NEXUS Gains:
Realizing Multiple Benefits
Across Water, Energy, Food
and Ecosystems

Reversing groundwater depletion in Northwest India: insights from agronomic interventions and potential opportunities

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Groundwater situation in Haryana, NW India

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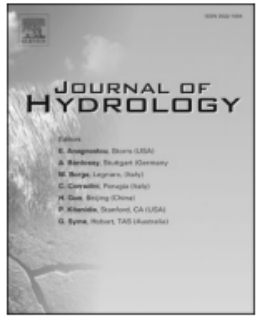


Research papers

Strongly heterogeneous patterns of groundwater depletion in Northwestern India

Suneel Kumar Joshi [a,b], Sanjeev Gupta [c], Rajiv Sinha [a,*], Alexander Logan Densmore [d], Shive Prakash Rai [e], Shashank Shekhar [f], Philippa J. Mason [c], W.M. van Dijk [d,g]

a slow gain in groundwater storage of + 0.58 ± 0.35 km^3 for the pre-monsoon and + 0.40 ± 0.35 km^3 for the post-monsoon period between 1974 and 2001. However, from 2002 to 2010, groundwater storage was rapidly depleted by −32.30 ± 0.34 km^3 in the pre-monsoon and −24.42 ± 0.34 km^3 in the post-monsoon period. Importantly, we observe marked spatial heterogeneity in groundwater levels and storage change and distinct

Background and objectives

- **Primary cause**
  - High cropping intensity 180-190%
  - Widespread conventional approach – puddled transplanted rice (PTR) under rice-wheat system
- **Options**
  - Adoption of water saving alternatives such as direct seeded rice (DSR)
  - Short duration rice varieties
  - Diversify rice to other high-value crops
  - Delayed sowing
- **Objectives**
  - Quantifying the boost in irrigation water productivity (IWP) under DSR relative to PTR
  - Variables driving the IWP under the two establishments

Why to focus on DSR-based systems

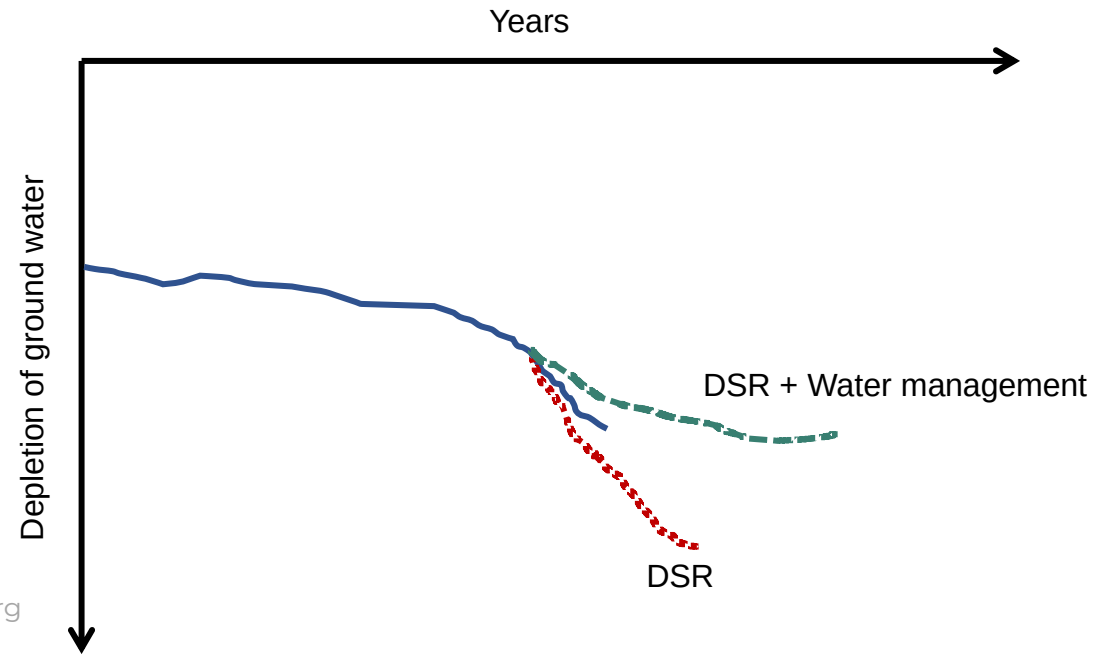
When water is managed like puddled field

