Power of Agency: Evidence from Community Driven Agricultural Transformation *

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1 Introduction

1.1 Abstract

Participatory development emphasizes community involvement in the planning and implementation of public goods to improve development outcomes. Given the mixed evidence of its success, we assess the value of community involvement by randomly allocating control to the community over the location and construction of a local public good (i.e., field irrigation canals). We plan to compare a participatory "bottom-up" approach to the standard "top-down" one by measuring social welfare outcomes such as the allocation of water for irrigation, agricultural outcomes and the ongoing maintenance of canals.

1.2 Motivation

"Participatory" development is based on the principle that community involvement in managing investment funds produces better outcomes than when they are managed by a centralized authority (Chambers, 1984). Proponents argue that participation empowers the community, improves the monitoring of funds, and strengthens the capacity for collective action. On the other hand, collective action and coordination failures among community members may lead to elite capture or inaction. Over the past decade, participatory development has become a central strategy for governments and international agencies. The World Bank alone currently supports more than 199 active participatory projects in 78 countries valued at USD 19.7 billion. Unfortunately, evidence on the effectiveness of this approach is scarce (Mansuri and Rao, 2004, 2011 Wong, 2012 and more recently Casey, 2018 and Wong and Guggenheim, 2018).

In this paper, we present experimental evidence of the effects of community involvement in the choice and/or the provision of local infrastructure projects - field irrigation canals - on the quality of construction, ongoing maintenance, satisfaction and community cohesiveness, and aggregate welfare in a context where preferences over infrastructure are well defined and can be elicited ex-ante.

Our study examines the construction of field canals linking local irrigation tanks to farmer plots in the command area of the tank (ayacut) . A tank is a small reservoir that captures surface water runoff when it rains. It serves the surface irrigation needs of farmers at a very local (village) level. Typically, tank structures are under the purview of government agencies but the construction and maintenance of field canals is left to the farmers. Canal construction

thus requires collective action and is particularly relevant in a context where many tanks have recently been repaired.[1] According to data from a sample of 300 tanks that were surveyed to develop this project, only about half had a functioning irrigation canal.

2 Experiment

2.1 Institutional Review Board

This study has been approved by the University of Chicago IRB No. IRB20-1128, with reliance agreements between University of Chicago, University of California Berkeley, University of California San Diego, and Individual Researcher agreement with Dr. Xavier Gine, the World Bank. Additionally, the study has also been approved by the Institute for Financial Management and Research (IFMR), Chennai, India.

2.2 Research Question

In the context of local commons, such as irrigation infrastructure, we ask two interrelated questions:

1. Does community involvement in both the choice of location and the construction of irrigation field canals lead to higher quality, maintenance, overall satisfaction, and aggregate welfare?
2. Once the costs of participation are taken into account, is there an optimal level of community involvement in public good provision?

2.3 Sample

Our sampling frame is the set of villages with functioning surface irrigation tanks in Telangana, India, but with field irrigation canals in need of repair. We use the universe of villages with functioning tanks from the Government of Telangana Tank Census to identify our sampling frame based on the following rules:

1. Tank that serves only one village (i.e., we exclude large tanks that serve more than one village downstream);
2. Tanks with functioning sluice gates;

[1] The collective action problem can be described as follows: Suppose a farmer makes the necessary investments in time and money required to construct a canal going through their plot but farmers upstream do not make comparable investments. Then the payoff to the investment made in improved water supply from the tank is negligible. Similarly, if all farmers upstream undertake the construction of the canal on their plots but the farmer decides not to do so, then the farmer will benefit from increased water supply from the tank at no personal cost. As a result, a rational individual deciding on their own will choose not to invest unless everyone cooperates.

3. Tanks where agricultural cultivation in both wet and dry seasons (Kharif and Rabi);

4. Tanks where irrigation canals are in serious disrepair or completely absent.

This yields a set of 300 villages/ayacuts across 15 districts in Telangana, that have surface irrigation tanks with either no canals or with canals in disrepair. Sixty villages had repaired their irrigation canals by the time we first visited the village and we excluded these from the study. We use the remaining 240 villages as our sample for the experiment.

We are interested in outcomes both at the ayacut-level (for e.g., the extent of coordination, quality of construction and maintenance, etc.) as well as plot-level (for e.g., the extent of access to surface irrigation at various locations in the ayacut, use of groundwater sources, crop production outcomes, etc.), therefore, both these form the key units of analyses.[2] Our sampling frame of plots is the universe of all plots downstream a tank within its ayacut. We conduct a complete listing of all plots in our study sample of villages from which we draw our sample of plots for data collection. We identify farmer-cultivators associated with each plot in the census, who then form the respondents for the plot sample.

