Community Participation in Decision-Making Evidence from an experiment in safe drinking water provision in Bangladesh

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Abstract

Benefits of community involvement in providing the community's own public services can be elusive despite the broad endorsement that the practice receives. This study contributes to understanding how re-allocating decision-making authority from the implementing agency to intended beneficiaries influences access to a service, in our case safe drinking water. The experiment randomly allocates villages in Bangladesh to a top down intervention and two different interventions that delegate decision-making, giving the treated communities the authority to determine outcomes. In one delegated intervention, the community organizes itself to make decisions (community participation). The second seeks to limit elite control by requiring that the community make all decisions in a meeting, which is subject to participation requirements, and that all decisions be unanimous (regulated community participation). All three interventions improve access to safe drinking water, but delegating decision making improves access relative to the top down approach only when the intervention controls the influence of elites. The regulated community approach increases access 67% more than do the other two approaches. The top down approach uses local information less effectively, and installs fewer sources than do the two participatory approaches. Under the community approach, elite control constrains access to safe water sources. The regulated community approach expands and diversifies the group of people who participate in decision-making relative to the other two approaches, and it results in bargaining that limits the influence of elites.

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1 Introduction

Engaging intended beneficiaries in the provision of public services is an accepted best practice (e.g. World Bank, 2003). However, the practice of community participation in provision, similarly to decentralization of governance more broadly, is not straightforward. Evidence points to cases in which community participation fails to improve or even worsens outcomes as well as to cases in which there are benefits, as is the case with decentralization. In order to guide decisions about how and when to involve communities in providing public services, we need more specific evidence about who benefits from what type of community participation and who does not, under what conditions, and why. This study contributes evidence in the context of access to safe drinking water. We focus on community participation that delegates authority to make decisions about project outputs to community members.

Access to public services remains inadequate throughout the developing world, slowing growth (World Bank, 2003). Poor access to safe drinking water takes a toll on health, especially among those who are more likely to be malnourished and have limited access to health care (World Health Organization, 2001, 2016). Episodes of poor health contribute to low productivity and poverty traps. At the same time, the water delivery infrastructure in places in which access is poor tends to be very decentralized, often consisting of communal wells. The installation and management of decentralized infrastructure may allow community input at relatively low cost to those who participate and may benefit from such input because of the need for local knowledge, potentially providing fertile ground for observing the benefits of community participation.

This study uses a randomized control trial to investigate two hypotheses. The first is the very general notion that community participation, as a vehicle for delegating decision making authority in provision of services, improves project outcomes. The experiment compares outcomes of decisions carried out in a conventional, centralized approach to outcomes that result when community members have the authority to make decisions. In the centralized approach, a non-government, non-profit organization (NGO) makes decisions regarding the installation of safe water sources, replicating a benevolent version of a top-down approach, in which the implementing organization makes decisions in the best interest of the community. In other treatment villages, community members have the authority to make several decisions.

The second hypothesis is that the outcomes achieved with community participation depend on whether or not the approach to engaging the community limits the power of the community elites. The role of elites is only one, but a prominent one, of a number of characteristics of the participating communities and the decision environment that could affect how community participation influences outcomes. We randomly assign two different approaches to community participation to villages. In one approach, which we call community participation, the community organizes itself to make decisions. In the second approach, regulated community participation, NGO staff require that all decisions be unanimous and that they be made in a meeting, which is subject to participation requirements by various groups within the community including traditionally excluded groups: women and low income residents.

The test of the first hypothesis contributes to the small literature that uses experimental evidence to understand the difference that community participation makes for outcomes.[1] Overall the studies have reported mixed results. The contribution in this study is twofold. First, we compare outcomes that result when the same decisions are made in a top-down way by the agency that implements the intervention and when these decisions are made by community members. Second, the community participation treatments give community members the authority to determine outputs, reducing the concern that community participation will not be effective because the communities do not believe that their actions will affect outcomes. The most closely related papers are Alatas, Banerjee, Hanna, Olken, and Tobias (2012) and Olken (2007).

Alatas et al. (2012) compare a centralized and two participatory approaches to targeting the poor in communities. The participatory approaches give communities control over outcomes, as in our study. Also, as in our study, one of the participatory approaches accepts targeting selected by the community while the second seeks to limit the power of elites by combining elements of participation and the top down approach. Olken (2007) compares the effectiveness of government audits to monitoring carried out by community members in reducing corruption that affects building of roads. Community members and the government in Olken (2007) differ in their abilities to turn decisions about monitoring into less corrupt outcomes.

Several other papers report results of experiments that investigate interventions based on community participation, but these studies do not compare outcomes when that intervention is carried out with community participation and when it is carried out without community participation, and they principally induce more or better-informed participation in a pre-existing process.[2] Differences in whether or not more participation is effective may be explained by differences in the ability participants have to influence outcomes (Banerjee & Duflo, 2008). Other related studies compare different ways in which the community can participate in selecting development projects. For example Olken (2010) finds that direct democracy results in more satisfaction with the choice

[1] Most of the evidence that community participation improves outcomes is either descriptive or based on data from communities in which either the community or the implementing organization selects the participatory mode of interaction. Mansuri and Rao (2013) provide a review of this evidence. In such cases, influence of participation on outcomes cannot be distinguished from the influence of other characteristics that led to the selection of the participatory engagement.

[2] Banerjee, Banerji, Duflo, Glennerster, and Khemani (2010) report limits on community members' involvement in monitoring school outcomes when the intervention provides information about possible courses of action or a way of measuring educational outcomes. An intervention that engages community members in tutoring students does improve outcomes. Duflo, Dupas, and Kremer (2015), Pandey, Goyal, and Sundararaman (2009) and Pradhan et al. (2014) show positive effects of certain types of community engagements in schools. Björkman and Svensson (2009) find positive impacts of increased community participation in monitoring health delivery on use of health services and on some health outcomes. Sheely (2015) finds no effect of inducing more participation in a nominally participatory government process while Beuermann and Amelina (2014) find that training and consulting in participatory budgeting improve outcomes in municipalities that are required to conduct participatory budgeting but only in ones that had administratively mature local governments and had been decentralized for some time.

of projects than representative-based democracy, but not in different choices.[3]

A number of papers discuss the problem that elites can capture the benefits of a project when the community participates (e.g. Rao & Ibáñez, 2005; Fritzen, 2007; Olken, 2007; Banerjee et al., 2010; Alatas et al., 2013). Elite capture may reduce the average project benefit relative to what could be achieved under a top down approach, and/or may redistribute benefits away from those who need the project the most. On the other hand, as Mansuri and Rao (2013) point out, elites sometimes use their status, resources, and human capital accumulated through education to improve project outcomes

We find that all three interventions improve the main outcome of interest, which is access to safe drinking water, but access increases much more in villages that were assigned to the regulated community participation mode of decision making than in villages that were assigned to the other two treatments. Access to safe drinking water increases by 14 percentage points in villages that used the top down approach, 15 percentage points under the community participation approach, and 26 percentage points, or 67% more than under the other two treatments, in villages which were assigned to the regulated community participation approach. We find larger benefits of community participation than do either Alatas et al. (2012) or Olken (2007). Alatas et al. (2012) find that both participatory approaches are somewhat worse at targeting those whose incomes fall below a pre-determined poverty line but not sufficiently to affect outcomes of projects. The reason is partly that communities apply a different conception of poverty. In Olken (2007), community monitoring, even with constrained elite influence, has a more limited effect on corruption than does the top down audit approach,[4] whereas in our study access to safe drinking water increases much more in regulated community participation villages than in the top-down villages. Olken also finds that the top down approach performs better than does community participation that does not limit the influence of elites, while the top down and the community participation approaches increase access to safe drinking water by the same amount in our study.

Delegation of decision making authority to communities can influence project outcomes, positively or negatively, through several mechanisms: (1) by determining what information is available during project choice, planning, and implementation; (2) by allocating the ability to influence decisions between the organization that is implementing the project and various members of the community; and (3) by influencing the level of acceptance of the process through which the project

[3]Beath, Christia, and Enikolopov (2016) replicates the findings in Olken (2010) in a different context and additionally shows that broader participation reduces elite influence over decisions. Hinnerich and Pettersson-Lidbom (2014) compare direct and representative democracy in a quasi-experimental historical setting, finding that direct democracy is more susceptible to elite capture. Another related group of experimental studies examine the impact of a participatory or 'community-driven' development project compared to a control group which does not receive any intervention e.g. Fearon, Humphreys, and Weinstein (2009, 2011), Humphreys, de la Sierra, and van der Windt (2012), Casey, Glennerster, and Miguel (2012), Avdeenko and Gilligan (2014). Other related experiments include varying requirements for participation of women (Humphreys et al., 2012; Casey et al., 2012; Chattopadhyay & Duflo, 2004); and an evaluation of dispute resolution training to improve informal institutions (Blattman, Hartman, & Blair, 2014).

[4]In Olken (2007) community monitoring only reduces missing expenditures on labor but not on materials and only when comment forms designed to elicit information are distributed through schools but not through other village institutions.

was chosen, designed, implemented, and monitored; and trust in the implementing organization on the part of the community. In our experiment, evidence suggests that the first two mechanisms help to explain the differences between the performance of the two participatory approaches to decision making and the top down approach, but the third mechanism does not.[5] Not surprisingly, the second mechanism accounts for the difference between the two approaches to community participation.

The top down approach uses local information less effectively than do the two participatory approaches.[6] Despite a significant effort by NGO staff to collect information from the community, the top down approach places water sources in locations that reduce the average walking distance to the nearest safe source of water less than do the two participatory approaches to decision making. The project staff located water sources on public land whenever possible in order to reduce the capture of the installed sources by elites. However, public land is scarce in Bangladeshi villages. The attempt to balance control of elite influence with selecting convenient locations combined with only partial access to local information results in longer walking times. The regulated community participation approach demonstrates that the communities had more effective means of broadening access at their disposal than placing water sources on public land.

The difference in use of information and the top down control over locations of water sources combined to result in somewhat fewer sources of water installed under the top down approach than under the two participatory approaches. The relatively inconvenient locations may have reduced the communities' incentives to contribute the share of funding that the project required from all treated communities for each installed water source. Also, well-off village residents were interested in contributing the entire share of the cost of a water source and placing the source on their own land. The project staff made an effort to avoid outcomes in which one person was perceived to "own" the source, thereby weakening the motivation to contribute. The difference between the number of sources installed under the different approaches is not statistically significant but it contributes to reducing the improvement in access to safe water under the top down approach.

The outcomes of the two approaches to community participation differ mainly because elites appear to exert more control over decision making under the community participation approach than under the regulated approach. In regulated community participation villages, decision making and community contributions to funding the sources of water engage a more diverse group of community members than in the community participation process. Contributions of funding to a source of water lend legitimacy to using the source in view of village residents. Those who do not contribute express hesitation and discomfort about using the source. Significantly fewer residents contributed to funding the water sources in community participation villages than under the other two approaches, and in more community participation villages one influential person paid

[5]In contrast, Alatas et al. (2012) find that the two participatory approaches significantly improve community satisfaction with the outcomes of the targeting process. Also,Olken (2010) compared local public good projects implemented under either direct or representative democracy, and found that direct democracy resulted in much higher levels of project satisfaction and legitimacy, but had little measurable impact on decisions taken.

[6]The literature frequently notes that community participation incorporates local information more effectively than does the top down approach. See Mansuri and Rao (2013).

for each source of water. Therefore the perceived "right" to use the installed sources is more widely distributed in regulated participation villages.

In villages assigned to the community participation approach, a common dynamic was that a small group of influential persons or village leaders made decisions about safe water sources, while in villages assigned to the regulated approach the communities made decisions in large meetings attended by a diverse group of people. Participants in focus group discussions report active negotiations in the meetings in regulated participation villages, in which people worked hard to win support for their safe water source proposals. Those negotiations successfully secured broader access to the water sources, whether because the meeting participants agreed to installation only on land belonging to people whose reputations assured other residents that they would allow wide access, or because the individuals on whose land sources were installed entered into agreements that they would allow wide access, and the agreements proved to be at least partly enforceable.

An additional dynamic that contributed to the larger increase in access to safe drinking under the regulated community approach is an increase in access among community residents who are not using sources of water installed by the project. The regulated community approach is the only one that significantly increases access to safe water in this group. The most likely explanation is that village residents renegotiate the rights to use existing safe water sources in order to secure the agreement to install new sources from people who would not benefit from the new sources under the requirement that decisions be unanimous.

The participation and unanimity rules successfully ensured a broader representation of the village community in all stages of the project in the regulated participation villages and broader access to safe water. These rules are not necessarily the optimal approach to expanding access to safe water in the study communities.

The result that community participation did not improve access to safe drinking water any more or less than did the top down approach seems to have occurred by chance. There is no a priori reason why the drawbacks of the top down process should have affected access to safe drinking water with the same magnitude as did the restriction of access under the community participation process. In other contexts, one of these effects may be larger than the other.

The remainder of the paper is organized as follows. Section 2 presents a framework, which informs the analysis of community participation. In section 3, we describe the context in Bangladesh and the problem with access to safe drinking water that motivates the intervention. Section 4 describes the experiment, including the selection of study sites. We decribe the data collection process and the main impact variable in section 5. Section 6 reports and explains the number of safe water sources installed. We present the methodology for estimating the average impact of the intervention across all decision making processes on access to safe drinking water, and we report the results in section 7. Section 8 presents the methodology for estimating the differences in impacts across decision making processes and reports the results. Section 9 investigates the causal mechanisms that produce the results. Section 10 reports the results of robustness checks. Section 11 concludes.