No

Water saving with DSR

Yes

When water is managed appropriately



Hindustan Times

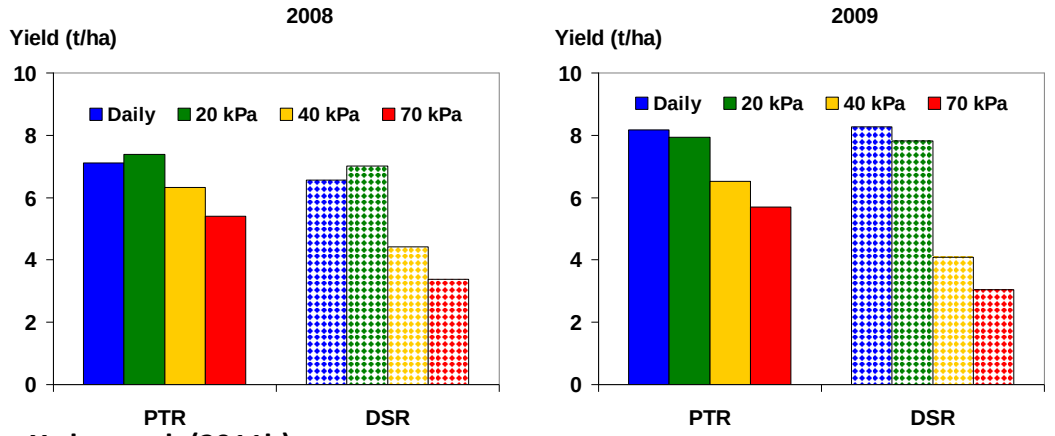
Home / Cities / Chandigarh News / Haryana farmers to get ₹ 4,000 per acre f...

Haryana farmers to get ₹4,000 per acre for growing paddy using direct-seeded rice method