2.4 Research Design

We conduct a randomized control trial (RCT) where we vary (a) whether the location of the canal was chosen by the community through secret ballot voting or by a central agency and (b) whether the construction of the canal was undertaken by the community or a third party.

2.5 Description of treatments

The intervention follows a 2-factorial stratified RCT varying how the location of the canal is chosen (choice-arm), crossed with how it is constructed (implementation-arm). All treatments are randomized at the tank-ayacut level and since we only include one tank in the study per village, treatments are also randomized at the village level. We stratify the randomization by district since our sample of villages span multiple districts with different agronomic conditions.

In addition to the 2x2 matrix implied by the two-part randomization, the design also includes a pure control group (C). Farmers in this control group receive the cash equivalent of the per capita cost of the total project but the choice of location or construction are not facilitated.

[2]The specific outcome measures are discussed in detail in the Data subsection below.

Choice(↓)/Implementation(→)	Top-down construction	Bottom-up construction
No Community Choice	T4 (NN): Location chosen by a central agency with canal construction carried out by an external contractor identified by the same agency.	T3 (NC): Location chosen by a central agency with canal construction carried out by local village community.
Secret Ballot	T2 (CN): Location chosen by local village community via a secret ballot (simple majority) with canal construction carried out by an external contractor identified by a central agency.	T1 (CC): Location chosen by local village community via a secret ballot (simple majority) with canal construction also carried out by local village community.

In each study village, we worked with a group of key informants to identify potential locations for 2-3 canals that were feasible for construction. Subsequently during the baseline survey of the sample plots, we asked respondents (farmer cultivators of the sampled plots) to state how much they would be willing to contribute for the construction of each of these canals previously identified by the key informants. The canal chosen under "No Community Choice" is the one with highest aggregate valuation from this private elicitation exercise. In the "Secret Ballot" treatment, we gave each farmer cultivator a ballot card with the location of the 2-3 feasible canals identified earlier, covering all those farmers associated with the universe of plots within the ayacut. We told these farmers to select one location of their choice (one farmer-one vote) by indicating so on the card and to deposit the card in a box kept at a prominent place before the end of 3 days from the time of our communication.[3]

We expect that in a majority of cases, the most preferred canal from the secret ballot should coincide with that obtained from the elicitation exercise. However, the most voted canal could differ from the most valued one, for example, if there was vote-buying, or elite pressure, or some form of coordination between farmers. We will verify the extent to which both these methods align, so that the canals thus selected will be a valid counterfactual. In cases where they differ, we plan to execute an analysis that explores the determinants of these disagreements.

[3]Due to COVID19 pandemic, we could not conduct a polling day in the village that would have led to queuing up of farmers to cast their votes.

2.6 Data

We plan to collect data using primary surveys administered to farmer-cultivator of the sample plots and investigator-led random audits with our field implementation partner J-PAL South Asia at IFMR.

Data Collection

We plan to collect the following self-reported (survey) instruments: (a) a set of feasible locations for canal construction within the ayacut from key informants, (b) a listing census of ayacut plots and its owners, (c) a baseline survey containing private elicitation of preferences over the feasible set of canal locations under (a), (d) the number of valid ballots cast for each canal in "Secret Ballot" villages, (e) follow-up survey data collected via phone surveys on various satisfaction and cost of participation measures during and post intervention, and (f) a comprehensive endline survey containing detailed agricultural production measures for all cultivation seasons during the year following the intervention, including wet (Kharif) as well as dry (Rabi). Finally, we plan to measure the quality of canal construction including the dimensions of constructed canal relative to the initial specification through random site visits and measurements by trained enumerators.

We plan to collect several primary and secondary outcomes as well as intermediate outcomes related to the construction of the canals.

Intermediate Outcome: Tank-Level Community Effort

These include the first-stage measures of type of the public good (canal), including: (a) whether a canal is constructed, (b) status, including deviation, of the constructed canal relative to the initial proposed design (length, width, depth, geotrace polyline) at multiple time periods post construction, (c) duration of construction, (d) local labor hours used for construction, (e) whether machinery is used to dig the canal, and (f) total realized cost of construction (including deviations from the budgeted cost). We will use a summary index measure combining all the above components of the first stage, in addition to examining these separately.