2 A framework

In this section, we propose three mechanisms through which community participation may influence the outcomes of projects that provide public services. The focus is on community participation elicited by the organization that is implementing the project to provide public services, which for brevity we refer to as the NGO, though in general the organization could be the government, an international donor, or even a private, for profit entity.[7] This type of participation should be distinguished from participation that arises on the initiative of the community itself (or organic participation in Mansuri & Rao, 2013).

This study implements two types of community participation: (1) delegating decision making to the community, and (2) community contributions of funding to the project. We only analyze the impacts of delegating decision making. Each treatment village receives safe water sources only if the community contributes a pre-determined percentage of the costs. This community funding contribution is constant across all three approaches to decision making. Thus our top down approach includes an element of community participation in the form of the funding contribution. As we shall see in section 4, the funding contribution necessarily entails that the community has the authority to make certain decisions, for example how many sources of safe water the community will install. The allocation of authority to make these decisions, that follow from the funding requirement, is constant across all three approaches to decision making. When we speak about delegating decision making, we refer to allocating authority to make remaining project decisions differently across the three approaches to decision making.

Delegating decision making to the community can affect project outcomes through one of three causal mechanisms: (1) by determining what information is available during project choice, planning, and implementation; (2) by allocating the ability to influence decisions between the NGO and various members of the community; and (3) by influencing the level of acceptance of the process through which the project was chosen, designed, implemented, and monitored and trust in the implementing organization on the part of the community. Each of these mechanisms affects outcomes directly and indirectly, by interacting with the other mechanisms.

Delegating decision making authority to community members may help to integrate local information into the project.[8] The NGO can consult the community but the information obtained through consultation is not likely to be the same as the information that shapes decisions made by the community. Community members may understand the decisions and therefore the information that is needed better if they are responsible for making them. They may be motivated to think and search for information harder if they can control the resulting decision. Even with the same understanding and motivation, information is degraded in the process of communicating it to the NGO, and the decision making process may not allow for sufficiently frequent interaction to integrate local information in all stages of the decision. In addition the third mechanism may influence outcomes indirectly through delegation of decision making if trust in the NGO and therefore the willingness

[7] In the language of Mansuri and Rao (2013), we focus on induced participation.
[8] e.g. Mansuri and Rao (2013) note this potential benefit of community participation.

to use local information to help make decisions is different if the NGO is making decisions than if the community members have that authority. The available information and its effect on decisions will depend on who in the community has the decision making authority.

On the other hand, assigning decision making authority to community members changes the way in which the information that the NGO possesses influences decisions. For example, the NGO may have technical, scientific, and/or engineering expertise that the community may lack.[9] Again, the third mechanism may affect outcomes indirectly through the structure of decision making if the community's trust depends on allocation of decision making authority and trust influences whether or not the community uses technical information communicated by the NGO.

As we noted above, the NGO can integrate local information into project decisions by consulting community members. We do not regard consultation as community participation in projects, though opinions on this point may differ. In our top down approach, the NGO elicits a considerable amount of information from the community. As the results will show, such consultation does not result in the same integration of local information into project decisions as does decision making by the community.

The second mechanism for influencing decisions includes the explicit authority to make decisions, as well as the ability to influence decisions indirectly in ways other than by providing information. In our experiment, delegation gives the communities the authority to decide the type of water source and its location subject to the technical assessment that the location will yield water that is safe. The two different ways of delegating decision making authority, with and without rules regarding how the community must arrive at the decisions, in effect endow different members of the community with influence over the decisions. When the NGO requests that the community make decisions in any way in which the community chooses to do so, the request is likely to mobilize existing mechanisms for decision making in the community. Every community has an implicit or explicit organization for addressing community-wide matters and a set of relationships developed over a long period of interaction that establish a pattern of bargaining power and any norms that the community may observe. If the community has elites, these elites will most likely organize the decision making, unless the issue of safe drinking water mobilizes a coalition that challenges established authority.

On the other hand, the mode of delegation may disrupt established ways of making decisions. The condition that all decisions be made in an open meeting subject to minimum participation rules and that all decisions be unanimous may make it more difficult to obtain outcomes that favor elites. The project team monitored the restrictions placed on decision making, improving the chances that they would indeed alter the balance of influence. The team met with various subgroups within the community and motivated them to participate in the decision making process. All final decisions had to be made at a subsequent community meeting at which at least one team member was present. The team member ensured that the community observed the rules regarding attendance

[9] Khwaja (2004) notes that delegating technical project decisions to the community has an adverse effect on outcomes.

at the meeting and that all decisions that the community planned to implement were unanimous. Since team members later observed the installation of safe water sources, they were in the position to ensure that decisions made at the meeting were actually implemented.

The requirement that decisions be made unanimously at a meeting may alter outcomes in several ways. (1) Elites who are present at the meeting may be embarrassed to propose a self-serving allocation publicly in front of many community members. (2) The elites may understand that such proposals will not gain unanimous approval. (3) The elites may make proposals that they selfishly prefer and these proposals may not be approved by some. (4) The presence of NGO staff may dissuade elites from making self-serving proposals and may give other attendees the courage to withhold approval. The final allocation will still be influenced by the preferences of the elites, but will benefit a larger number of community members than the elites may have liked. Even in more egalitarian communities or ones in which some or all elites want to achieve outcomes that benefit many, the approach to delegation may still influence whose voices are heard in the decision making process.

In order for the decision making rules to influence outcomes, the resulting decisions must be enforceable. In the first stage, the NGO staff ensure that decisions reached at the meeting are implemented. However, elites who wish to own a source of water may offer to fund the entire community contribution to a water source that they install on their land, promise to allow all to access the source, and then renege on the promise of access after the source has been installed. An important obstacle to such deceit, confirmed in focus group discussions, is that community members understand the fragility of promises and are not likely to agree to proposals whose terms can be easily violated after the source has been installed. In several focus group discussions, participants discuss that they expected some wealthy individuals who wanted to install the water sources on their own land to allow broad access to those sources, while they knew that other individuals would not.[10] The former were more likely to win agreement from meeting participants. Also, focus groups discussed the commonly held belief that those who contribute funding have more right to use the sources of water than do people who do not contribute. Agreements in which more people contribute funding to any given source are likely to increase access to that source, because each contributor is also connected to others to whom s/he can extend access. Focus groups report a considerable amount of time and energy spent on considering various proposals in the meetings.

The effect of limiting elite influence on outcomes is ambiguous a priori. The approach in our experiment aims to increase the difficulty of proposing safe water source locations that will serve few people, rather than limiting the control of elites per se. The approach should limit the influence of self-serving elites, but not those who are pursuing a broader common good. Nevertheless, the approach may have negative effects. First, even elites who are pursuing a narrow self-interest may increase access to safe drinking water more than can be achieved with broad community negotiations. Elites may have patron client relationships with community members, in which the elites offer services as implicit payments for support offered in other contexts. For example, a

[10]These expectations were not always correct but they did affect the likelihood of agreement.

member of the elite may need community members' votes to retain a political position and may reward community members by helping to install a source of water and allowing those who vote for her/him to use that source. Those whose support the elite person "buys" may have the greatest need for safe water. Second, limiting the control of elites may result in conflict within the community, which may produce a project with small benefits or prevent agreement on any safe water sources at all.

The second mechanism, influence over decisions, can also affect outcomes through influence over decisions that the community does not have an explicit authority to make. For example, no community in our study has the authority to decide the maximum number of water sources that the community can receive, but communities can accept or reject any water source. A community can try to influence the decision about the maximum number of water sources by threatening to refuse all water sources. The more decisions the project explicitly delegates to the community, the more leverage the community may have to bargain over other decisions.

Delegating decision making may change outcomes through the third mechanism because community members may consider the process by which the project was carried out more acceptable with or without delegation. Community members who believe that the process was legitimate and fair and who trust the implementing organization are more likely to use the new sources of water than are members who disagree with the process or who mistrust the organization. Acceptance and trust are also likely to affect maintenance of the water sources.

The three mechanisms do not operate independently. The influence that the NGO, community members and community groups have on decision making affects the information that is available for decisions since the NGO and different community members all possess different sets of information. The information that different individuals and groups possess affects their interest in influencing decisions. The acceptance of process and trust in the NGO affect the willingness of agents to contribute information, their trust of information provided by others, and their engagement in decision making.

However, we can make some progress on identifying the operation of each of the three mechanisms in order to determine which of the three mechanisms produce the differences in outcomes between the three approaches to decision making. We will show that the participatory approaches to decision making result in different outcomes from the top-down approach as a result of the first two mechanisms. The two participatory approaches differ from each other due to the second mechanism. We do not find any evidence that the third mechanism is responsible for the observed differences in outcomes.

3 Context

The main threat to safe drinking water in rural Bangladesh is arsenic contamination of groundwater. Massive education campaigns in the 1970s and 1980s promoted groundwater as a safer alternative to surface water, which is contaminated by pathogens. The education campaigns, led by UNICEF, were so effective that by 2000 over 80% of rural households were using groundwater pumped by tubewells, with three out of four of these wells being privately owned, and child mortality declined precipitously.[11] However, in the 1990s high levels of naturally occurring arsenic were discovered in the groundwater. The high concentrations occur in patches throughout the river delta on which Bangladesh lies, with the southern part of the country being the most densely contaminated.

Information about arsenic contamination spread slowly. Signs of arsenic exposure develop gradually over a span of years (WHO, 2011). Early symptoms include discoloration of the skin and skin lesions. Effects of chronic exposure include cancers, strokes, heart problems, organ failures, and eventually death. Smith, Lingas, and Rahman (2000) refer to the epidemic of diseases associated with arsenic exposure in Bangladesh as "the largest poisoning of a population in history."

In 2007, when this project began, UNICEF (2008) estimated that 20 million people were still using water from wells with arsenic concentrations above the Bangladeshi standard of 50 ppm (parts per million), which is itself five times higher than the WHO standard of 10ppm. Most people in rural areas had heard of the arsenic problem by then: 81% of respondents to our baseline survey said that they had both heard of arsenic and believed that water with high concentrations of arsenic was unsafe to drink; and another 16% said that they had heard of arsenic after the interviewer probed further. However, access to safe drinking water remains limited.

Contaminated wells are difficult to identify because a chemical test is required to determine whether the water is safe. Furthermore, the arsenic problem is not uniform. Contaminated wells are in close proximity to safe ones. The Bangladeshi government has tested many wells and painted the safe ones green and the unsafe ones red, but the paint wears off relatively quickly and people forget the test results.

The great majority of wells in Bangladesh are privately installed and owned. However, access to water that has safe levels of arsenic is a problem of access to a local public good. Only wealthy households can afford technologies that provide water with low concentrations of arsenic. For most households, safe water sources must be provided at the community level.

The technology that most rural residents prefer that can provide uncontaminated water is a deep tubewell that draws water from deep aquifers (up to 700-800 feet below ground level). Arsenic occurs in high concentrations mainly at shallower depths, reached by the ubiquitous wells that are privately owned (van Geen et al., 2003). Standard deep tubewells are relatively expensive to install, but easy to use and maintain, and replacement parts are readily available. In some areas, safe water is available at lesser depths of approximately 300-400 feet. In these areas, shallow tubewells can provide safe drinking water, at a lower installation cost.[12] In areas in which there is considerable seasonal variation in water pressure in the aquifer, deep-set tubewells are required. In a deep-set

[11] See Bangladesh Bureau of Statistics and Ministry of Planning, Government of the People's Republic of Bangladesh with UNICEF (1998). Mean under 5 mortality in Bangladesh fell from 239 deaths per 1000 in 1970 (UNICEF, 2008), to 65 deaths per 1000 in 2007, when this study began (UNICEF, 2010).

[12] During the study, information emerged about manganese contamination in shallow tubewells. We installed replacement wells free of charge using alternative technologies in villages where shallow tubewells that we had already installed tested positive for manganese.

tubewell the pumping mechanism is installed below the ground, as opposed to on the surface in the standard design, making the deep-set tubewell much more expensive to install and difficult to repair than the standard deep tubewell. However, it is equally convenient and easy to use. In some areas, there is no accessible underground aquifer that is low in arsenic, for example because the aquifer lies beneath a layer of rock that cannot be penetrated using local drilling techniques. An alternative technology in these cases is the arsenic iron removal plant (AIRP). AIRPs remove arsenic by oxidation and filtration. They are more expensive, larger, and significantly more difficult to operate and maintain than tubewells.[13]

4 The experiment

4.1 The intervention

The project provided information about arsenic, technical advice about safe water sources, and most of the funding for up to three safe drinking water sources per community. We carried out the interventions between 2008 and 2011, in partnership with a Bangladeshi NGO, NGO Forum for Public Health. NGO Forum is a large organization working on safe water and sanitation issues in Bangladesh with more than 30 years experience in the field. NGO Forum works closely with communities and is well-known among residents in its program areas.

We began the project with an information campaign in all villages, treatment and control, that described the arsenic problem, consequences of arsenic exposure, and how to identify safe wells. The campaign served to ensure that residents in all study villages were initially equally well informed about the arsenic problem.

The project then held meetings with residents in all treatment villages that described how the project would offer assistance with installing safe water sources. The meeting presented the process for the specific decision making model that was allocated to the village. We did not inform the villages that the process would be different in other villages, although some learned of the differences over the course of the project.

