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Adoption of water-saving technology in agriculture: The case of laser levelers

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ABSTRACT

Water saving agricultural technologies like laser leveling are a potentially important but under-utilized lever to conserve groundwater in India. We report findings from a survey about laser leveler adoption among farmers in Punjab in India. Despite high private returns, many farmers have not invested in laser leveling when it was available. We investigate factors associated with (and impediments to) adoption, including financial constraints and social network influence.

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1. Introduction

This paper presents evidence on the adoption of laser land leveling, a water-saving agricultural technology, by farmers in the Indian state of Punjab. Farmers have traditionally leveled their fields because a flatter planting surface permits more efficient irrigation, and may save labor and improve crop yields. Laser leveling improves upon the traditional process by using a laser guidance system to flatten fields to higher precision. This makes it possible to reduce irrigation time and use roughly 25% less water in total.[1] Because farmers typically do not internalize the full scarcity value of the water they use, the social returns to investing in laser leveling are thought to be higher than the private returns, and so policies to encourage adoption may be appropriate.

Within this context, our study uses survey data to identify factors that are positively associated with laser leveler adoption and those that tend to constrain it. Among other factors, we consider whether social networks play a role in adoption. We also attempt to quantify the private and social returns to laser leveling, both of which appear to be substantial, and discuss whether our results can shed any light on appropriate policy interventions.

While water scarcity is a growing concern worldwide, it is worth noting that it poses a particularly acute problem for the area we study. India is the largest user of groundwater in the world. With more than 60% of Indian agriculture sustained by groundwater irrigation, and 80% of the 743 million people who live in rural areas relying on it to meet domestic water needs, groundwater is a vital resource for food and water security in the country [35].

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[1] We review the agronomic evidence on benefits of laser leveling in Section 3.

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Unfortunately, current patterns of groundwater use are not sustainable. Water tables are falling rapidly, in large part because widespread subsidies prevent many users from bearing the full cost of the water they consume. According to the central groundwater board, 15% of the administrative blocks are over-exploited (more water is extracted than is replenished each year) and the number of over-exploited blocks is growing at a rate of 5.5% per annum. Moreover, the northwestern breadbasket states of Punjab and Haryana, whose grain is critical for India's self-sufficiency in food production, are experiencing the most significant declines [35]. If these trends continue, some estimates suggest that national food production could fall by around 25% by 2025 [36] and that India could lose self-sufficiency in food by 2050 [33].

Within agriculture, farmers have limited incentives to conserve irrigation water because they do not have to pay for the groundwater they extract and the electricity needed to pump water to the surface is typically highly subsidized.[2] While removing these subsidies and pricing water closer to its true social cost would be the natural policy suggestion from the standpoint of conservation, political realities make this extremely unlikely in the near-term future. Even if it were politically feasible, pricing irrigation groundwater would require a strategy for metering and enforcing payment at the roughly 27 million private wells nationwide [37], which could be prohibitively costly.

As an alternative to pricing, several state governments have tried to address groundwater depletion with new regulations or supply-side interventions such as mandatory harvesting of rain water. However, very limited attention has been paid to policies that attempt to scale up the adoption of water-saving technologies and practices like laser leveling, for which extensive monitoring and enforcement is not required. Given the likelihood that water will remain (in social terms) under-priced for some time, policy interventions to encourage practices like laser leveling may be a logical second-best measure.

The state of Punjab is an appealing area in which to study laser leveler use, not just because the state's water issues are particularly severe and affect food security in the rest of the country, but also because it has a network of village cooperative societies that provide a natural point of contact with local farmers. These cooperatives offer a number of services to farmers including equipment rental, and in recent years many cooperatives have acquired laser levelers that are available to farmers for custom hire.

Our survey was carried out in a sample of villages where farmers had access to laser leveling services through nearby cooperatives. The overarching goal was to shed light on farmers' decisions about whether to adopt this new technology. One key question is whether they *should* adopt – that is, notwithstanding any positive externalities, do the *private* returns make laser leveling a worthwhile investment for farmers? Our results suggest that they should – conservative estimates indicate that a typical farmer will recoup several times the cost of his investment in the first year alone (see Sections 5.6 and 5.7). While many of the farmers we survey have tried laser leveling, many others have not. Given the apparently large private return on investment, it is natural to investigate how adopters and non-adopters differ, and in particular, what impediments the latter might face to adoption.

Many impediments to adoption can be categorized in very broad terms as financial or informational. The former is shorthand for a medley of reasons that a farmer's personal cost–benefit calculus might make investment unattractive or impractical (such as liquidity constraints, for example). By informational impediments, we simply mean all of the reasons that a farmer might not know, or fail to be convinced, that investing really is worthwhile. Because a farmer's information and beliefs may be closely related to who he talks to, we carried out a comprehensive census of social network ties in a subset of the surveyed villages, as well as asking farmers about their connections to more official sources of agricultural information.

We find that both financial constraints and poor information act as barriers to the use of laser levelers by farmers in Punjab. Furthermore, both of these barriers tend to create a divide between farmers with larger landholdings and smaller farmers. The median non-adopter would be willing to try laser leveling if the cost were 20% lower; this discount represents less than one-tenth of our estimated social value of water savings, indicating that subsidies could be a cost-effective way to promote adoption.

On the information side, better-connected farmers are likelier to have tried laser leveling. This is true both for institutional connections (to government officials or the cooperative society) and also for informal social ties: a farmer is significantly more likely to adopt when his social contacts have already done so. Our survey cannot identify the precise channels through which social ties and adoption are related – further research on this point would be useful. However, the results suggest that policy interventions intended to leverage a “social multiplier” effect linking peers' adoption decisions could be a fruitful avenue to explore.

The rest of the paper is organized as follows. Section 2 situates our study within the literature, with a focus on past work on laser leveling in particular, and adoption of agricultural technology in developing countries more generally. Section 3 describes the technology of laser leveling in more detail and discusses the institutional environment surrounding its use in Punjab. Section 4 describes the design of our study, and Section 5 presents the results. In light of these results, Section 6 concludes with suggestions about policy options and directions for future research.

2. Literature

Our study complements several strands of the literature on technology adoption in agriculture. Feder et al. [9] give an early and comprehensive survey of factors that

[2] Within Punjab, the electricity tariffs for agricultural pumping involve a monthly fee based on a farmer's installed pumps (sometimes waived), but no payment based on usage. Thus the effective marginal cost is zero. Institutional details are discussed further in Section 3.

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