Extended Abstract
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Paper/Poster Title	Impact and drivers of informal water markets in irrigation regions in India

Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.

Abstract	***200 words max***
Significant water supply-demand gaps are projected in many regions of India under current scenarios. The government is considering and implementing different measures to support a sustainable water resources management in irrigated agriculture, e.g. incentives to reduce water abstractions, metering, effective water pricing or community-based water management. Also, informal water markets are widespread in India; however, their impacts are largely unknown and under-researched. We analyse the development and determinants of farmers' water purchasing behaviour and related expenditure using a large representative survey for India over two years. Modelling results show that irrigation water purchases were more likely where groundwater levels were already low, farmers have a diversified access to water sources but no access to public piped drinking water supply. For groundwater, water purchases were also more likely in villages with prevalent conflicts and where farmers were not members in a cooperative, with low confidence in local governments. Increased expenditure (INR/acre) for irrigation water was associated when purchasing mainly from private tubewell owners. Results underpin the severity of the state of India's groundwater resources and the need for better regulation and monitoring in water management, e.g. with regards to informal water markets, to better serve local farming communities and the environment.	

Keywords	irrigated agriculture, groundwater, informal water markets, India
JEL Code	Q12 Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets; Q15 Land Ownership and Tenure; Land Reform; Land Use; Irrigation; Agriculture and Environment

Introduction	***100 – 250 words***

Water is central to the current climate crisis and the reason for many conflicts in the world. Agriculture in India accounts for around 90% of freshwater withdrawals and 65% of the irrigation water is sourced from groundwater. Farmers in many regions receive subsidised electricity for groundwater pumps leading to widespread groundwater depletion and over-exploitation. In many water scarce countries, economic instruments (e.g. water pricing/trading, education/incentives for adopting water conserving practices) became a prominent measure to manage a scarce resource after rising environmental problems and the realisation that technological solutions have limits in water supply augmentation. In India, volumetric pricing is recommended in the National Water Policy and water rates should signify water

resources' scarcity values. However, the prerequisites of installing widespread water metering infrastructure and adequate monitoring systems hinder its implementation. The government is also considering and implementing other measures to better manage water, e.g. incentives to reduce water abstractions, decreasing energy subsidies, or community-based water management. Informal water markets are also widespread in India, but their impacts are largely unknown and under-researched due to a paucity in related data. We investigate the impacts and drivers of irrigation water purchases over two years in India. We are particularly interested whether there is an association between increased irrigation water purchases and characteristics of local (water) governance, (water) conflicts and memberships as well as the diversity of access to water sources. It is also expected to find a difference for related expenditures when purchasing from private as compared to government tubewell owners.

Methodology	***100 – 250 words***

We use household level data from the India Human Development Survey (IHDS), a nationally representative, multi-topic panel survey of 41,554 households in India. The survey is a collaborative research program produced by the National Council of Applied Economic Research (NCAER), New Delhi, and the University of Maryland. The survey spanned over 1,503 villages and first took place in 2004/05. Interviewers returned for a second survey in 2011/12 to re-interview the same households with over 83% re-survey rate. For the purpose of this study, we concentrate on a subset covering all irrigating farms (n=19,330). In addition, we collected precipitation (mm/day), temperature and groundwater storage (percentile) data from NASA Earthdata and merged the district level average statistics with the survey data. To analyse the drivers of farmers' decision to purchase irrigation water for their crops in the previous year we estimated several probit models for the survey years separately and combined (pooled cross-section), using a year indicator variable to account for aggregate changes over the period, and separately for groundwater and surface water. As an extension we estimated the models by State, focussing on those states with a sufficient amount of irrigation farms, such as Uttar Pradesh and Madhya Pradesh. Furthermore, fixed-effects panel regression models were estimated to examine determinants of farmers' irrigation water expenditure per year and per acre (INR/acre). We used the Hausman-test to check whether the individual characteristics are correlated with the regressors to decide whether random- or fixed-effects models fit our data.

Results	***100 – 250 words***

Modelling results for both models (groundwater and surface water) show that, after accounting for several control variables, irrigation water purchases were more likely where: a) Groundwater levels were already low; b) Farmers have access to both water sources; and c) Farmers have no access to public piped drinking water supply. Particularly in groundwater irrigation areas, purchases were also more likely where: a) Conflicts are prevalent within the village; b) Families solve (water supply) conflicts individually; c) Farmers are not members in a cooperative; and d) Farmers have low confidence in State or village government.

Furthermore, modelling results for irrigation water expenditure showed a strong association between increased expenditure INR/acre when purchasing mainly from private tubewell owners as compared to government tubewell owners.

There is a need for future research to examine this dataset at local spatial scales and per different irrigation types, because of highly varied irrigation systems and pricing in India. This is reflected in the different results for the state-specific models.

Discussion and Conclusion	***100 – 250 words***

Results underpin, on the one hand, the severity of the state of India's groundwater resources and, on the other hand, issues regarding community cohesion and confidence levels regarding local governments. A greater connection within communities, or better sector specific networks, could potentially lead to more refined purchasing/farming decisions. Local networks may need to be reinforced, such as water users associations, accompanied by participatory approaches to better understand the diverse role water plays in rural livelihoods in India. Studies have shown that better water governance systems improve the cooperation among stakeholders and the resilience in communities. Overall, there is a need for better regulation and monitoring in water management, e.g. with regards to informal water markets and energy/other agricultural subsidies, to better serve local farming communities and the environment. At the same time, different water-related policies need to take into account the effects of multiple implemented measures as well as the existence of informal water markets.