The intervention had four elements that were the same in all treatment villages. First, each village could install at most 3 water sources. Second, each village had to contribute between 10% and 20% of the cost of each source, depending on the type of water source and the number of sources chosen. Table 1 shows the cost of installing each of the safe water technologies and the community contribution that we required. The difference in the required community contributions reflects the difference in the cost of the selected technology. Also, the price per water source increased as more water sources were installed in the village.[14] Villages could install 3 sources if the sources were

[13] Two other alternatives are rainwater harvesting systems and pond sand filters. No community in our study selected either of these options. Both technologies have limitations with respect to tubewells and AIRPs.

[14] The lower contribution required for fewer water sources made the sources more affordable, and was in line with financial contributions required by other development projects in similar communities. We could not offer more water sources at the same contribution level given our budget. We offered more sources for a higher contribution in case communities wanted more water sources despite the greater expense. Many communities did in fact choose to install 3 sources.

shallow or deep tubewells, but they could install at most 2 sources if the sources were deep-set tubewells or AIRPs, because of budget constraints and the higher cost of the latter two sources.

The third common element was that the project staff provided all technical information that the treatment communities needed. Project staff identified feasible safe water sources in each village. They informed the village residents if a shallow tubewell would yield safe water or if the tubewell had to be deep or if the only option was a deep-set tubewell or an AIRP. They identified a qualified team who could install the chosen source. Those communities that were assigned to participatory decision making processes had the option to choose their own installation teams but in practice all communities used the installation teams identified by project staff. The project staff also informed the communities if a location chosen by the community was not technically appropriate for a source of water, they tested the water after installation, and they replaced water sources in those cases in which we identified problems.

The fourth common element was that residents were informed that they would be responsible for maintaining the safe water source in the future and for paying all maintenance costs. The time period of our grant did not allow us to fund maintenance.[15]

4.2 Decision-making processes

The remainder of the decision making followed 3 different processes, with each treatment village being assigned to one of these processes. Table 2 summarizes the main features of each of the three approaches to decision-making. The decisions that were made differently through these processes were: the choice of the water source if more than one type was feasible and the location of the water sources.

The top down process (TD) The top-down process was designed to represent the historically conventional approach to development projects, in which the community does not participate in decision making. Our approach strays from typical top-down practice in that the common elements of the process, especially the funding contribution, include more community involvement than is conventional. The community's decision about the funding contribution implies that the community ultimately determines how many sources of safe water it will install. The project staff proposed how many sources a community should install and named who should contribute to each of the sources and how much, and who should maintain the installed sources. However, the project only installed those sources for which the community successfully raised contributions. Also, most communities either redistributed contributions among each other after initially following the lists of contributors or never followed the lists at all.[16] The project staff's decisions about maintenance were also unenforceable. The project staff did decide what types of water sources would be installed and

[15] Most development projects, not only research projects, are unable to fund long-term maintenance. In our case, this presents a problem mainly for communities that installed AIRPs or deep-set tubewells. Most of our focus group participants reported that maintenance costs for regular tubewells are small and easily born by the owner of the land on which the well sits.

[16] As contributions could be easily reported as coming from different individuals, it was impossible to enforce the recommended contribution lists.

where they would be located.

We implemented a benevolent version of the TD structure, in which the NGO Forum made decisions in the best interest of the community and informed the community about its plans. The project staff made decisions about types of water sources and locations after an extended (typically 2-day) period of gathering information. The information gathering consisted of participatory mapping of the village with members of the community in order to identify locations of safe water sources relative to locations of households. Project staff then determined sites for new safe drinking water sources, prioritizing locations with the highest density of households who did not have access to a safe source of drinking water. The staff chose sites located on publicly owned land, such as a school or a mosque, whenever possible, and convenient locations where no suitable public land was available. Staff then organized and publicized a community meeting at which they presented the selected locations. The community then attempted to raise the contribution to fund the water sources. The amount raised determined how many water sources were installed.

The community participation process (CP) The process delegated decisions about the types of water sources to be installed and where the water sources would be located to the community and did not interfere in the community's decision making process. Decisions about the number of water sources, contributions, and maintenance were also made by the community, as in the TD approach. If the community decided to install one or more sources and selected preferred sites, the project staff determined whether the sites were technically feasible. If they were, then the community's plan was implemented as long as the community raised the required contribution. If any of the chosen sites were not technically feasible then the community would choose other locations until a desired number of locations were determined to be feasible.

The regulated community participation process (RCP) Under this process, the community made the same decisions as under the CP process but the project staff imposed the decision-making rules that had to be followed. The community's decisions would be implemented only if they were made unanimously in a meeting attended by a minimum of 20 people, with a minimum of 5 being low-income women, 5 being low-income men, 5 higher-income women, and 5-higher income men. The project staff held preliminary meetings in the RCP villages separately with small groups of low-income and higher-income women and low-income and higher-income men. Women and low-income people are often excluded from community decisions in Bangladesh, and they are likely to choose not to participate even if their participation is allowed because they do not believe that they will be allowed to speak or that their opinions will matter. The preliminary meetings were designed to motivate these groups to participate actively. The project staff were present in the general meeting at which decisions about the project were made, and they ensured that everyone had a chance to express their opinion and that the decisions were indeed unanimous. If the community could not reach a consensus in one meeting then they held subsequent meetings until consensus was reached or the community stopped the process.

Subsequently, as in the CP process, the project staff determined if the locations chosen by the community would yield safe water. If any locations were not appropriate then the community could choose different locations. The project implemented the community's plan if the community raised the required contributions.

After the decision-making meetings under all three processes, project staff gave the communities up to 12 weeks to raise the funds for the community contributions. Construction of the drinking water sources began as soon as the community had raised their contribution. If the community could not raise the contribution within 12 weeks, then the project did not construct water sources in that community.

The same project staff implemented the project under all three decision-making processes. We implemented the intervention in 7 cycles during which project staff completed the entire process from organizing initial meetings to installing water sources for a group of villages, which were grouped geographically.

4.3 Selection of study sites

We conducted the study in villages located in two upazilas (subdistricts): Gopalganj, about 60 miles southwest of Dhaka, and Matlab, about 30 miles southeast of Dhaka. We focused on these sites because of the severity of the arsenic contamination problem and the absence of other major interventions that were addressing the problem.[17]

We initially selected 250 villages for the study, focusing on the villages most affected by the arsenic problem. We selected 125 villages randomly from villages in which at least 65% of wells had unsafe levels of arsenic in Matlab, and 125 villages randomly from villages in which at least 75% of villages had unsafe levels of arsenic in Gopalganj.[18] Our experiment only makes sense in villages in which a high percentage of wells are unsafe, since otherwise communities have no reason to spend money on more expensive wells. However, villages with high levels of arsenic contamination may be different from villages with low levels of contamination in unobservable ways that affect how these communities respond to our interventions and therefore affect the population of villages to which our results apply. We argue that this is unlikely. There are no clear reasons why the geo-chemical processes that determine arsenic contamination should be correlated with community characteristics. Several papers look for such correlations. Madajewicz et al. (2007) find that average assets are negatively correlated with arsenic contamination across villages, though not across households, in one upazila, but Field, Glennerster, and Hussam (2011) find the opposite relationship for a different region of Bangladesh. Therefore, there does not seem to be any systematic relationship.

We randomly assigned 50 villages to the control group and 75 villages to the treated group in each upazila. However, in the end, 126 villages received treatment, rather than 150. We initially dropped 36 villages from treatment because costs of providing safe water sources increased over the course of the project. The omitted villages were selected randomly. We were then able to add 12 of those omitted villages to treatment when funding became available, adding back villages

[17]We used data on arsenic contamination of pre-existing tubewells from the Bangladesh Arsenic Mitigation Water Supply Project to identify locations.

[18]In Matlab, we excluded three unions because other organizations were working in those unions. In Gopalganj, we excluded two unions because the government had responsibility for wells in those areas.

that were randomly selected from the 18 that we initially dropped in Gopalganj, resulting in a treatment sample of 57 in Matlab and 69 in Gopalganj. In two villages in Gopalganj, project staff determined that there were no feasible technologies to provide safe drinking water, because no safe aquifer was accessible, and arsenic concentrations in the shallow groundwater were too high for removal with an AIRP. Project staff identified one of these villages before we began the interventions, and we replaced that village with another village randomly drawn from the villages which we had initially assigned to treatment but in which we had not carried out the intervention due to budget constraints. The problem in the second village emerged only after interventions had begun, and we dropped that village from treatment.[19] Finally, we lost all baseline data for one village in Matlab. The final treatment sample for which we have both baseline and follow-up data consists of 56 villages in Matlab and 68 in Gopalganj.

We later established that the project director at the time did not follow the original protocol when he implemented the division of the villages into control and treatment, and he included all villages in the southern area of Matlab in the treatment group. Villages in South Matlab have much lower access to safe drinking water than the average village in the Matlab sample, therefore treated villages report lower access to safe drinking water at baseline than do the control villages in Matlab.[20] Throughout the paper, we define treated villages as villages that received our intervention. The treated villages installed varying numbers of sources of safe water and some did not install any sources.

In Table 3, we show baseline summary statistics and randomization checks for villages by treatment status, that is whether or not the village received our intervention. Column 1 reports the sample means and standard errors for a selection of variables, which measure baseline access to safe drinking water, factors that might influence the ease of providing safe drinking water, and community-level variables that might influence the likelihood of a successful collective action. The first two variables in the table are village-level variables, and the remainder are household-level variables, collapsed to village-level means. Column 2 reports the coefficient from a simple Ordinary Least Squares (OLS) regression on village means that tests whether the difference in means between treated and control villages is statistically significant:

$$Y_v = \alpha + \beta I_{treated,v} + \gamma I_{G,v} + \epsilon_v \tag{1}$$

where Y_v is the mean of a variable in village v; $I_{treated,v}$ is an indicator which is one if village v was treated and zero if village v was not treated; and $I_{G,v}$ is an indicator that takes the value 1 if the observation comes from Gopalganj. We include the upazila indicator because (1) we stratified the treatment at the upazila level, and (2) the fraction of treatment villages is different in Gopalganj

[19]We could potentially introduce bias by dropping the two villages in which no safe water source was feasible. However, we have not identified any plausible mechanisms that would link the geo-physical conditions that determine the feasibility of safe water sources to socio-economic conditions that influence the impacts in this study. Furthermore, dropping the two villages barely affected the comparison of baseline characteristics across villages.

[20]Villages in South Matlab also report significantly higher rates of collective action than the average village in the Matlab sample.

than in Matlab. If the treatment was randomly assigned, the coefficient on $I_{treated,v}$ should be zero in all cases. Robust standard errors are in parentheses. Asterisks denote statistical significance as defined below the table.

The results in column 2 of Table 3 show that households in treatment villages had worse access to safe water than households in control villages at baseline. They were less likely to change to an arsenic-free source of water in the past 5 years, most likely because fewer sources of safe water were available in these villages. Also, the communities had slightly more collective actions.

We correct the bias induced by the failure of randomization in Matlab by three methods, reported in columns 3-5 of Table 3. First, we drop South Matlab from the sample. We report the resulting difference in means between treated and control villages in column 3 of Table 3. Second, we create a synthetic treatment variable, which re-assigns a fraction of the villages in each treatment group in South Matlab to control and a fraction of the control villages in North Matlab to each treatment group. The variable is equal to the treatment variable in Gopalganj.[21] The results are in column 4. Third, we use this synthetic treatment variable to instrument for treatment, and we report the results in column 5. We discuss the IV estimator further in section 7.1. All three approaches mitigate the bias, producing a treatment sample that is not significantly different from the control.[22]

We randomly assigned the three decision-making processes to the treatment communities. The final treatment sample for which we have both baseline and follow-up survey data consists of 124 villages, 41 villages assigned to CP, 41 assigned to RCP, and 42 assigned to TD.

Table 4 shows that the villages assigned to each decision-making process were comparable at baseline to the villages assigned to the other processes. Asterisks denote those cases in which the difference between the mean of villages assigned to the given decision-making process and the pooled means of villages assigned to the other two processes is statistically significantly different from zero. The p-values come from an OLS regression on village means in which the indicator $I_{m,v}$ is one if village v received treatment under decision-making structure m, and zero otherwise.[23]

$$Y_v = \beta_m I_{m,v} + \epsilon_v \tag{2}$$

Only the treated villages are included in the regressions in Table 4. We compare the baseline values of 15 variables across the 3 decision-making processes, resulting in a total of 45 tests. In 44 of these tests we fail to reject the null hypothesis that there is no difference in means between groups treated under one decision-making structure and the other treated villages at the 10% level. In 1

[21] Ideally, we would have used the original random assignment to treatment rather than this synthetic alternative but we have not been able to recover the initial, randomly assigned treatment lists.

[22] Since the variables we test are not independent, we also carried out a Hotelling's T-Square test for joint significance of differences in means for all 12 variables listed in the table. This test confirms failure of random assignment to treatment, rejecting the null hypothesis that the means of all 12 variables are jointly equal in treatment and control groups with an F-statistic of 1.88, but does not reject equality of means across all 12 variables 1) in the sample in which we drop South Matlab or 2) when we compare the villages that were synthetically assigned to treatment and control, rather than the implemented assignment to treatment and control.

[23] We stratified assignment to decision-making process by upazila. Including an upazila control in this regression makes no change in the significance levels of baseline differences estimated.

test, we reject this null hypothesis at the 5% level. This is consistent with what we would expect due to chance if the variables were independent.[24] Therefore, there is no evidence that assignment to model, conditional on treatment, was not random, as required by the project protocol.