Intermediate Outcome: Farmer-Level Coordination

These include: (a) complementary investments by ayacut farmers (effort cost incurred during construction and maintenance including voluntary labor contribution, monitoring costs, cash and material support) as a measure of local community effort, (b) farmer satisfaction with participating in decision-making and construction of the canal, (c) measures of trust between farmers with plots in different locations within the ayacut, (d) farmer-level voting outcomes

(whether aligned with private elicitation, and whether voting influenced by others in the village), and (e) cost of participation in voting (time cost involved in voting) and implementation (hours worked beyond compensation).

Primary Outcome - Plot-Level Access to Irrigation

These include: (a) surface water availability at sample plots in various locations (head, middle, tail) within the ayacut (extensive margin - whether receives, as well as intensive margin - number of days), and (b) extent of water-related conflicts (number of conflicts, number of farmers involved in the conflict).

Primary Outcome - Plot-Level Production

We will examine total production (quantity produced) and total yields (qty per acre), in aggregate as well as on average across a random sample of ayacut farmers. Usually, farmers in the ayacut grow paddy since paddy requires irrigation. We will verify the crop grown so that the production outcomes are specific to crop grown.

An important outcome relating to our research design is the cost per unit increase in aggregate agricultural production output - cost per unit increase in quantity of output, cost per unit increase in yield.

Secondary Outcomes - Plot-Level Climate Change Mitigation and Adaptation

Two important consequences of helping overcome coordination and collective action failures in the context of irrigation management are climate change mitigation and adaptation. First, reliance on surface water for irrigation minimizes extraction of groundwater resources, addressing climate change mitigation. We measure the extent of groundwater use at the sample plot-level, both on the extensive margin (number of plots with functioning well) as well as on the intensive margin (number of days). Second, increase in access to (whether sample plot has access to tank water through field irrigation canals) and the extent of (number of days) surface irrigation through rainwater harvested in the tanks addresses climate change adaptation to increased drought conditions (specifically, aiding cultivation during the dry season or wet seasons with low rainfall).

Secondary Outcomes - Plot-Level Production Cost and Revenue

These include plot-level measures of cost and revenue from agricultural production: (a) sales revenue by crop-season, and (b) expenditure by crop-season and expense-type (i.e. labor, capital, fertilizers and input). Since we don't expect prices to change due to our treatment, these are secondary outcome measures.

Secondary Outcomes - Village-Level Agricultural Wages by Gender

Since paddy is typically the main irrigated crop cultivated within the ayacut, the gender dynamics are particularly important to study given the substantial role played by female agricultural labor at various stages of paddy life-cycle. We collect detailed agriculture wage data, by gender and agricultural task.

2.7 Sample Size and Power

Two hundred villages with 30 farmers/plots per (village-level) ayacut generates statistical power at 80 percent under significance level at 5 percent to observe even a modest treatment effect using access to surface irrigation as a key outcome. We simulated statistical power using the estimated empirical effect sizes from a pilot we conducted in similar villages.[4] We include more villages than the required sample size allows us to account for any compliance or take-up issues at the time of intervention. Therefore we sample 20% more villages/tanks than required, generating a study sample of 240 villages.

We draw a stratified random sample of upto 30 plots per ayacut, stratified by plot location (i.e. head, middle, and tail), from a complete census listing of all plots in the ayacut that includes the name of the cultivating farmer associated with each plot, generating $\approx$ 7200 sample plots across 240 study villages.

We use stratified sampling of plots due to the differences in outcomes and bargaining options faced by farmers based on the location of their plot. We attempt to draw equal number of plots from head, middle, and tail portions of the ayacut. In practice, however, some ayacuts have less than 30 plots and/or some location strata with less than 10 plots. In such cases, we sample the universe of plots within the ayacut/strata. Finally, a small fraction of farmers cultivate multiple plots within the ayacut whereas a majority of farmers cultivate only one plot. Since we sample at the plot-level, we interview the same farmer if more than one of their plots are sampled.

Plot-level Sample Expansion:

Post-construction of the irrigation canal, we will additionally sample all plots along the irrigation canal not covered by our baseline sample of plots, including along the canal that could have been constructed (as per elicitation data) in the control group.