Chandigarh News

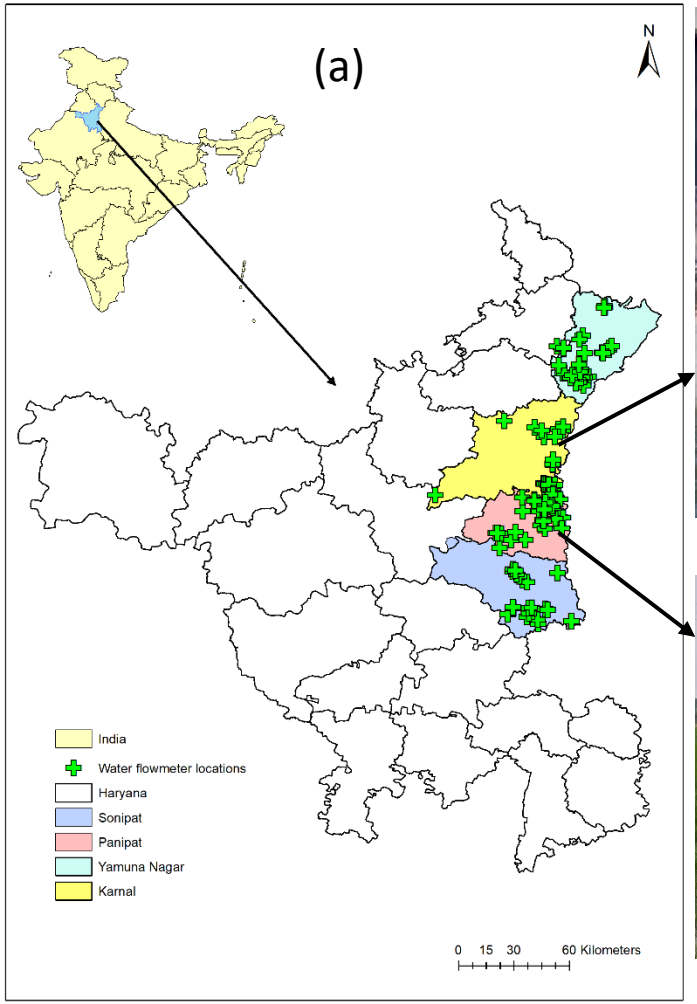
Published on May 18, 2022 12:55 AM IST

Encouraged by the cultivators' response to its incentive-driven policy of promoting direct-seeded rice (DSR) technique last year, Haryana agriculture department on Tuesday set one lakh acre as the target of sowing paddy with this water-saving alternative method in 12 leading paddy-growing districts



Yadav et al. (2011b)

Study area



