- **reliability and variability of supply, operational constraints**
- Rainwater and flood water provide **ample recharge**; **groundwater irrigation making space for more recharge** – mean recharge from 132 mm/year between 1975-1980 to 190 mm/year in 2002–2007 (Shamsudduha et al. (2011))

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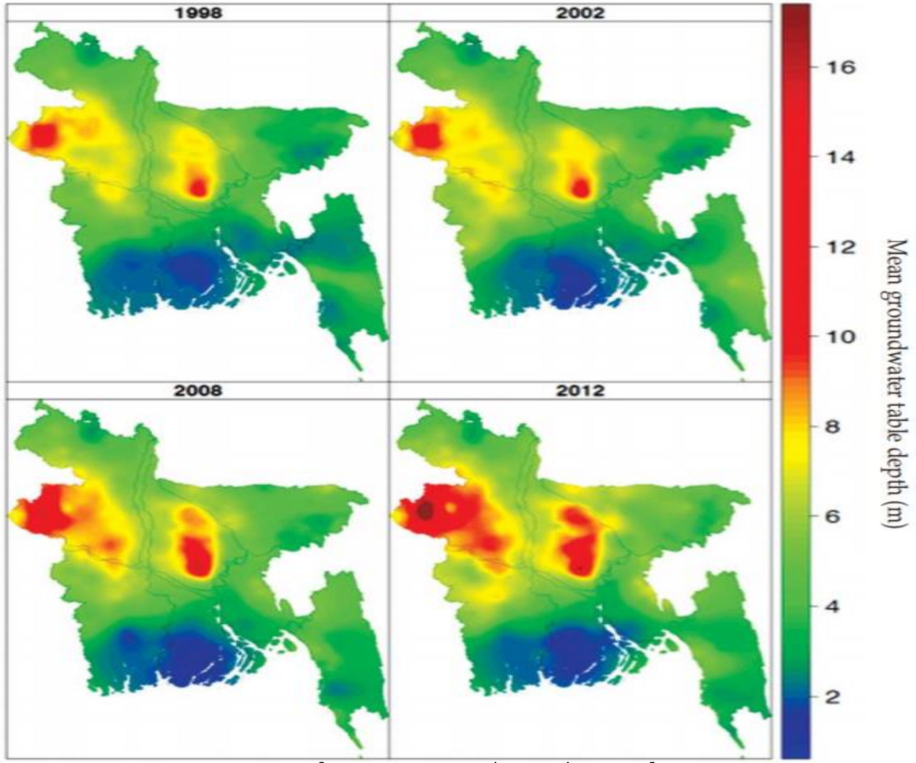
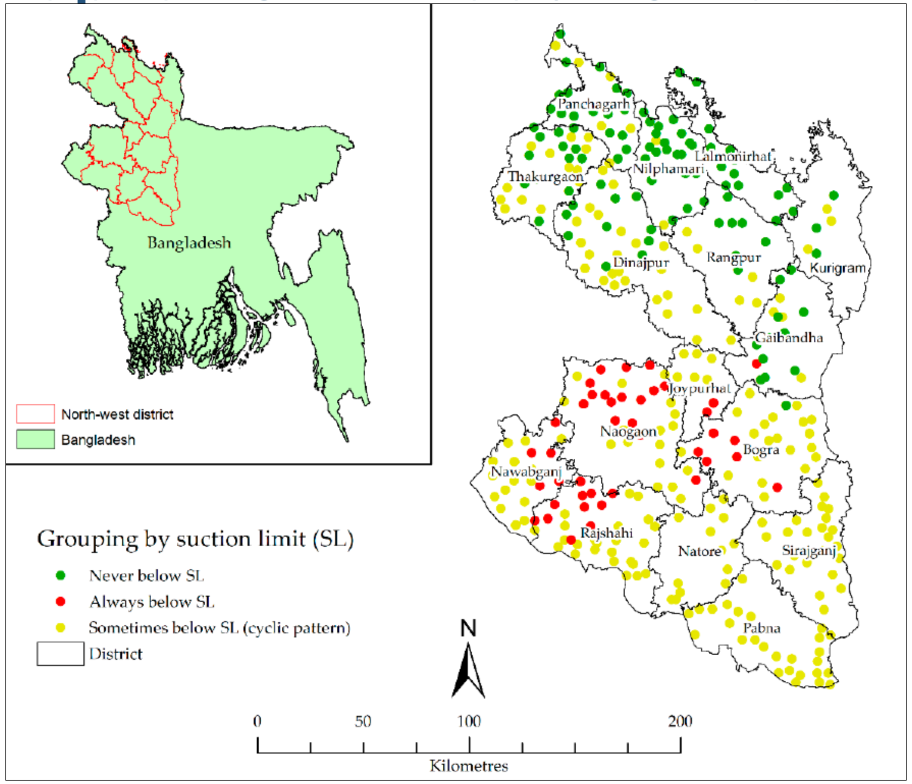
Pockets of depletion : need for caution



[Source: Qureshi et al. 2014]



[Source: Mojid et al. (2020)]