5 Description of data

We carried out a baseline survey in 2007, after the information campaign about arsenic but before any other project activities began. We surveyed 40 households in each of the 250 villages. We surveyed a total of 9,797 households, as in some very small villages fewer than 40 households from the sampling frame could be located. The baseline questionnaire included detailed information about awareness of the arsenic problem, the water sources used by the household, household characteristics, and the household's social networks and relationship to the village community. We did not have the resources to do a full income or expenditure survey. We collected data on proxy measures of a household's socio-economic status, such as assets owned, materials with which the house was built, access to electricity, and a sanitary latrine. The interviewers also assessed each household's socio-economic status qualitatively, using standards that we discussed during training.

We encountered several problems with the entry of the baseline data. Some of the individuals who were employed to enter the data copied and pasted entire villages of data, changing names and other identifiers. Data checking revealed this problem several months after data collection and entry had been carried out. We re-entered the missing data from the original questionnaires. However, by the time we discovered the problem, termites had destroyed a small percentage of the questionnaires. As a result, we are missing baseline data for 140 households from control and treated villages. We do not have any reason to think that there was any systematic pattern to either the false data entry or the losses to termites, so the remaining baseline data represent a randomly selected sample of the baseline population.

We carried out the follow-up surveys after the intervention was completed in all villages, in 2010 and 2011. We surveyed the same households that were included in the baseline survey in all villages that received treatment and all control villages. We did not carry out follow-up surveys in 24 villages which were initially assigned to treatment but in which we did not carry out the intervention. Of the 8,670 households surveyed at baseline in the villages that remained in the study after we dropped 25 villages from treatment and whose data were not affected by the bad data entry and the termite problem, we successfully re-surveyed 8,419, which represents an attrition rate of 2.9%. The attrition rates broken down by treatment group are as follows: 2.7% in control villages; 3.1% in treated villages. Among the treated villages, attrition rates were 2.8% in RCP villages, 3.1% in CP villages, and 3.5% in TD villages. The differences between attrition rates

[24] The variables we test are in fact correlated. The rule of thumb that we should expect approximately 1 in 10 tests to fail at the 10% level and 1 in 20 to fail at the 5% level assumes that the variables are independent. We confirm that a Hotelling's T-Square test, which accounts for correlation between tested variables, also fails to reject the null hypothesis that the means of all 15 variables are equal between groups treated under different decision making process. F-test statistics for the 3 pairwise Hotelling's T-Square tests and 3 tests of each decision making process against the other two processes pooled range between 0.31 and 0.75.

between any of the groups are not statistically significant.

We documented the numbers and types of safe drinking water sources installed, and the project staff kept detailed records of the implementation process, including the number of contributors in each community and the time taken to raise the community contribution. After the interventions and before the follow-up survey, we conducted focus group discussions (FGDs), separately with men and women, in 12 of the villages that received an intervention, 6 in Gopalganj and 6 in Matlab. The twelve villages were divided equally between the 3 decision-making processes, resulting in 4 FGDs for each process. The objective was to understand in more detail how the decision making proceeded under each process, what problems were encountered, and what was each community's assessment of the process.

5.1 Definition of the main impact variable

We measure the household's access to safe drinking water using an indicator variable based on the source of water that the household identifies as its most important source of water for drinking and cooking. The binary variable takes the value 1 if the household reports using a source of drinking water that is safe from both bacterial and arsenic contamination, and zero if they report that the source is unsafe, if they do not know whether the source is safe or not, or if the source is vulnerable to bacterial contamination, for example a dug well or surface water. Further details regarding the construction of this variable are in Appendix A.

The variable is based on the status of the water source reported by the household, which is not necessarily correct. We were able to verify whether the reported status matches the actual status for a subset of the wells used by households at baseline. We report the results that use the alternative measure of access to safe water, a combination of the status reported by households and verified status for those wells for which we were able to verify the status, in Section 10. The results are very similar.

6 Number of safe water sources installed

The impact of the project on access to safe drinking water depends on the number of water sources that the project installs, and the number of people who were using unsafe water at baseline and who are able and willing to use the newly installed sources. In this section, we report the number of sources that the project installed.

The project installed 2.2 safe water sources in the treated villages on average. If we had installed all water sources allowed by our project rules and technically feasible given the hydro-geological conditions in each village, the average number of installed sources would have been 2.8. The largest possible average is less than 3 because in some villages only the more expensive water sources were feasible, the deep-set tubewells or the AIRPs, and each village could only request two of the more expensive sources. Table 5 reports the maximum possible number of water sources, the number installed, and the proportion of the maximum possible installed for all treated villages in columns

1, 3, and 5.[25]

The number of sources the project installed depended strongly on the feasible technology. Residents of treated villages chose shallow tubewells wherever possible, followed by standard deep tubewells and deep-set tubewells. AIRPs were the least preferred technology. AIRPs were the only feasible technology in 16 out of 68 villages in Gopalganj, which were in the final treatment sample. We could have installed a maximum of 32 AIRPs, but we were able to install 5, yielding a success rate of approximately 16%. In the remaining villages in Gopalganj, in which tubewells were feasible, we installed 79% of the maximum number of wells we could have installed under our project rules. The reasons given by the communities for rejecting AIRPs were that they took up too much space, required too much work to operate and maintain, and were not perceived to be reliable or trustworthy.

The rejection of AIRPs did not seem to be a function of the price of the technology. In 10 villages in Matlab, only deep-set tubewells could be installed, which cost the same amount as AIRPs and for which we required the same level of community contribution. We installed on average 90% of the maximum possible number of deep-set wells in those 10 villages, compared to an average of 89% of the maximum possible number of tubewells in all other villages in Matlab. Either shallow or regular, deep tubewells were feasible in all the other treatment villages in Matlab.

The project did not experience big differences in success rates of installing the three different kinds of tubewells. In the villages in which tubewells were feasible, the average number of water sources that the project constructed rises to 2.5 out of a maximum possible 2.9. Table 5 reports the maximum possible number of tubewells, the number of tubewells installed, and the proportion of the maximum possible number of tubewells that was actually installed, in villages in which tubewells were feasible, in columns 2, 4, and 6.

We installed different numbers of safe water sources under the 3 different decision making processes but the differences are not statistically significant. We installed 9% more water sources in the villages in which communities participated in decision-making than in the villages in which project staff made decisions, as shown in column 3 of Table 5. The difference declines when we consider only villages in which tubewells were feasible, shown in column 4.

Interestingly, in villages in which only tubewells were feasible, villages assigned to the CP process installed the most sources of safe water. The difference between the number of tubewells installed under the CP process and the RCP process is small and not statistically significant, but it suggests that people may have been more likely to install sources of safe water when they could expect to have individual control over them. Participants in focus group discussions also noted that people are more likely to contribute funding if they can pay the entire contribution alone and place the source on their own land.

[25]We replaced some of the shallow tubewells we constructed with alternative sources after a problem with manganese contamination emerged. Additionally, in one village in Gopalganj, we constructed deep tubewells that later turned out to have inadequate water quality. We replaced these deep tubewells with an AIRP. In this section, we focus on the number of water sources constructed at the initial time of project implementation, given the best available technology at the time.

We produce the results shown in Table 5 by estimating two sets of regressions. The first have the regression equation:

$$Y_v = \beta_{TD} I_{TD,v} + \beta_{CP} I_{CP,v} + \beta_{RCP} I_{RCP,v} + \epsilon_v \tag{3}$$

$I_{TD,v}$ is one if village v received treatment under the TD decision-making process, and zero otherwise, and so on for the other indicators and decision making processes. We then test pairwise the equality of the coefficients β_{TD}, β_{CP} and β_{RCP}. Second, we estimate regressions with the same equation as Equation 2, and test equality between the coefficient under a given decision-making process and the pooled coefficients under the other decision-making processes.[26]

7 Average impact on access to safe drinking water

In this section, we estimate the average impact of the intervention on access to safe drinking water. The estimate is the average across all decision-making processes.

7.1 Methodology

We collapse the household-level observations to village level means for the purpose of the regressions..[27] The approach serves two purposes. First, the treatment was assigned at the village level, but we collected data at the household level. Within-village correlation of household characteristics implies that it is more likely that differences between mean outcomes in treated and control villages in a household-level regression arise due to chance, than if we had been able to assign treatment at the household level. Standard errors in a village-level regression do not have this problem.[28]

Second, some villages had fewer than 40 households, the number that we interviewed in all other villages. Also, part of the data in several villages was lost because of the baseline data entry problems. Survey weights could compensate for these differences in the number of households between villages but survey weights also introduce problems (Deaton, 1997). Each village counts equally in a village-level regression.

A simple OLS regression that compares the means between the control and the treatment groups at follow-up takes advantage of the experimental set-up but is subject to the bias introduced by the non-random selection of treatment villages in South Matlab. In addition to this regression, we estimate an OLS regression on a sample that excludes the villages in South Matlab, which were all assigned to treatment, and a regression that instruments treatment with the variable that assigns

[26] Appendix Table B1 reports similar results for each upazila where we carried out the project. In both upazilas, villages assigned to one of the participatory processes installed the most sources of safe water. In Gopalganj, villages assigned to the CP process installed the most sources of safe water. In Matlab, villages assigned to the RCP process installed the most sources of safe water.

[27] We show results obtained from household-level regressions in Section 10.

[28] See for example Bertrand, Duflo, and Mullainathan (2004).

some villages in South Matlab to control, some in North Matlab to treatment, and and is the same as the assignment to treatment everywhere else.

The OLS regressions follow Equation 1, in which we regress access to safe drinking water at follow-up on an indicator for treatment and an indicator variable for Gopalganj.[29]

The instrumental variable estimate yields a Local Average Treatment Effect (LATE) (Imbens & Angrist, 1994). In principle, this might differ from the average effect of treatment because it corresponds to the effect on the compliers, the subset of villages who received treatment as a result of assignment to treatment, which differs from the study population (Angrist & Pischke, 2009). However, in practice the IV estimates in this context will in general be very similar to the OLS estimates.

We also estimate the effect of treatment on the change in access to safe drinking water between baseline and follow-up for all three specifications: OLS on the entire sample, OLS excluding South Matlab, and IV. We use the following first difference equation using data from all households for which we have both baseline and follow-up data:

$$\Delta Y_v = Y_{f,v} - Y_{b,v} = \alpha + \beta I_{treated,v} + \gamma I_{G,v} + \epsilon_v \tag{4}$$

where ΔY_v is the mean change in access to safe drinking water between baseline and follow-up in village v. With two time periods, the first difference analysis is equivalent to including village fixed effects.

The regression in first differences on all villages can yield an unbiased estimate of treatment in a model in which any unobserved differences between treatment and control villages in Matlab affect access to safe drinking water additively, and they are at least approximately constant over the period of time between the baseline and follow-up. We believe that such a model is very reasonable in our case and that the estimate of treatment in the first difference regression based on all villages is a credible one. The strongest observable differences between the treatment and control villages in Matlab at baseline are access to safe drinking water and the proportion of respondents who changed their source of water due to arsenic during the last 5 years. There are statistically significant but relatively small differences in village size and the number of collective actions, which might hypothetically affect the likelihood of undertaking collective action to build new sources of safe water.[30] The likelihood that the magnitude of the effect that these or any unobservable differences have on access to safe drinking water changes considerably over a period of 2 years is small. In order to be conservative, we do estimate the regression in first differences with the corrections for

[29]Again, we include the indicator variable for Gopalganj because we stratified the randomization by upazila, and the proportion of control villages to treatment villages is different in Gopalganj and in Matlab. The inclusion of the upazila control variable can result in a biased estimator of treatment (Freedman, 2008; Deaton, 2010) unless the sample is large enough, because the treatment effects differ across the upazilas as we discuss later in the paper. In Appendix Table B7, we show that results from a fully saturated regression, which returns an unbiased estimate of treatment (Imbens, 2010), are very similar.

[30]Randomization checks for Matlab alone are in Appendix Table B2.

failed randomization; dropping South Matlab and using an IV. A regression-based Hausman test (Wooldridge, 2002) fails to reject the null hypothesis that treatment status is uncorrelated with changes in access to safe drinking water.

7.2 Results

The drinking water sources that our project installed increased access to safe drinking water by 15% to 17% in all villages. Table 6 reports access to safe drinking water at follow-up in Panel A, and the change in access between baseline and follow-up in Panel B. We show results for a simple OLS regression on all villages in column 1. The effect of the project is not statistically significant at follow-up (Panel A) because the villages in South Matlab had worse access to safe drinking water at baseline than did villages in North Matlab and the improvement between baseline and follow-up does not completely outweigh these initial differences. In Gopalganj alone, the impact is statistically significant in the cross-section at follow-up. The OLS regression in first differences in column 1 of Panel B shows a statistically significant effect of the project for all villages. The effect of the project is statistically significant at follow-up and in first differences in column 2, in which we drop South Matlab, and in column 3, in which we report the IV results. The differences between the coefficients on treatment are small across all corrections for non-random assignment of villages to treatment.

In columns 4, 5, and 6, we estimate the average effect of the project only in those villages in which tubewells were feasible, including shallow, deep, and deep-set tubewells, and excluding those villages in Gopalganj in which only AIRPs were feasible. On average, the project increased access to safe drinking water by 18% to 20% in these villages. Column 4 shows the OLS estimate based on all villages in which tubewells were feasible, column 5 the estimate when we drop South Matlab, and column 6 the IV estimate. There was no significant change in access to safe drinking water in villages in which only AIRPs were feasible, as shown in column 7.[31] Estimates of the treatment effect only in villages in which tubewells were feasible are larger than estimates in all villages, not surprisingly, since there was no change in access to safe drinking water in villages in which only AIRPs were feasible.