(a) Location of study districts with water flowmeters; (b) farmer monitoring the water flowmeter; (c) a happy DSR farmer

4 districts – rice dominant cropping (48 – 71% of total land area)

Collaboration with national partners, KVK Yamuna Nagar, KVK Karnal, KVK Panipat, and KVK Sonipat – identify the farmers and installation of WFM

50 water flowmeters installed (25 each for DSR and PTR farms)

Installed at the outlet of the tubewell

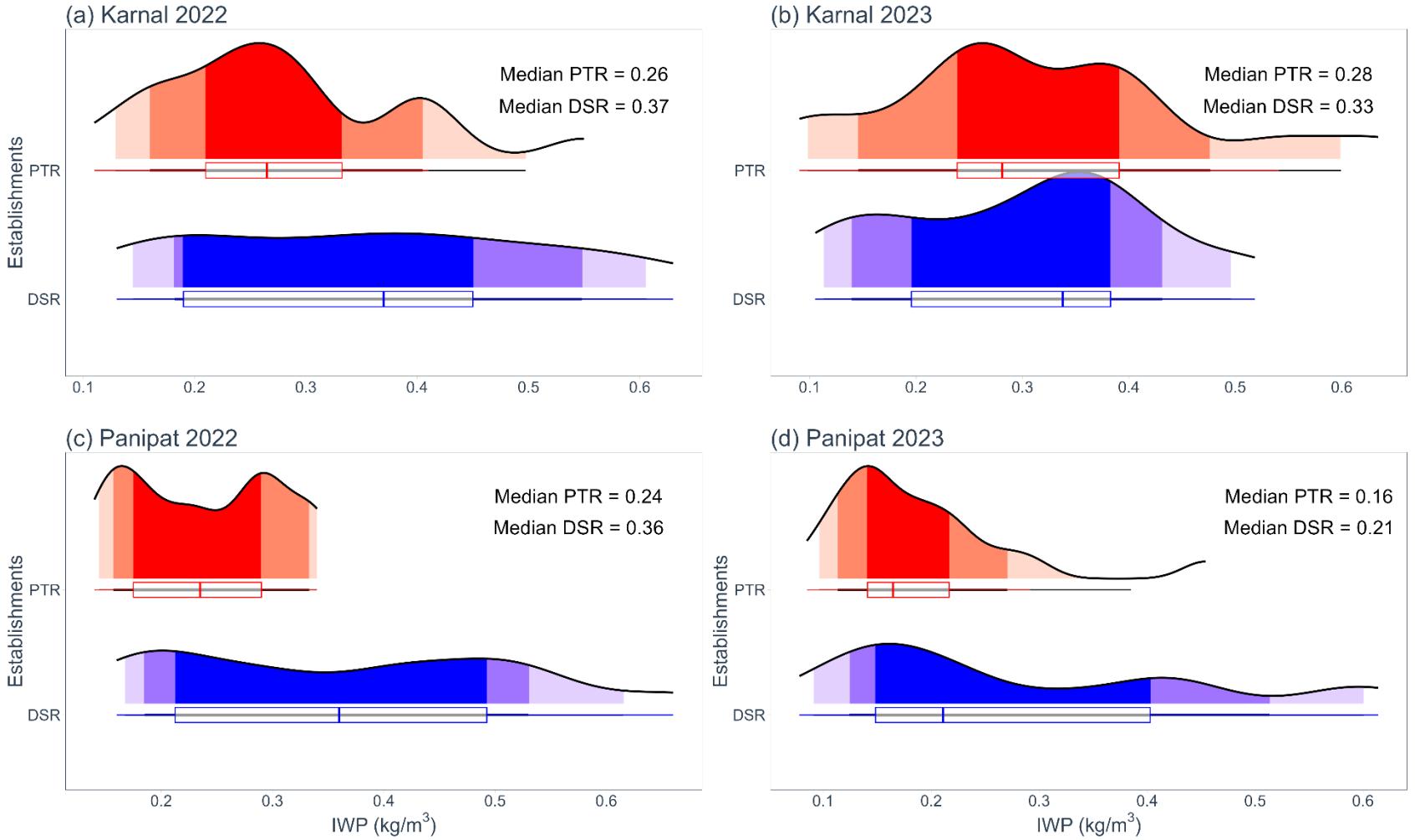
Short duration basmati (PB 1509) and non-basmati rice (PR126)