- Pockets of depletion ➔ Impact visible in dry season in **north central and western regions**
- Mojid et al. (2019) found 65.71% wells had significant falling trend for annual maximum depths between 1985 to 2016 ➔ GW tables went below suction limit (> 6 m), making STWs inoperable
- "Underground Water Management Law" 2018 reintroduced the pump licensing – **how to implement retrospectively?**

1.2.1 GW-related studies – key questions

1. How does the pumping behaviour of farmer-irrigators differ and what will be its long term implications on GW sustainability going from diesel to solar?
    - *Difficult to say apriori*
    - *How does it compare to recharge?*
    - *Even with differences in water application does consumptive water use change?*

2. How different is water use across SIPs with different cropping patterns & climatic regions?

3. How will groundwater sustainability be affected if SIPs were to be up-scaled?

- ❑ Monitor GW use pattern in SIP command areas across different agro-ecological zones; compare SIP vs diesel farmers
- ❑ Evaluate alternative water management practices through soil moisture measurements and soil modelling
- ❑ Construct and validate groundwater numerical models for future projections on GW usage

SIP Spatial Mapping

- Detailed SIP spatial mapping, flow characteristics (flow meter, full/partial flow) and crops
- To be used for feasibility of instrumentation & selection of plots/farmers [Monitoring from Aman 2021]

16 SIPs map

- From 82 SIPs surveye
- NW area [to be expar
- At least one year old
- Pump size and comm

2145 plots

8 plots

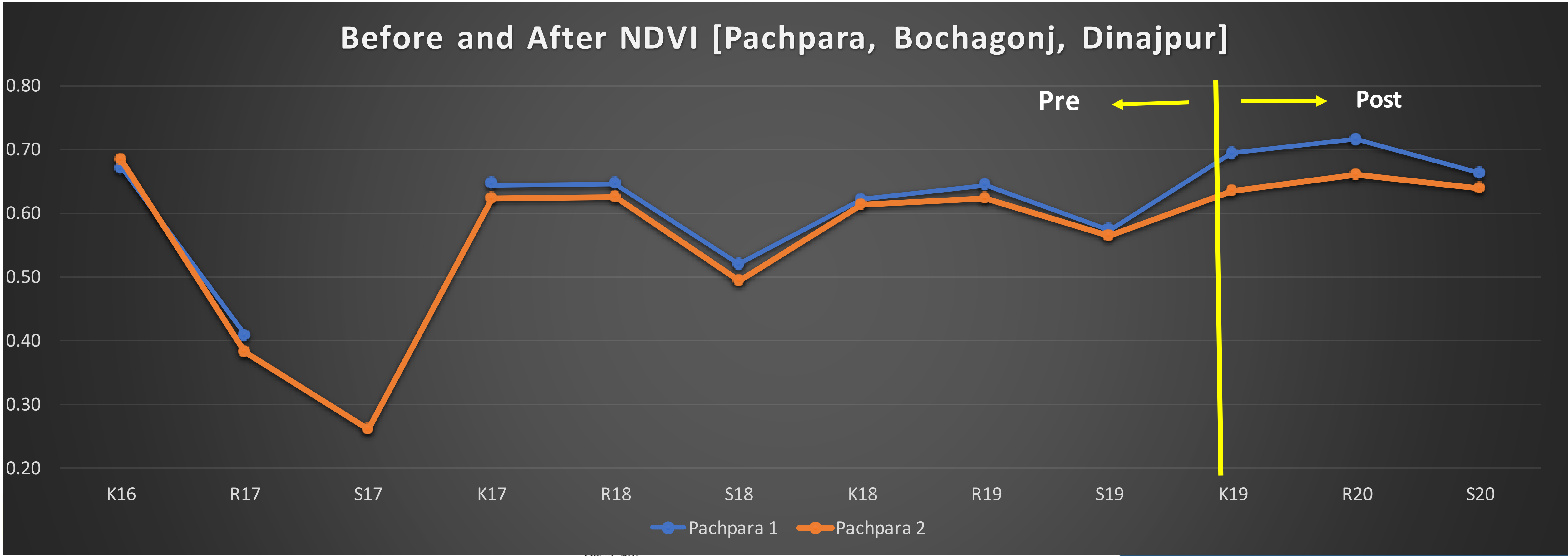
Currently, only 4 mea

m

ro as primary crops

Assessing cropping Intensity and NDVI changes

- Sentinel-2 optical satellite data with 10m resolution [2015 onwards]
  - Within and outside SIP command: Difference in crop area and intensity
  - Before and after: Assessing crop area and consumptive use
- NDVI Threshold based, filtered for expected peak NDVI [to be streamline for local SIPs]
- Kharif season: Consistently high and uniform, Summer: Lowest and improvement over years



Key Takeaways

- SIPs still at a nascent stage but big targets, multiple models (majority grant : loan : equity)
- Irrigation demand periodic → excess energy in non-peak season; *Boro* crucial for financial sustainability
- Revenue generating alternative uses of energy is important: **running machineries, grid connection**
- But also to focus and **quantify** the co-benefits - ***reducing GHG emissions, reduced subsidy burden, poverty and food-security, more convenience, equity***
- Simultaneously need to study groundwater sustainability and GESI implications of diesel to SIP transition

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Thank You

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