2.8 Empirical Specifications

The empirical specification (long-form) is as follows:

[4]We note that during the pilot we had 100% compliance. All treated villages constructed the canal while none of the control villages did.

$$Y_{ivdt} = \delta_d + \delta_t + \sum_{j=1}^{4} \beta_j T(vt)_j + \mathbf{X}_{ivdt}\Gamma + \epsilon_{ivdt} \quad (1)$$

where d indexes the district, v indexes the ayacut in our sample, i indexes sample farmer (some specifications are at the ayacut-level itself), and t indexes data collection round. The leave out group is C_v, the baseline pure control. All the treated variables switch on after the baseline round. Standard errors will be clustered at the level of treatment assignment, i.e. at the ayacut level (Abadie, et al., 2017).

Table 1: Definition of dummies

	Channel Construction	Community involvement in ... Location	Implementation	Com. involvement in both
$T1$	Yes	Yes	Yes	Yes
$T2$	Yes	Yes	No	No
$T3$	Yes	No	Yes	No
$T4$	Yes	No	No	No
C	No	No	No	No
Test	$\beta_4 = 0$	$\beta_2 = \beta_4$	$\beta_3 = \beta_4$	$\beta_1 = \beta_2, \beta_1 = \beta_3, \beta_1 = \beta_4$

We will also use the following specification using interaction terms between location and implementation:

$$\begin{aligned} Y_{ivdt} &= \phi_d + \phi_t + \gamma_1 \text{Ballot}_{vdt} \text{ x Bottom-up}_{vdt} + \gamma_2 \text{Ballot}_{vdt} + \gamma_3 \text{Bottom-up Construction}_{vdt} \\ &+ \gamma_4 \text{No Choice Top-down Construction}_{vdt} + \mathbf{X}_{ivdt}\Psi + \xi_{ivdt} \end{aligned} \quad (2)$$

Table 1 maps the original treatment dummies to the ones in the above specification. The leave-out group in this specification is also the pure control (cash-only) group. Standard errors will also be clustered at the level of treatment assignment, i.e. at the ayacut level (Abadie, et al., 2017).

We will account for multiple outcomes using two approaches: First, we will generate single summary measure (index) for each class of outcome in standardized units, either using Principal Component Analysis (Kling, Liebman, Katz, 2007) or standarding the variables in the index and then adding them.

Second, we will test each family of measures (under different groups presented under the data section - ayacut-level measures, farmer-level measures, and plot-level measures) jointly using family-wise error rate (FWER) corrections. We plan to also address the concern for multi-

ple hypotheses using rich theoretical framework linking our intervention design with measures of collective action and production outcomes.

Predetermined Variables as Controls

We will use the following variables for balance check after random assignment: tank area; tank storage capacity; ayacut area; history of past repairs; number of plots in ayacut; number of cultivating farmers in ayacut; number of feasible locations of irrigation canals within ayacut; value of highest elicited canal; farmer (cultivator)-level demographics - age, gender, jati, total landholding, total irrigated land, sample plot-area, presence of borewell on plot.

First, we will account for baseline measures that remain unbalanced after the random assignment. Additionally, we control for include the following: (a) deviation between the canal selected from secret ballot exercise match the highest-valued canal from the private elicitation exercise at the aggregate ayacut level, (b) demographic details of persons in-charge of canal construction under bottom-up construction, (c) a summary index for baseline measures of collective action - joint sale, joint input purchase, joint investments (e.g. transportation to markets), and baseline-level of trust between farmers.

Second, in order to discipline our selection of control variables, we will implement the post-double-selection method of Belloni et al. (2014) to identify the subset of the control variables from above.

We will also report the equivalent ANCOVA specification to Equation 1 and Equation 2, controlling for baseline measures on the RHS.