Irrigation application and crop yield

District	Crop establishment	Irrigation (mm/ha/irrigation)	Total irrigation (mm/ha)	Yield (t/ha)
Yamuna Nagar	DSR	202.1	3672	6.3
	PTR	204.2	4238	6.2
Karnal	DSR	225.9	3153	5.5
	PTR	160.1	3558	5.9
Panipat	DSR	205.3	2380	5.2
	PTR	160.6	2884	4.9
Sonipat	DSR	188.9	2897	4.8
	PTR	144.7	3334	5.2
Panipat (trial)	DSR	72.5	873	5.9
	PTR	64.3	1135	6.0

Note: 3-5 nos. of irrigation more in case of PTR relative to DSR

Irrigation water productivity (IWP)

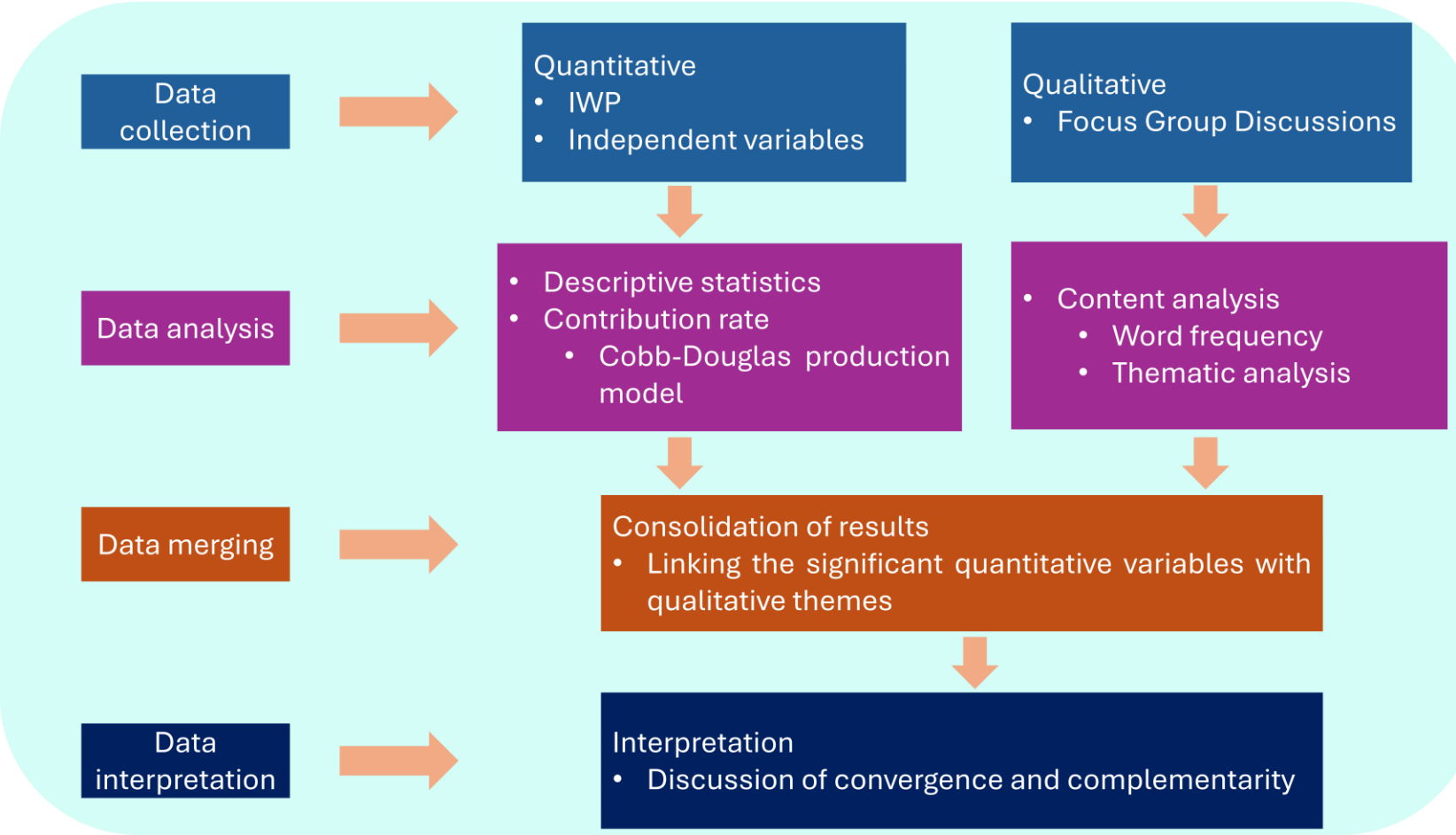


$$IWP = \frac{\text{crop yield/ha (kg)}}{\text{water applied/ha } (m^3)}$$

IWP is higher in DSR compared to PTR (~18% to 50%)

Yield obtained is **at par**

Drivers of IWP: workflow



$$\text{IWP} = \frac{\text{crop yield/ha (kg)}}{\text{water applied/ha (m}^3\text{)}}$$

Contribution rate of variables: Cobb-Douglas production model

$$Y = AK^{\alpha}L^{\beta} \quad \text{.....(1)}$$

$$Y = A\prod_{i=1}^{n} X_i^{\beta_i} \quad \text{.....(2)}$$

$$\ln Y = \ln A + \sum_{i=1}^{n} \beta_i \ln X_i \quad \text{.....(3)}$$

$$E_i = \beta_i \frac{\frac{\Delta X_i}{X}}{\frac{\Delta Y_i}{Y}} \quad \text{.....(4)}$$

Partial least square method was used for estimating parameters.

DOST: Date of sowing or transplanting; Ant. RZSM: Antecedent root zone soil moisture; PUA: no. of plots unit area; WDUA: Well depth unit area; PSUA: Pump size unit area; DT: Diurnal temperature; SH: Sunshine hours

