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Sustainable intensification of groundwater irrigation in the Eastern Indo-Gangetic Plains

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Groundwater irrigation has played a critical role in the Green Revolution in South Asia, helping to increase crop yields and improve livelihoods of millions of rural households. However, the spread of irrigation has not been homogeneous, with many farmers in the Eastern Indo-Gangetic Plains (EIGP – Nepal Terai and parts of eastern India) still lacking reliable and affordable irrigation access. As a result, agricultural productivity in the EIGP is some of the lowest found across South Asia, with many farmers trapped in chronic cycles of poverty and food insecurity.

A major focus of government and donor efforts to support intensification of groundwater irrigation in the EIGP has been the replacement of existing diesel-based pumping systems with alternative electric or solar powered pumping technologies. These technologies are viewed as being cheaper for to operate and less environmentally damaging due to their lower operational carbon emissions. However, scaling these technologies in practice has proved challenging due to their high upfront capital costs and the unique socio-technical constraints posed by farming systems in the EIGP (e.g., land fragmentation and poorly developed supply chains).

In response to these challenges, our research explores whether opportunities exist to make existing diesel pump systems more cost effective for farmers to support adaptation to climate change and reduce poverty. In particular, we seek to identify what factors lead to disparities in groundwater access costs for irrigation, how these disparities affect farmers' water use behavior, and in turn how this impacts agricultural production outcomes. Our work draws on evidence from a recent survey of over 400 farmer households in the Nepal Terai, along with detailed in-situ testing and analysis of the fuel efficiency and cost-effectiveness of over 100 diesel pumpsets in the same region conducted between 2019-20.

Our results demonstrate that substantial variability exists in the costs of diesel pump irrigation in the EIGP and that higher costs of groundwater access are associated with lower levels of

agricultural productivity and household income. Dependence on expensive pumpset rental markets, in particular amongst credit constrained households, is a major driver of the highest irrigation access costs. Additionally, many farmers also continue to operate and invest in pumpset models and designs that are significantly oversized for local hydrological conditions, resulting in fuel inefficiencies and excess costs that reduce the overall profitability of irrigation water use.

Our findings have important implications for national and regional policy debates about sustainable intensification of irrigated agriculture in the EIGP and other regions. We suggest that intensification of water use and improvements in agricultural productivity can be achieved in the near-term without need for radical technology changes. Targeted credit support, combined with data-driven advisories and improved supply chains for maintenance services and spare parts, could incentivize and enable adoption of low-cost fuel-efficient diesel pumpsets resulting in substantial reductions in costs of irrigation for many farmers. This would have positive near-term impacts on agricultural productivity and rural livelihoods, supporting adaptation to climate change and future transitions to alternative low-carbon irrigation technologies in the region.