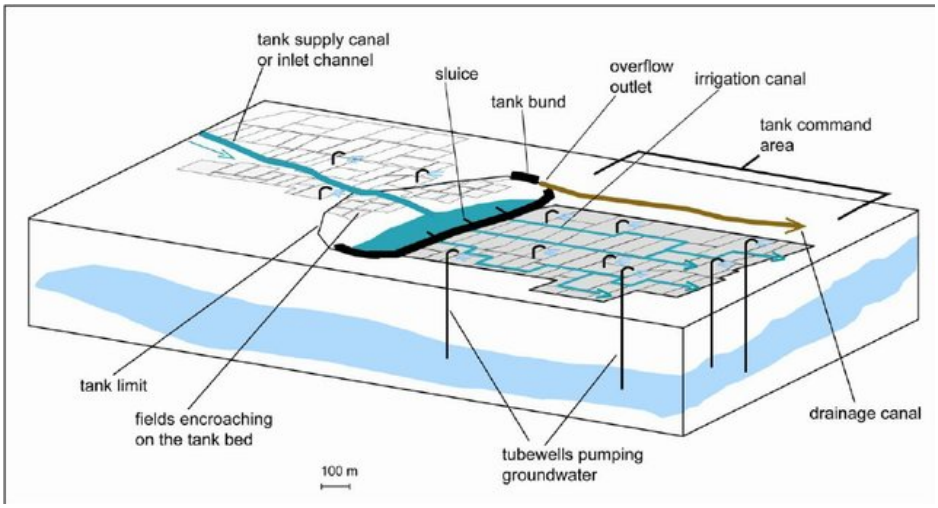
Heterogeneity

We will examine heterogeneity by (a) by plot location, (b) by presence of groundwater source on plot, (c) extent of disagreement between ballot outcome and highest aggregate WTP, and (d) extent of caste/jati-level fractionalization among ayacut farmers, to examine the extent of coordination between individual farmers in the ayacut across the various experimental arms. This heterogeneity analysis directly speaks to the internal collective action problem within ayacut arising out of differential costs and benefits accruing to plots based on its location within the ayacut and access to alternate sources of irrigation.

In addition to specifying the subgroups for heterogeneity analysis as per a theory of collective action as above, we will follow a disciplined approach for any additional heterogeneity following Chernozhukov, et al, 2020.[5]

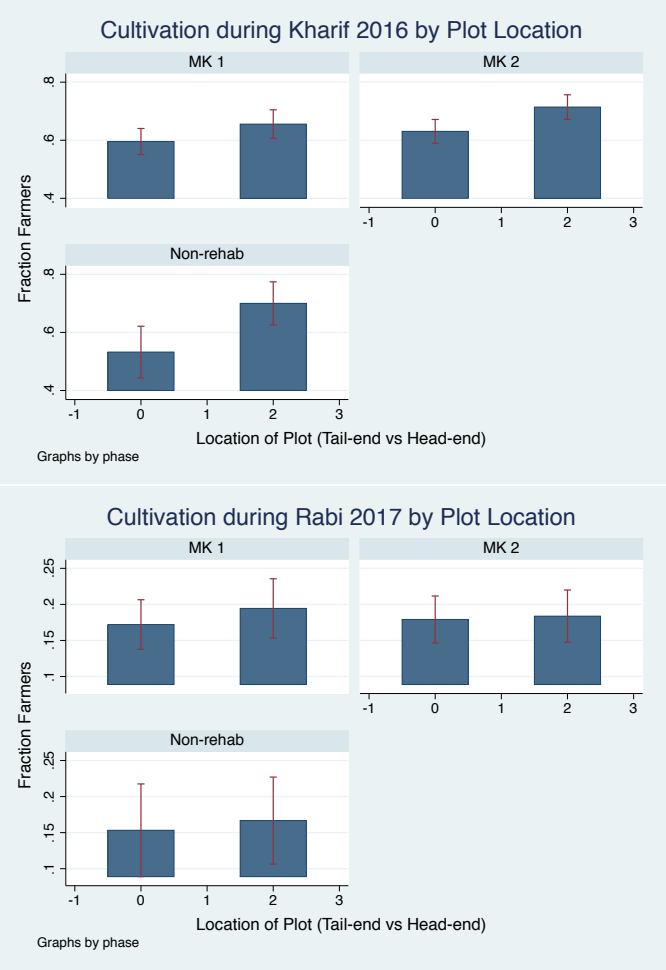
[5]Additionally, we will also explore selecting subgroups for heterogeneity using causal forest approach as in Athey and Imbens (2016) and Wager and Athey (2017). However, since our sample size is limited due to budget constraints, we will consider whether any of the approaches is adequately powered for the analysis without overfitting.