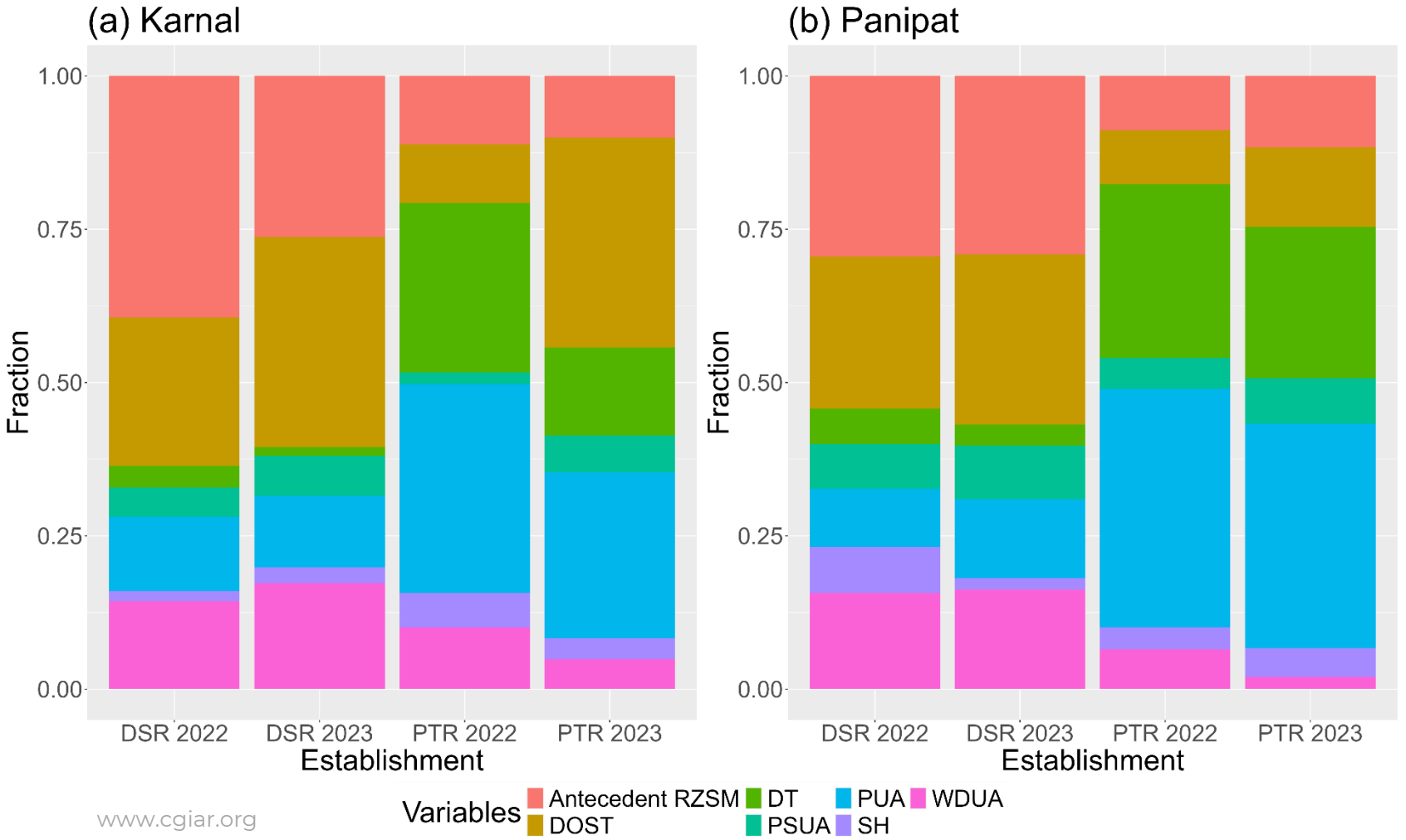
Focus Group Discussion

- 4 FGDs with 2 groups: PTR and DSR farmers (total 50 farmers)

- Identify irrigation, productivity, and diversification related decisions:
  - When do farmers irrigate (frequency)?
  - How much they irrigate?
  - Does electricity influence irrigation behavior? If yes, how?
  - Average per hectare NPK, herbicide application?