We believe that the estimate of the treatment effect in villages in which only tubewells were feasible is unbiased. As discussed in Section 6, we installed very few AIRPs, and we believe that the reason was that village residents did not like the AIRP technology, and not other differences between the villages. There is strong spatial correlation between locations where only AIRPs are feasible, which reflects the extent of the rock layer that overlays the deep underground water aquifer, and other village level characteristics are also spatially correlated. However, a comparison of means at baseline in Gopalganj alone suggests that villages in which only AIRPs were feasible and villages in which only tubewells were feasible are only marginally more different from control villages than is the full group of treatment villages.[32]

[31] In Gopalganj assignment to treatment was random so we simply report OLS results for the villages in which AIRP was the only feasible technology.

[32] The only statistically significant differences between villages in which only AIRPs were feasible and control

Furthermore, in 8 of the 17 villages in which only AIRPs were feasible, we did not know ahead of time that the rock layer existed. In these villages, the residents agreed to install deep tubewells and raised the contributions. The residents did not install any AIRPs in these villages once the project staff informed them that only an AIRP would be feasible in their village. Therefore, these villages do not seem to be different in their response to our project in any way except with respect to the feasible technology, and dropping them from the analysis should not bias the estimated effect.[33] It is possible that the villages in which we knew about the rock layer ahead of time and therefore did not attempt to install tubewells were different in other unobservable ways that would influence the response to our project from villages in which tubewells were feasible, but this does not seem likely.

In order to be conservative, we use a matched control group when we report effects on access to safe drinking water for villages in which a specific technology was feasible. The construction of the matched control group exploits spatial correlation in the location of villages in which AIRPs were the only feasible technology.[34] There are no statistically significant differences in baseline characteristics between villages in which only tubewells were feasible and matched control villages.[35]

Notably, there was no change in average access to safe drinking water in the control villages between baseline and follow-up. Any initiatives other than our project that were seeking to increase access to safe drinking water over the same period of time did not result in an average increase in access. Lack of change in the control villages indicates in particular thatany collective action initiated by residents, if it occurred, was not sufficient to increase access on average.

8 Impact on access to safe drinking water under different allocations of decision making authority

8.1 Methodology

We can estimate the difference between the three decision-making processes using only the treatment villages. The estimates in a regression that includes binary indicators for each process and no intercept reflects the change in access relative to the control villages since the average change in access in the control villages is zero throughout the study area. We estimate the impacts of each process using an OLS regression on village means that takes the following form, exactly as

villages is with respect to access to electricity. Villages in which tubewells were feasible and control villages have both significantly lower access to electricity, and are significantly more likely to be famers, than the control villages. In Gopalganj, there are no statisticaly significant differences between treatment and control for all villages. The results are shown in Appendix Table B3.

[33] In another village, tubewells were constructed and only later replaced with an AIRP after water quality was found to be inadequate.

[34] Details of the construction of the matched control group are given in Appendix A.

[35] See Appendix Table B4 and Appendix Table B5. In Appendix Table B7, we show that the estimated effect on access to safe drinking water in villages in which tubewells were feasible is almost identical if we use the full set of control villages instead of the matched villages.

in Equation 3:[36]

$$\Delta Y_v = Y_{f,v} - Y_{b,v} = \beta_{TD} I_{TD,v} + \beta_{CP} I_{CP,v} + \beta_{RCP} I_{RCP,v} + \epsilon_v \quad (5)$$

8.2 Results

The regulated community participation model has a considerably larger effect on access to safe drinking water than do the other two decision making processes. The RCP increases access to safe drinking water by 21%, while both the CP and the TD increase access by 12%. When we exclude the villages in which only AIRPs were feasible, the RCP increases access to safe drinking water by 26%, the CP by 15% and the TD process by 14%. The difference between the RCP approach and the other decision making processes combined is statistically significant at the 5% level when we exclude the villages in which only AIRPs were feasible, and marginally significant (p = 0.102) in the full sample. The differences between the CP and the other two processes combined, and between the TD and the other two processes are not statistically significant.

We show the results in Table 7. We show the impacts of the decision making processes on the change in access to safe drinking water between baseline and follow-up in all villages, in villages in which tubewells were feasible, and in villages in which only AIRPs were feasible respectively. The p-values for the pairwise differences between the processes and the differences between each process and the other two processes combined appear below the coefficients. The pairwise differences between the RCP process and each of the other processes are statistically significant at the 10% level in villages where tubewells were feasible, and just outside statistical significance in the full sample.[37] The pairwise difference between the CP villages and the TD villages is not significant in any sample.

The statistically significant difference between the RCP approach to decision making and the other two approaches is remarkable given the relatively small number of villages in the experiment. First, all approaches in effect required collective action. The two participatory approaches required communities to make collective decisions, and all approaches required communities to contribute money. One may expect the behavioral response to such an experiment to be highly variable, with large standard errors on the effect. Second, the performance of different approaches to decision making should differ across communities with different characteristics, and indeed differences across contexts may account for the mixed results in the literature cited in the introduction, al-

[36] Assignment to model was stratified by upazila, but the proportion of villages in Gopalganj is identical across models. Including an upazila control in the presence of heterogeneity of program effects between upazilas introduces bias into the estimates (Freedman, 2008). In Section 10 we estimate a fully saturated model which allows effects to differ across upazilas.

[37] The differences between processes in the cross-section at follow-up are shown in Appendix Table B9. Differences between processes are not statistically significant in the cross-section at follow-up either for the full set of treated villages, or the subset of tubewell villages, because access to safe drinking water was lower at baseline in the RCP villages than in the other two groups of villages. The difference in access to safe drinking water at baseline is not statistically significant but is large enough that, combined with heterogeneity across villages, the effects of the decision making processes on access become more difficult to distinguish.

though differences between the approaches implemented may be another reason. That one approach dominates on average across all villages is striking.

We illustrate the performance of the three approaches to decision making further by plotting the cumulative density functions (cdf) of the probabilities of changing to a source of safe water under each approach (Figure 1) and the fraction who change to sources of safe drinking water for different levels of access to safe water at baseline under each approach to decision-making (Figure 2). The cdf for the RCP approach lies everywhere below the cdfs for the other two approaches. In villages in which tubewells were feasible, a higher fraction change to a source of safe water under the RCP approach at most levels of access to safe water at baseline. A slightly larger fraction switch to safe water under the CP approach than under the RCP approach in villages in which access to safe water at baseline exceeds 60%, but the difference is very small.[38] The difference between the RCP and the other two approaches is inversely related to access to safe water at baseline.

9 Explaining the results

Within the framework suggested in section 3, the participatory decision processes may differ from the top down process for one or more of three reasons: (1) availability of information; (2) distribution of influence over project decisions; and (3) acceptance of the project process and trust in the implementing organization. Our data suggest that the first two mechanisms explain the difference between the TD process and the two participatory processes, while the second mechanism explains the difference between the two processes that involve the community. Throughout this section, we focus only on villages where tubewells were feasible.

The evidence that explains the results differs across the two districts in which we implemented the study, and heterogeneity in the main results reflects these differences. The performance of the RCP approach is particularly strong in Gopalganj. The pattern of impacts on access to safe water of the 3 approaches is the same in Matlab as in Gopalganj but the differences between the impacts of the 3 approaches are much smaller in Matlab and not statistically significant. Table 8 shows the results for the impacts of the three approaches to decision making on access to safe drinking water separately for Gopalganj and Matlab.[39]

We suggest reasons below, which stem from several baseline differences between Matlab and Gopalganj. A greater percentage of households had access to safe water in Matlab: 58% of treated households in Matlab had access to safe drinking water at baseline, compared to 27% in the sample of treated villages for which tubewells were feasible in Gopalganj. Households in Gopalganj are poorer on average than those in Matlab, and report lower levels of collective action and trust in leaders. Villages in Gopalganj are also larger, and more unequal, as measured by the GINI coefficient on baseline within-village asset distribution, than those in Matlab.

[38] A higher fraction change to a source of safe water under the RCP approach at all levels of access to safe water at baseline when we consider all villages.

[39] Appendix Table B8 shows corresponding estimates for the average treatment effect separately for Gopalganj and Matlab, and Appendix Figure B2 replicates Figure 1 for villages in which tubewells were feasible in Gopalganj and villages in Matlab separately.

9.1 Comparing the top down approach to the participatory approaches

The first drawback of the top down process relative to the two participatory processes is less effective use of local information coupled with centralized authority to decide the location of each source — the combination of the first and second mechanism. This effect is stronger in Gopalganj but also appears in a muted form in Matlab. The most objective measures of the use of information are the distance to the nearest well installed by the project and the distance to the nearest safe well. These are not affected by households' decisions to use a well, but these measures could also be affected by elite capture. In Gopalganj, the TD and the CP processes installed wells farther from households, on average, than did the RCP process, and the difference between the RCP process and the other two is statistically significant. However, the TD process resulted in a smaller decline in the distance to the nearest safe well than did the other two, which supports the frequently stated hypothesis that community participation results in better use of local information. The decrease in the distance to the nearest safe well in TD villages was less than half of that in RCP villages. The decrease in distance to safe wells in CP villages lies in between the TD and RCP villages. The pairwise difference between the TD and the RCP villages is statistically significant, while the pairwise difference between the TD and CP villages has a p value of 0.15 in analysis conducted in levels and a higher p value when we analyze the distance in logs.[40] The results are in Table 10a.

The fact that the CP process installs wells equally far from households as does the TD process but results in a larger decline in the distance to the nearest safe well suggests that the CP villages place wells closer to households who have unsafe water at baseline, rather than those who had safe water at baseline, than do the TD villages. The results support this conclusion, providing additional evidence for better use of local information in the participatory processes in Gopalganj. The difference between the TD process and the CP process with respect to the change in the distance to the main source for households who did not have access to safe water at baseline has a p value of 0.13 when we analyze distances in levels, and is clearly statistically significant in analysis carried out in a log transformation.

In Matlab, the TD process results in the smallest decline in the distance to the nearest safe well in levels, consistently with the result in Gopalganj, but none of the differences are statistically significant, as shown in Table 10b. Unlike in Gopalganj, in Matlab the TD process installs wells closer to households and places safe water sources closer to households who use unsafe water at baseline than do both participatory processes.

The TD process also performs worse than the two participatory approaches on other measures of well location in Gopalganj, while it performs better on these measures in Matlab. These other measures, the change in the distance to the main source of water used by the household, and the change in this distance for households who used unsafe water at baseline and those who used safe water at baseline, depend on households' choices of water source. Not all the differences are statistically significant. On average, the intervention made little difference to the distance to the main source of water used by a household because households who lacked access to safe water at

[40]Results available from the authors on request.

baseline increased the distance they walked when some of them switched to a safe but possibly more distant source, while households who already used a safe source decreased the distance they walked when some of them switched to a nearer source.

The second possible reason that may partially account for the differences between the top down and the participatory processes is the influence over decisions, the second mechanism above, in the form of the extent of elite control. We do not have a definitive measure of elite capture but several pieces of data contribute suggestive evidence. Participants in all FGDs mention that contributions of funding to sources of water affect use of the sources. Households who contribute funding feel that they have the right to use the well and are perceived to have this right by others. Households who have not contributed feel awkward about using the source. When a single person contributes the entire required amount to a source of water, that person may restrict the use of the well to his family and close associates, or s/he may extend the use of the well more widely through a patron/client relationship in which s/he allows households who have supported her/him in the past and whose support s/he expects in the future to use the source.[41] Therefore, the number of contributors and the percentage of villages in which only one person contributed to each source are two possible measures of the distribution of the right to use wells. However, these measures are not dispositive. A single wealthy person can contribute funding to a well in order to provide safe water for those who need it in a community. We combine these measures with other evidence to discuss the possibility of elite control.

Under the TD process, project staff strove to secure broad access to sources of water by placing them on public land, such as at schools, mosques, or by the roadside, whenever possible. Indeed, the sources of safe water installed by the project are much more likely to be on public land in villages assigned to the TD process than in villages assigned to the other two processes, and the differences are statistically significant, as we show in Tables 10a and 10b. However, wells placed on public land can be controlled by elites through patron/client relationships and/or explicit policing of the well. More people contributed to wells under the TD approach in Gopalganj than in CP villages but fewer than in RCP villages, as Table 11a shows. The fraction of villages in which a single person contributed to each of the wells installed is largest in TD villages in Gopalganj, though it is very similar to the fraction in the CP villages. None of the differences are statistically significant though the difference between the fraction of villages with single contributors in TD and RCP villages is almost significant. In Matlab, on the other hand, TD villages have the largest average number of contributors, and match RCP villages with the smallest fraction of villages with single contributors, as we show in Table 11b. Furthermore, the number of contributors in TD villages in Matlab is larger than in Goplaganj and the fraction of villages with single contributors is considerably smaller. Therefore the better performance of the TD process relative to the two participatory processes with respect to location wells and access to safe water in Matlab as compared to Gopalganj is accompanied by lower measures of elite influence in the TD process.

[41]The support may take the form of votes in an election, agreement with village-level decisions, labor in the fields at critical times, etc.

The third reason why access to safe water increased less under the TD approach is that villages assigned to this approach installed somewhat fewer sources of water, as discussed in section 6. The relatively inconvenient placement of wells in the TD villages may have discouraged contributions in Gopalganj. Also, several FGDs note that sources were more likely to receive contributions if the contributor could place the source on his/her own land. The TD process made this outcome more difficult to achieve by allocating decision-making authority over the location to the project staff, who were attempting to avoid placing sources on private land. The differences in number of sources installed are not statistically significant but they contribute to the lower average access under the TD process relative to the RCP process, and to the tie between the TD process and the CP process.