Figures



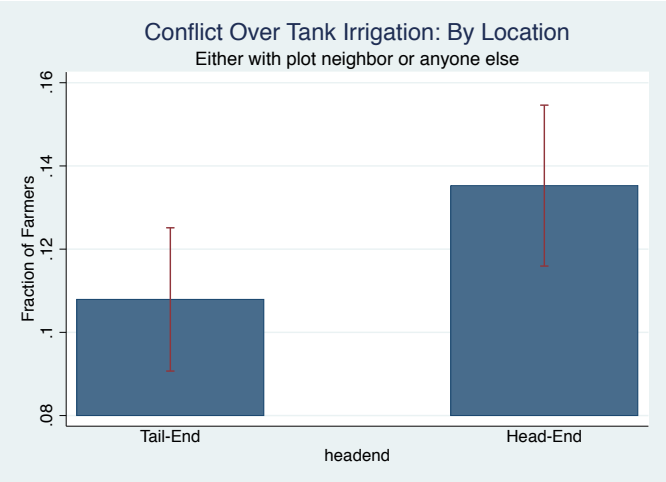
Source: Mathevet, et al, 2020

Figure 1: Structure of Minor Irrigation Tank



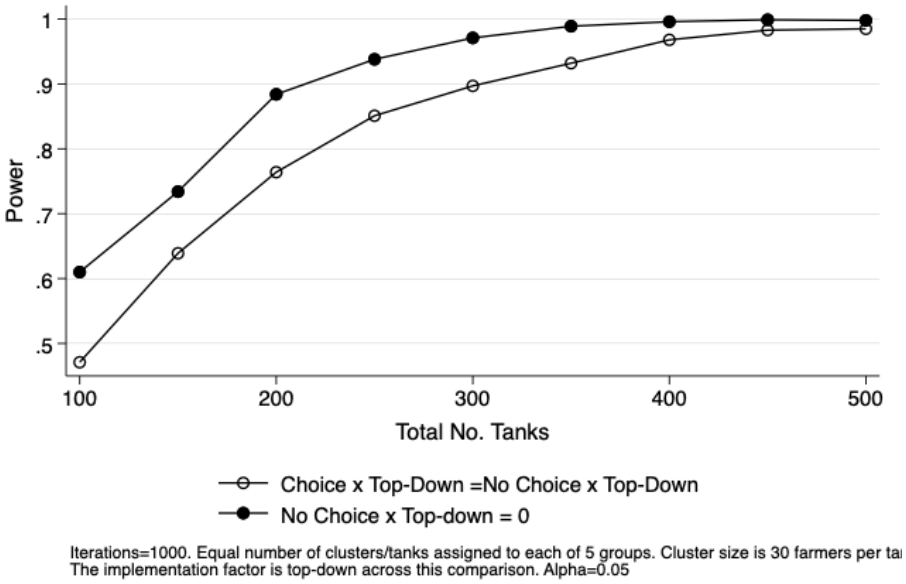
Notes: Data from a related study. 0 Tailend 1 Headend. MK1 - tank rehabilitated, MK2 - partial tank rehabilitated, Non-rehab - status quo

Figure 2: Cultivation by plot location



Source: Related Study Data

Figure 3: Water-related conflicts



Source: Pilot Exercise

Figure 4: Power Simulations

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Appendix

A Experimental Protocol

The experimental protocol involves the following steps:

Step 1: We obtain necessary permissions for the study from the village representative, the village official in-charge of revenue and water management (Village Revenue Assistant or the VRA), and other key members of the farmer community, who are typically involved in village irrigation management. In this stage, we sketch out a schematic map of the tank and ayacut and identify three or four possible locations for different field canal connecting the mouth of the tank where the sluice gate is to different downstream locations in the ayacut.

Step 2: We conduct a detailed baseline survey of farms/plots within the ayacut by interviewing the cultivator. This survey includes basic demographic background details of the farmer, plot level characteristics such as soil type, location relative to the tank, whether there is a functioning well, main irrigation sources, quantity of water available for irrigation by season, value per acre, and agricultural investment and yield. We also ask about water conflicts with other farmers in the ayacut and elicit the farmers' valuation of the possible locations identified by a village official in Step 1, using an incentive compatible elicitation method.

Step 3: We announce whether the choice of the location of the field canal to be constructed will be made by the community via secret ballot among the three or four possible locations identified by the village official or by a third party (mimicking a government agency or a social planner).

Step 4: We vary whether the field canal selected is constructed by the community or by a third-party (local contractor directly hired by the research team). When the community is involved in the construction of the canal, funds are given to a local village contact that will organize construction. Since farmers control the construction of the canal, they may decide to extend the length of the canal, add additional branching canal, or make other modifications on their own. In contrast, under the third-party implementation approach funds are given directly to a local contractor. In both cases, the funds allocated per village by the research team amount to Rs. 10,000 (140 USD) everywhere.