Drivers of IWP: Quantitative

Proportion of contribution rates of the governing variables



Ant. RZSM: antecedent root zone soil moisture

DT: diurnal temperature

PUA: plots under irrigation for each tubewell

WDUA: well depth unit area

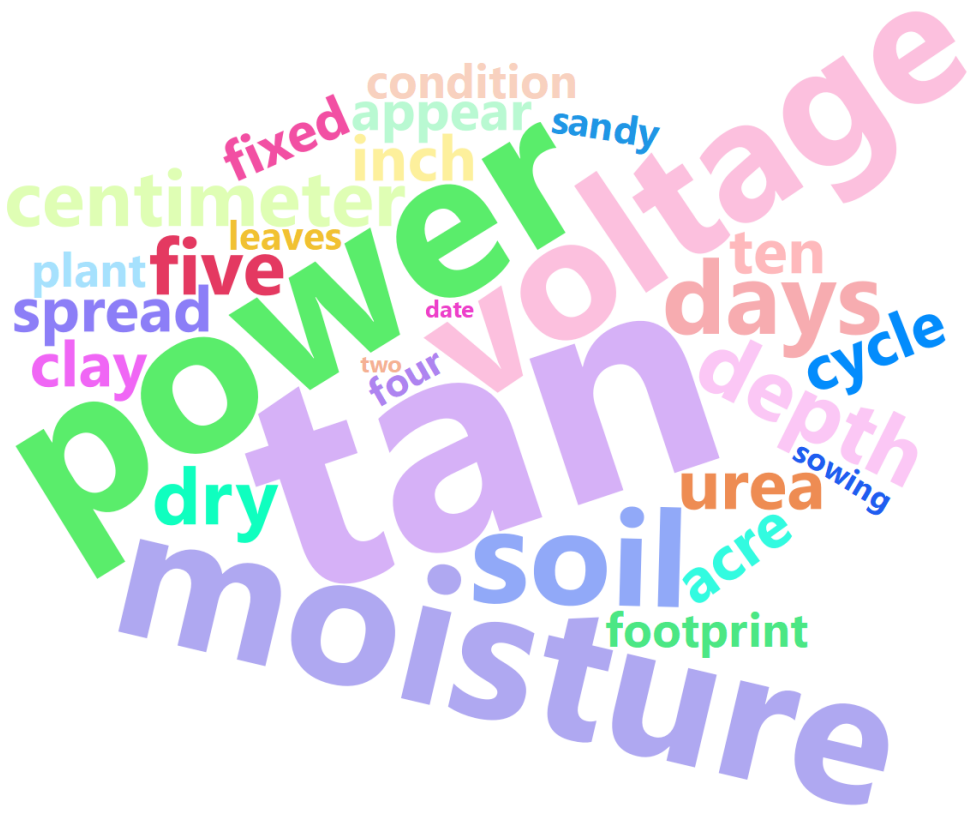
DOST: date of sowing or transplanting

PSUA: pump size per unit area

SH: sunshine hours

Drivers of IWP: Qualitative

(a) DSR



(b) PTR

Drivers of IWP: Qualitative

Thematic analysis

DSR

Irrigation frequency	Irrigation duration
Soil factor	Plot characteristics
Plant characteristics	Water application
Weather	Energy
Water application	
Energy	

PTR

Irrigation frequency	Irrigation duration
Water application	Energy
Weather	Water application

Soil: soil type, soil moisture, tan soil, footprint on soil

Plant: leaves start turning upside down, dry

Weather: hot and dry

Water application: depth, uniform flooding

Energy: blackouts, power cut, low voltage

Plot: uniform water distribution

Summary

- DSR improves IWP compared to PTR; water application per irrigation is higher in DSR
- Multiple co-occurring variables exist among irrigation decision making in DSR and PTR establishments
- Farm intrinsic variables mostly drive the irrigation decisions in DSR; fixed criteria of uniform depth governs irrigation decision in PTR
- Significant adoption of DSR in the study districts: Basi Akbarpur village in Karnal has seen 30+% increase in DSR acreage since 2022
- Farmers are saving more water since the inception of NEXUS Gains: “I have heard about DSR a several years ago from one of the scientists from Haryana Agricultural University…… Last year when IRRI scientists approached me and discussed the benefits of DSR (particularly water saving), I thought to try it out on 2 acres (~0.809 ha) of my farm with reduced water application. Yield is comparable, and more significantly I saved 5 irrigations during the season” – Gurmail Singh from Talakaur, Yamuna Nagar

p.deb@irri.org

CGIAR NEXUS Gains

All the Farmers

CCS Haryana Agricultural University (KVK YNR, Karnal, Panipat and Sonipat)

Central Soil Salinity Research Institute

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