The difference between the TD and the participatory approaches in the number of water sources installed seems to echo a frequent critique of the top down process in the literature, which posits that communities are less likely to accept and use new ideas or technology when they are not involved in providing them. One reason for this lack of engagement may be dissatisfaction with the decision process. However, survey respondents and FGD participants do not systematically express less satisfaction with the TD process than with the other two processes.[42] In fact, they praise its fairness and the protection it provides against the influence of elites, particularly in Matlab. Therefore, the third mechanism does not appear to play any role in differentiating the outcomes of the three approaches. Rather the reason why villages assigned to the TD process install somewhat fewer sources seems to be that the outcomes suit the community's preferences less well than when the community participates in decision making.

While the TD approach used local information less effectively than did the participatory approaches, it may have had an advantage in with respect to scientific and/or technical information. Poor access to or use of such information can jeopardize the performance of participatory approaches (e.g. Khwaja, 2004; Mansuri & Rao, 2013). The communities in our project indeed did not have the knowledge necessary to identify potential safe water sources and to test arsenic levels in the water. However, they fully accepted information provided by the NGOF staff, who determined which water sources would successfully provide safe water, and tested the water after installation to ensure that it was safe in all three approaches. Therefore, there were no differences in access to technical information between the three approaches.

In summary, the TD process is likely to perform worse than the RCP process because it uses local information less effectively and attempts to control elite capture by locating sources on public land, both of which contribute to inconvenient placement of wells, discouraging funding contributions and use. Its performance may be relatively better in Matlab because there may be less elite capture of TD wells in Matlab than in Gopalganj and the RCP process may have weaker control over elite capture in Matlab than in Gopalganj. The TD process achieves a similar change in access to safe water as the CP process because any gains in access that it achieves through better control over elite capture relative to the CP process, it loses through more inconvenient well placement.

[42] See Tables12a and 12b .

9.2 Comparing the two participatory approaches

The difference in the change in access to safe water between the two participatory approaches stems mainly from the allocation of influence over decisions — the second mechanism. Differences between the two processes and the characteristics of village residents who use the installed water sources suggest stronger influence of elites in the CP process. In the RCP process, a broader cross-section of the village community participates in the decision making process, and more people contribute funding to the sources of safe water.[43] Also, more people who do not use wells installed by the project switch to safe water.[44]

We first examine participation in the decision making process. The process consisted of meetings organized by the project and meetings organized by the communities to discuss installation of safe water sources. Meetings organized by the project served to make decisions only under the RCP process, while the meeting in the CP process instructed the community to make their own decisions outside the meeting, and the meeting in the TD process informed the community about the decisions made by project staff.

Evidence suggests that more people participated in decision making in the RCP process than in the CP process. More than 94% percent of survey respondents in villages that were assigned to the RCP process reported that decisions about safe water sources were made in a big meeting.[45] 63% of respondents in CP villages reported that the village made decisions in a big meeting, while 27% said that influential people made the decision in a small meeting, and 9% said that men took the decisions in a meeting which excluded women. However, the survey responses in CP villages are at odds with focus group discussions, which are a more suitable method of learning how a process unfolds. In every FGD conducted in a CP village, FGD participants initially respond to a request to describe the decision making process by saying that the community made decisions in a meeting. However, after a follow-up question that asks who made the decisions, all say that a small group of influential people, usually men, or village leaders met by themselves and made all decisions. Survey respondents, who were asked how the decisions were made, are most likely offering the initial response that FGD participants give and the survey does not provide the opportunity for a clarifying question. All FGDs in CP villages report that influential people installed the sources on their own land, for their own benefit, and are restricting the use of the source by others. One person installed a fence around the source. There were exceptions. One FGD mentions that one of the people who installed a source changed the location from his own land to a more accessible place to benefit a greater number of village residents.

FGDs in RCP villages report a much more inclusive process, and participants praise attendance at the meetings by various groups. They report that individuals who were proposing plans for locating the sources of safe water worked hard to convince other attendees that their proposed locations would benefit many in the community. FGD participants also praise the requirement

[43] See Tables 11a and 11b.
[44] See Tables 13a and 13b.
[45] Among respondents who answered the question.

that decisions be made unanimously. Not all those who attended the RCP meetings may have participated in the discussion but the project staff met with small groups before the meeting to encourage participation, and project staff attended the meetings at which decisions were made and they encouraged people to participate. All decisions had to have unanimous agreement, and this requirement was enforced by project staff, so at least at the agreement stage there was broad participation.

Attendance at meetings organized by the project is not a good indicator of participation for villages assigned to the CP and TD processes. However, these also indicate broader participation in RCP villages. As we show in Tables 11a and 11b, the average number of participants was somewhat higher in the RCP meetings than in CP or TD meetings in both Matlab and Gopalganj. The differences are not statistically significant. Participants are generally more diverse in the RCP meetings, though the only difference that is statistically significant is greater attendance by women in Matlab.

Second, we consider contributions to safe water sources. The mean number of contributors per water source installed was lowest in the CP villages in both districts and the differences between the CP process and the other two processes are statistically significant in both, as we show in Tables 11a and 11b.[46] Also, in villages in which we installed at least one source, the fraction of villages in which there was only one contributor per safe water source for each of the installed water sources was the largest in the CP process in Matlab, while the TD process and the CP process had the largest fraction in Gopalganj. The smaller number of contributors in CP villages, and the larger percentage of villages in which only one person contributed to each source suggest that the perceived right to use the well was much less widely distributed in CP villages.

Third, households who do not use wells installed by the project increase access to safe water under the RCP process but not in villages assigned to the other two processes. The RCP process has the smallest effect on fraction of users who use wells installed by the project in all income groups in Matlab, but it has the largest impact on access to safe water in Matlab, though most of these differences are not statistically significant.[47] The most likely reason is that the negotiations that produce agreement on installing new sources under the RCP process also re-negotiate the rights to use existing safe water sources, as a strategy to win the agreement of those for whom the new safe water sources are not convenient.

The requirements for participation and unanimity in the RCP process, enforced by project staff, appear to have successfully changed the community interaction relative to the decision making that the community undertakes without any restrictions, reducing the influence of the elites. The participation requirements helped to represent a diversity of interests in the decision making meeting, while unanimity forced proposals that could win the agreement of all those present. More than one meeting was required to arrive at consensus in several RCP villages. Most residents of the villages have known each other their entire lives. Residents, especially the elite, have well-

[46]We installed no wells in five villages. In these five villages, we code the number of contributors as equal to zero.
[47]See Tables 13b and 14b.

established reputations and most people know well which agreements are enforceable and which are not. Meeting participants may have agreed to installing the sources on land owned by persons who had a reputation in the village for respecting the needs of others, following social norms with respect to sharing, and/or abiding by agreements made, for example to allow access to the source to households specified in an agreement in the meeting. Alternatively, meeting participants may have entered into agreements supported by enforceable sanctions or rewards. The negotiations almost certainly did not eliminate the capture of access to water sources by elites, but they reduced the extent of capture.

The bargaining carried out under the RCP approach had a weaker effect on outcomes in Matlab than in Gopalganj. As in Gopalganj, many outcomes in Matlab, except number of contributors to wells and fraction of villages in which only one person contributed funding to all wells, are very similar under the TD process and the CP process. The difference is that many outcomes of the RCP process are worse than the outcomes of the TD and CP processes, for example many measures of well location. The reason that the RCP process still improves access to safe water no less than do the other two processes in Matlab is that the RCP process improves access to safe water among those who do not use wells installed by the project. One possible reason why the performance of RCP is weaker in Matlab is that the broader access to safe drinking water at baseline in Matlab made bargaining under the RCP process more difficult because people viewed agreement as less urgent. One version of this reason is that elites may have had less incentive to capture the new wells because many of them already had access to safe water at baseline and they were less willing to make compromises needed to win unanimous agreements, potentially driving all except those residents who had the greatest need away from the meetings at which negotiations happened. A second possibility is that there is less wealth inequality in villages in Matlab because the elites in the district have a stronger culture of serving the communities, and elite capture in Matlab was more benevolent than in Gopalganj. In such an environment, the unanimity requirement in the RCP approach may have had the undesirable effect of producing too much conflict.

Another potential explanation for the difference in access to safe water between RCP and other villages is the third mechanism, that people are more satisfied with the decision making approach under the RCP process and/or they develop more trust in the project team under that approach. We asked respondents a number of questions about the decision making process implemented by the project. The largest fraction of households agreed with decisions taken under the RCP process in Gopalganj and the TD process in Matlab, and perceived the RCP process as most fair in Gopalganj, and the TD process as most fair in Matlab. There was therefore no systematic preference for participation models, suggesting that the third mechanism did not drive differences in outcomes. Tables 12a and 12b reports the results of this analysis.

The suggestion has been made in the literature that some degree of elite control can improve project outcomes because elites can contribute resources to the project and/or help resolve community conflicts and arrive at decisions (e.g. Dasgupta & Beard, 2007; Fritzen, 2007). The extent to which elites improve outcomes will depend on how self-interested the elites are and whether they have an interest in project outcomes. Our data offers qualified support for the potential benefits gained by involving community elites. The CP process allows elite involvement with no control over their influence, and outcomes are no worse than result from the TD process. Some FGDs do mention the positive role of individual elite members in providing water for the community, countering the selfish influence of other elites, and/or mediating community conflict to the benefit of the entire community. On the other hand, limiting the influence of elites, as the RCP process does, improves outcomes. We cannot say whether outcomes would be better or worse with stronger limitations on elite involvement.

10 How robust are the results?

In Table 9, we show that the main results are robust across a range of different specifications. We focus on the differences in change in access to safe drinking water across models in villages in which tubewells are feasible.[48] Column 1 shows the main results for comparison. In column 2, we estimate the same analysis at the household level, using weights that correspond to allowing each village to count equally in the analysis, and clustering standard errors at the village level. The results are almost identical.

In column 3, we include the matched control villages as a comparison group. As the control group experienced no net change in access to safe drinking water, this changes the point estimates very little. In column 4, we estimate an instrumental variables regression where we instrument for treatment under a given model with synthetic treatment interacted with model assignment. The point estimates are almost identical, although the standard errors are somewhat larger. In column 5, we estimate a fully saturated model and report the population mean effect by aggregating the estimated effect in Matlab with the estimated effect in Gopalganj. The point estimates are mechanically identical to the main estimates, with some gain in precision resulting from modelling the upazila-level heterogeneity.

In column 6, we use an alternative measure of access to safe drinking water, which uses a verified measure of access to safe drinking water where this is available. This was verified by the enumerators who examined the source for evidence of whether the source was safe or unsafe. This measure was not available for all households, so we use the reported measure when this measure was unavailable. Using this measure strengthens the main results.

Analysis shown in Appendix Table B10 confirms that the results for the full sample of treated villages are similarly stable across different specification choices.

When we measure changes in access to safe drinking water at the household level, the variable is a limited dependent variable (LDV), as it can only take the values -1, 0 or 1. When collapsed to the village level, the variable is a continuous measure that is bounded between -1 and 1. Appendix Table B11 confirms that results are very similar if we use alternative estimation techniques that explicitly model the outcome as an LDV.

[48]We also show similar robustness checks for the average treatment effect in Appendix Table B7.

Although baseline differences between villages treated under different decision-making models were not statistically significant, there were nonetheless relatively important differences in baseline variables between models. In particular, villages treated under the RCP model had lower access to safe drinking water at baseline. One might worry that these differences might influence the comparison across models for a number of reasons. In particular, the change in access to safe drinking water is mechanically correlated with baseline access to safe drinking water, and the maximum feasible change in safe drinking water is bounded by the size of the population without access to safe drinking water at baseline. Figure 2 plots the change in access to safe drinking water against baseline access to safe drinking water for all treated villages and the matched control group, and shows that the RCP model dominates the other two for most of the range of baseline access to safe drinking water.[49]

Villages treated under the RCP model were also somewhat smaller, and although the predicted effect of group size on collective action is ambiguous (Banerjee, Iyer, & Somanathan, 2008), the effect of our intervention might have been larger in smaller villages because the number of wells per head is higher. Figure 3 shows that the average treatment effect does indeed decline with village size, as does the absolute difference between the models, but that the RCP model dominates the two other models across the full range of village sizes.[50]

11 Conclusion

This study uses a randomized control trial to examine whether and how delegation of decision-making authority to the community influences access to safe drinking water relative to a traditional top-down process. We implement two approaches to delegating decisions to the community: an approach in which the community decides how it will make decisions, and a regulated community approach, which uses participation requirements and the rule that decisions must be unanimous to limit the influence of elites.

We find that delegating decisions improves access to safe drinking water relative to a top down approach only if the delegation mechanism limits the influence of the community's elites. The regulated community approach appears to achieve better outcomes for two reasons: it uses information that the community has more effectively than does the top down approach, and it induces the communities to negotiate agreements to install sources of safe water that limit the influence of elites more successfully than do both of the other approaches. The effectiveness of the regulated community approach in limiting the influence of elites depends on characteristics of the social context.

Despite an effort to collect extensive information from the community, the top down approach achieves a smaller reduction in distance to the nearest source of safe water than does the regulated community approach. The reasons are the relatively ineffective use of local information relative to the other two approaches and an effort to balance locating sources of water on public land to avoid

[49] Appendix Figure B3 repeats this exercise for both upazilas separately.

[50] Appendix Figure B4 repeats this exercise for both upazilas separately.

capture of the sources by elites with selecting convenient locations. Locating sources on public land seems to reduce elite control over the sources more effectively in some places than in others.

More people and a more diverse set of people attend the meetings under the regulated community approach, and more people contribute to sources of safe water, than under the community participation approach. Participants in focus group discussions consistently report that in villages assigned to the community participation approach a small group of village leaders makes decisions behind closed doors. In regulated community approach villages, FGD participants report that intensive negotiations take place in order to win the agreement of the people present at the meeting with the decisions, to meet the unanimity requirement. These negotiations also increase access to safe water among community members who do not use the sources of water installed by the project. The other two approaches to decision making do not benefit households who do not use the installed sources.

The benefits, as measured by access to safe drinking water, are no different under the community approach than they are under the top down approach. The equivalence of the two approaches occurs in our experiment despite different mechanisms that limit the benefits under the two approaches. In the top down approach, the main shortcomings seem to be lack of access to or poor use of information that the community possesses and lack of effective means of influencing control over the installed sources. In the community approach, the limitation is due to decisions that represent a relatively narrow set of interests within the community.

There are a number of issues that this study leaves to future research. First, the results show heterogeneity in the performance of the three approaches to decision-making across contexts with different socio-economic characteristics. The reasons why the performance differs and the characterization of contexts in which the regulated community participation approach is more effective is an important outstanding question.

Second, we examine the short-term changes in access to safe drinking water that took place within months of the intervention. These effects may change over time, if the social interactions or agreements that shape the initial use of the wells evolve over time, and as communities and landowners on whose land the wells sit decide whether or not to maintain the wells. A follow-up grant is funding another study during which we collect data on use of the wells installed by this project 5-6 years after installation.

Third, in our experiment, the participation and unanimity requirements change the decision-making dynamic within communities sufficiently to influence project outcomes. While evidence is suggestive that these two requirements are complementary and work together to produce the outcome, we do not know how the performance of other limitations on elite influence would compare to these two requirements. This is a question for future research.

Fourth, the experiment compares two community participation processes to a top down process that includes more community involvement than is typical in top down approaches. Contribution of funding is an important form of community participation. Since we required funding contributions from the communities, a source of water could not be installed without the communities' agreement, as it could be if the community did not have to contribute funding. An important research question is how the relative performance of the top-down approach would differ in the absence of the requirement that communities contribute funding to the sources of water.

Finally, a remaining research challenge is developing a more comprehensive conceptual framework of the role that community participation plays in determining access to public services and development outcomes more broadly. Considerable empirical research is necessary to test the components that will be needed to construct such a framework.

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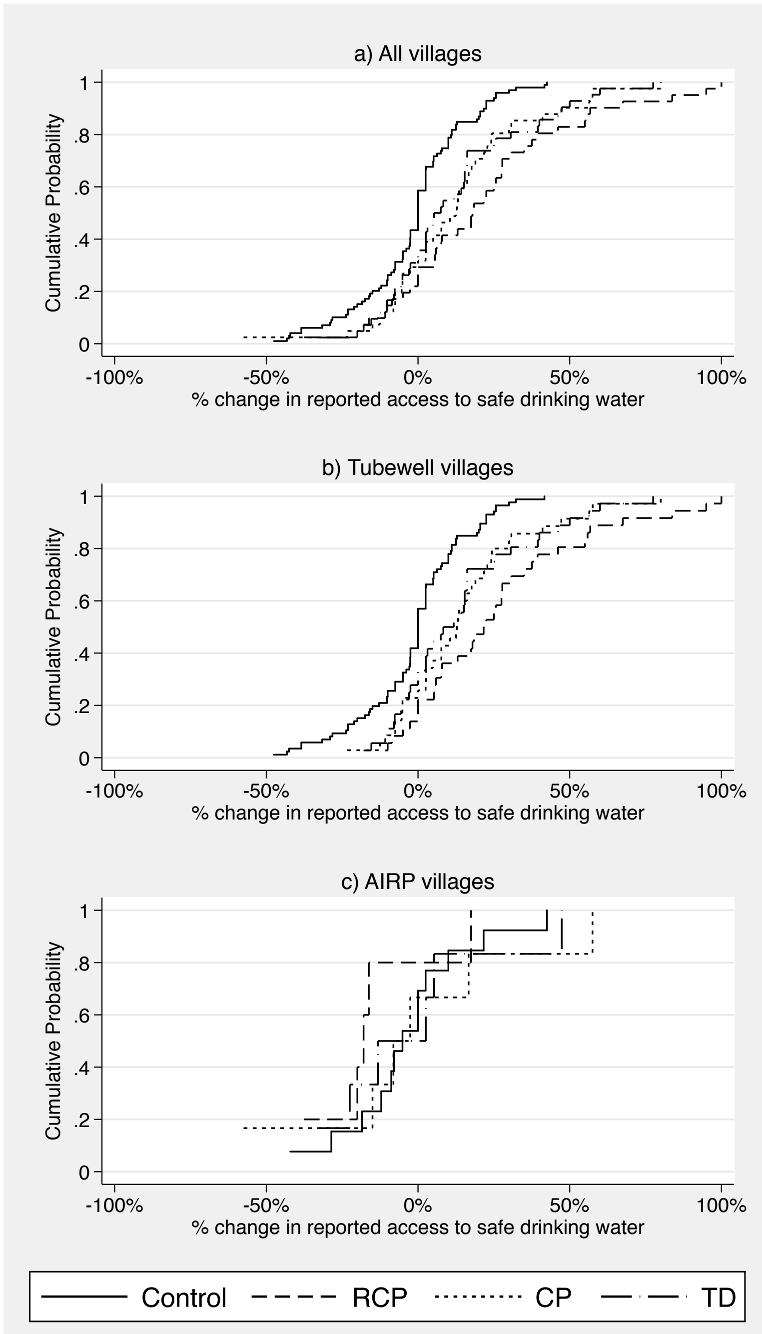
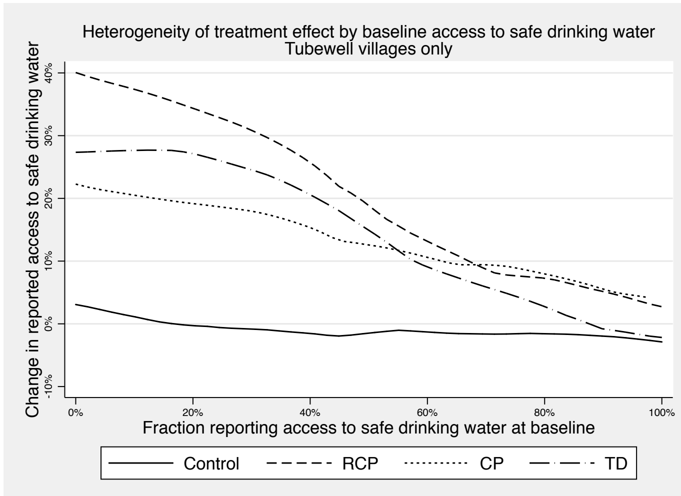
Figures and Tables

Figure 1: Empirical cumulative distribution functions of change in access to safe drinking water



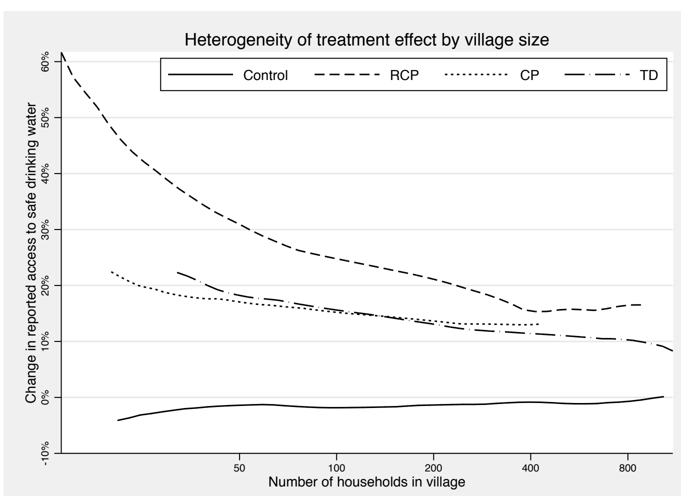
Graph shows empirical cumulative distribution functions of village-average change in reported access to safe drinking water for all study villages in panel a), villages in which tubewells were feasible and their matched control villages in panel b), and villages in which only AIRPs were feasible and their matched control villages in panel c).

Figure 2: Non-parametric estimates of heterogeneity of treatment effect by baseline access to safe drinking water



Graph shows results of a local linear regression plotting the change in access to safe drinking water against baseline access to safe drinking water for all villages in which tubewells were feasible and their matched control villages. Bandwidth = 0.2.

Figure 3: Non-parametric estimates of heterogeneity of treatment effect by village size



Graph shows results of a local linear regression plotting the change in access to safe drinking water against log village size for all villages in which tubewells were feasible and their matched control villages. Bandwidth = 0.75.

Table 1: Technologies to provide arsenic-safe drinking water

Technology	Cost	Required community contribution per safe water source installed: 1	2	3
Deep tubewell (DTW)	50,000	4,500	6,000	7,500
Shallow tubewell (STW)	20,000	3,000	3,500	4,000
Arsenic-Iron Removal Plant (AIRP)	60,000	6,000	7,500	N/A
Deep-set tubewell (DSTW)	60,000	6,000	7,500	N/A

Note: All prices in Bangladeshi Taka. 1 US$≈ 80BDT.

Table 2: Decision-making structures

Non-participatory	Top Down (TD)	Project staff took all project decisions, after an extended (typically 2-day) period of information gathering, using the following criteria to decide water source location: • public/convenient location • population density • existing safe water options
Participatory	Community Participation (CP)	The community took all project decisions using their own (unobserved) decision-making structures, following a community-wide information meeting led by project staff.
	Regulated Community Participation (RCP)	The community took all project decisions at a community-wide meeting, following smaller information meetings for different groups. We imposed two decision-making rules. If decisions made did not satisfy these rules, project staff did not implement the decisions: • Attendance at the community meeting had to include: at least 10 men, of which 5 had to qualify as poor; and at least 10 women, of which 5 had to qualify as poor. • Decisions had to be unanimous.

Table 3: Treated vs Control
Baseline Randomization Checks

		Sample	Treatment - Control			
		(1)	(2)	(3)	(4)	(5)
No of households in village	Mean	231	-25	-24	-17	-23
	s.e.	(13)	(27)	(29)	(27)	(35)
% of water sources arsenic contaminated	Mean	0.95	0.00	0.01	0.00	0.00
	s.e.	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Reports using arsenic safe water	Mean	0.47	-0.13***	-0.02	0.00	0.00
	s.e.	(0.02)	(0.04)	(0.04)	(0.04)	(0.05)
Changed water source due to arsenic, last 5 years?	Mean	0.41	-0.12***	-0.01	0.00	0.00
	s.e.	(0.02)	(0.03)	(0.03)	(0.04)	(0.05)
Symptoms of arsenic poisoing, anyone in hh?	Mean	0.0085	-0.0001	-0.0012	-0.0019	-0.0025
	s.e.	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)
Total value of household assets	Mean	555	-25	-15	-25	-33
	s.e.	(18)	(37)	(42)	(37)	(48)
Access to electricity?	Mean	0.424	-0.064	-0.046	-0.046	-0.060
	s.e.	(0.02)	(0.04)	(0.05)	(0.04)	(0.06)
Household head literate	Mean	0.604	-0.005	0.008	0.003	0.003
	s.e.	(0.013)	(0.026)	(0.030)	(0.026)	(0.033)
Household head Muslim	Mean	0.70	0.02	0.04	0.02	0.02
	s.e.	(0.03)	(0.05)	(0.05)	(0.05)	(0.06)
Household head farmer	Mean	0.43	0.02	0.03	0.02	0.03
	s.e.	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
Number of associations in community	Mean	6.26	-0.01	-0.20	-0.10	-0.14
	s.e.	(0.10)	(0.19)	(0.22)	(0.19)	(0.25)
Number of collective actions in community	Mean	0.93	0.15**	0.05	-0.02	-0.02
	s.e.	(0.06)	(0.06)	(0.05)	(0.06)	(0.08)
F-statistic from Hotelling's T-squared			1.88	0.94	0.35	
Number of villages			225	196	225	225
Number of households			8811	7676	8811	8811
Includes South Matlab?			Yes	No	Yes	Yes
Treatment variable?			Implemented	Implemented	Synthetic	Synthetic
Estimation			OLS	OLS	OLS	IV

Note: Column 1 shows the mean value across all sample villages. Columns 2-5 show the regression-estimated difference between treatment and control villages, controlling for upazila-level stratification (an indicator for Gopalganj). Data in rows 1 and 2 comes from the Bangladesh Arsenic Mitigation Water Supply Project. All other data is from baseline household surveys. Data is collapsed to village-level means and standard errors (in parentheses) are robust. F-statistics from Hotelling's T-squared test equality of means between synthetic or implemented treated and control groups, and do not account for stratification by upazila, which may overreject the null hypothesis of no difference between groups. Asterisks reflect regression-estimated significance of differences between groups. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Assignment to decision-making structure
Baseline Summary Statistics and Randomization Checks

		TD (1)	CP (2)	RCP (3)
Proportion of villages in Gopalganj	Mean	0.55	0.55	0.54
	s.e.	(0.08)	(0.08)	(0.08)
Proportion of villages in South Matlab	Mean	0.24	0.21	0.24
	s.e.	(0.07)	(0.06)	(0.07)
No of households in village	Mean	238	213	214
	s.e.	(32)	(24)	(34)
% of water sources arsenic contaminated	Mean	0.95	0.95	0.96
	s.e.	(0.01)	(0.01)	(0.01)
AIRPs only feasible technology	Mean	0.14	0.14	0.12
	s.e.	(0.05)	(0.05)	(0.05)
Reports using arsenic safe water	Mean	0.44	0.41	0.35
	s.e.	(0.05)	(0.05)	(0.05)
Changed water source due to arsenic, last 5 years?	Mean	0.38	0.35	0.31
	s.e.	(0.05)	(0.05)	(0.05)
Symptoms of arsenic poisoning, anyone in hh?	Mean	0.011	0.009	0.004**
	s.e.	(0.003)	(0.003)	(0.002)
Total value of household assets (in thousand BDT)	Mean	530	548	547
	s.e.	(31)	(42)	(41)
Access to electricity?	Mean	0.41	0.39	0.38
	s.e.	(0.05)	(0.05)	(0.05)
Household head literate	Mean	0.62	0.58	0.60
	s.e.	(0.02)	(0.03)	(0.02)
Household head Muslim	Mean	0.72	0.70	0.70
	s.e.	(0.06)	(0.06)	(0.06)
Household head farmer	Mean	0.43	0.46	0.44
	s.e.	(0.03)	(0.02)	(0.03)
Number of associations in community	Mean	6.49	6.04	6.28
	s.e.	(0.31)	(0.19)	(0.24)
Number of collective actions in community	Mean	0.99	1.00	0.92
	s.e.	(0.16)	(0.16)	(0.14)
F-statistic from Hotelling's T-squared		0.45	0.31	0.58
Number of villages		42	42	41
Number of households		1663	1635	1598

Note: Table shows village means of baseline variable in treated villages. Data from household surveys except rows 1), 2) and 5) which come from project records and rows 3) and 4) which come from the Bangladesh Arsenic Mitigation Water Supply Project. Standard errors (in parentheses) are robust. Asterisks reflect regression-estimated significance of differences between villages treated under one model and the pooled remaining treated villages. F-statistics from Hotelling's T-squared test equality of means on all variables between villages treated under one model and the remaining treated villages. Pairwise Hotelling's T-squared tests yield F-statistics as follows: RCP = TD 0.75; CP = RCP 0.50; TD = CP 0.32. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Number of water sources installed

		Max. possible no. sources		No. water sources installed		Proportion installed	
		(1)	(2)	(3)	(4)	(5)	(6)
Treated	Mean	2.79	2.91	2.18	2.45	0.76	0.84
	s.e.	(0.04)	(0.03)	(0.10)	(0.08)	(0.03)	(0.03)
TD	Mean	2.79	2.92	2.05	2.36	0.71	0.81
	s.e.	(0.06)	(0.05)	(0.18)	(0.16)	(0.06)	(0.05)
CP	Mean	2.76	2.89	2.21	2.53	0.77	0.87
	s.e.	(0.07)	(0.05)	(0.17)	(0.14)	(0.06)	(0.05)
RCP	Mean	2.83	2.92	2.27	2.46	0.79	0.85
	s.e.	(0.06)	(0.05)	(0.15)	(0.13)	(0.05)	(0.04)
RCP = CP	p-value	0.452	0.669	0.815	0.718	0.808	0.708
CP = TD	p-value	0.797	0.695	0.505	0.428	0.477	0.429
TD = RCP	p-value	0.619	0.973	0.351	0.624	0.329	0.634
TD = pooled	p-value	0.903	0.829	0.366	0.467	0.340	0.473
CP = pooled	p-value	0.569	0.642	0.782	0.498	0.765	0.492
RCP = pooled	p-value	0.461	0.779	0.485	0.927	0.465	0.938
	N	125	109	125	109	125	109
Villages included in sample:		All treated	Tubewells feasible	All treated	Tubewells feasible	All treated	Tubewells feasible

Note: P-values test: (1) pairwise significance of the difference between the means across models indicated, from a regression of the outcome variable on indicators for the three types of treatment (with no constant); (2) significance of the difference between means under one model and the remainder of the treated villages. Robust standard errors shown in parentheses.

Table 6: Estimates of average treatment effect

		OLS (1)	OLS (2)	IV (3)	OLS (4)	OLS (5)	IV (6)	OLS (7)
Panel A: Reported access to safe drinking water at follow-up								
Treated	Coeff.	0.04	0.14***	0.16***	0.05	0.16***	0.20***	0.01
	s.e.	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.05)	(0.08)
Gopalganj	Coeff.	-0.46***	-0.57***	-0.47***	-0.41***	-0.53***	-0.42***	
	s.e.	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	
Constant	Coeff.	0.76	0.82	0.70	0.76	0.81	0.68	0.18
	s.e.	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.06)
	First-stage F-test			303			211	
	Hausman test p-value			0.000			0.000	
	N	224	195	224	194	165	194	30
Panel B: Change in reported access to safe drinking water								
Treated	Coeff.	0.17***	0.15***	0.16***	0.20***	0.18***	0.20***	-0.02
	s.e.	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)	(0.09)
Gopalganj	Coeff.	-0.02	0.00	-0.02	0.02	0.03	0.02	
	s.e.	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	
Constant	Coeff.	0.00	-0.01	0.00	-0.02	-0.02	-0.02	-0.04
	s.e.	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.06)
	First-stage F-test			301			208	
	Hausman test p-value			0.707			0.971	
	N	223	194	223	193	164	193	30
	Feasible technology	All	All	All	Tubewell	Tubewell	Tubewell	AIRP
	Sample	All	No S. Matlab	All	All	No S. Matlab	All	Gopalganj
	Control villages	All	All	All	Matched	Matched	Matched	Matched

Note: Treatment is instrumented using synthetic assignment to treatment in Matlab in columns 3 and 6. In columns 4 to 7 the control group is matched to the subset of treated villages. Data is collapsed to village-level means and robust standard errors are shown in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 7: Comparison of access to safe drinking water by decision-making model

		Change in access to safe drinking water		
		(1)	(2)	(3)
TD	Coefficient	0.12***	0.14***	-0.02
	s.e.	(0.04)	(0.04)	(0.12)
CP	Coefficient	0.12***	0.15***	-0.02
	s.e.	(0.04)	(0.04)	(0.16)
RCP	Coefficient	0.21***	0.26***	-0.15
	s.e.	(0.05)	(0.05)	(0.09)
	RCP = CP	0.157	0.062*	0.468
	CP = TD	0.934	0.929	0.973
	TD = RCP	0.131	0.055*	0.399
	TD = pooled	0.319	0.205	0.716
	CP = pooled	0.406	0.260	0.708
	RCP = pooled	0.102	0.035**	0.321
	N	124	107	17
	Feasible technology	All	Tubewell	AIRP

Note: Outcome variable is change in reported access to safe drinking water. Data is collapsed to village level means and robust standard errors are in parentheses. Regressions on treated villages only. P-values reported test i) pairwise significance of the difference between the means across models indicated, from a regression of the outcome variable on indicators for the three types of treatment (with no constant) ii) significance of the difference between means under one model and the remainder of the treated villages. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Comparison of access to safe drinking water by decision-making model
Sub-sample estimates

		Change in access to safe drinking water				
		(1)	(2)	(3)	(4)	(5)
TD	Coefficient	0.12	0.16	0.12	0.20	0.04
	s.e.	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)
CP	Coefficient	0.11	0.15	0.15	0.17	0.13
	s.e.	(0.06)	(0.05)	(0.05)	(0.09)	(0.06)
RCP	Coefficient	0.26	0.38	0.16	0.24	0.07
	s.e.	(0.08)	(0.07)	(0.05)	(0.08)	(0.06)
	RCP = CP	0.116	0.017**	0.883	0.557	0.480
	CP = TD	0.904	0.854	0.742	0.738	0.286
	TD = RCP	0.143	0.035**	0.626	0.725	0.700
	TD = pooled	0.391	0.226	0.625	0.991	0.399
	CP = pooled	0.290	0.108	0.923	0.599	0.293
	RCP = pooled	0.092*	0.012**	0.715	0.579	0.859
	N	68	51	56	29	27
	Feasible technology	All	Tubewell	Tubewell	Tubewell	Tubewell
	Upazila	Gopalganj	Gopalganj	Matlab	S. Matlab	N. Matlab

Note: Outcome variable is change in reported access to safe drinking water. Data is collapsed to village level means and robust standard errors are in parentheses. Regressions on treated villages only. P-values reported test i) pairwise significance of the difference between the means across models indicated, from a regression of the outcome variable on indicators for the three types of treatment (with no constant) ii) significance of the difference between means under one model and the remainder of the treated villages. *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Comparison of access to safe drinking water by decision-making model
Main robustness checks

		Change in access to safe drinking water					
		OLS	OLS	OLS	IV	OLS	OLS
		(1)	(2)	(3)	(4)	(5)	(6)
TD	Coefficient	0.14	0.14	0.15	0.17	0.14	0.15
	s.e.	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
CP	Coefficient	0.15	0.15	0.16	0.16	0.15	0.15
	s.e.	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
RCP	Coefficient	0.26	0.26	0.27	0.27	0.26	0.31
	s.e.	(0.05)	(0.05)	(0.05)	(0.06)	(0.04)	(0.05)
Constant	Coefficient			-0.01	-0.01		
	s.e.			(0.02)	(0.02)		
	RCP = CP	0.062*	0.061*	0.060*	0.095*	0.053*	0.014**
	CP = TD	0.929	0.954	0.929	0.743	0.931	0.921
	TD = RCP	0.055*	0.057*	0.053*	0.182	0.047**	0.012**
	TD = pooled	0.205	0.222	0.203	0.503	0.208	0.096*
	CP = pooled	0.260	0.258	0.258	0.217	0.258	0.133
	RCP = pooled	0.035**	0.035**	0.033**	0.098*	0.026**	0.006***
	SW First stage F-stat: TD				182		
	SW First stage F-stat: CP				196		
	SW First stage F-stat: RCP				180		
	Hausman test p-value				0.51		
	N	107	3977	193	193	107	107
	Unit of analysis	Village	Household	Village	Village	Village	Village
	Includes control group	No	No	Yes	Yes	No	No
	Fully saturated	No	No	No	No	Yes	No
	Measure of access	Reported	Reported	Reported	Reported	Reported	Combined

Note: Outcome variable is change in reported access to safe drinking water. Results shown are for villages in which tubewells were feasible and matched control villages only. Corresponding regressions for the full sample are shown in Appendix Table B10. Data is collapsed to village level-means except in column 2, where the unit of analysis is the household. Weights are applied in column 2 so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. In column 4, the instruments for treatment under a given decision-making model are the synthetic treatment dummy interacted with decision-making model assignment. In column 5, we show the point estimate obtained by estimating a fully saturated model with decision-making model - upazila interactions, and aggregating the estimated average population effected across the treated population. P-values reported test: i) pairwise significance of the difference between the means across models indicated, from a regression of the outcome variable on indicators for the three types of treatment (and a constant, when the control group is included) ii) significance of the difference between means under one model and the remainder of the treated villages. *** p<0.01, ** p<0.05, * p<0.1.

Table 10a: Location of wells
Gopalganj

		TD	CP	RCP		p-value
Number of sources built on public land	Coeff	2.18	1.06	1.18	TD = pooled	0.000***
	s.e.	(0.23)	(0.20)	(0.25)	CP = pooled	0.029**
	N		51		RCP = pooled	0.152
Fraction of sources built on public land	Coeff	0.96	0.42	0.57	TD = pooled	0.000***
	s.e.	(0.03)	(0.08)	(0.11)	CP = pooled	0.002***
	N		49		RCP = pooled	0.387
Distance to nearest project well (minutes)	Coeff	12.1	12.9	6.0	TD = pooled	0.349
	s.e.	(2.4)	(1.8)	(0.8)	CP = pooled	0.096*
	N		1815		RCP = pooled	0.000***
Change in distance to nearest safe source (minutes)	Coeff	-5.1	-9.1	-12.5	TD = pooled	0.024**
	s.e.	(1.7)	(2.1)	(2.5)	CP = pooled	0.833
	N		1566		RCP = pooled	0.068*
Change in distance to main source (minutes)	Coeff	-0.1	-0.6	-0.2	TD = pooled	0.499
	s.e.	(0.4)	(0.5)	(0.4)	CP = pooled	0.440
	N		1909		RCP = pooled	0.806
Change in distance to main source, if using unsafe water at baseline (minutes)	Coeff	0.9	0.4	0.6	TD = pooled	0.160
	s.e.	(0.2)	(0.3)	(0.2)	CP = pooled	0.259
	N		1402		RCP = pooled	0.925
Change in distance to main source, if using safe water at baseline (minutes)	Coeff	-2.4	-3.0	-4.4	TD = pooled	0.358
	s.e.	(0.83)	(0.99)	(1.67)	CP = pooled	0.895
	N		507		RCP = pooled	0.333

Note: Outcome variable as listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the village when the outcome variable of interest is only measured at the village level. When the unit of analysis is the household, weights are applied so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values. *** p<0.01, ** p<0.05, * p<0.1.

Table 10b: Location of wells
Matlab

		TD	CP	RCP		p-value
Number of sources built on public land	Coeff	2.42	1.21	1.47	TD = pooled	0.000***
	s.e.	(0.21)	(0.22)	(0.14)	CP = pooled	0.008***
	N		57		RCP = pooled	0.140
Fraction of sources built on public land	Coeff	1.0	0.49	0.54	TD = pooled	0.000***
	s.e.	(0.0)	(0.08)	(0.05)	CP = pooled	0.005***
	N		54		RCP = pooled	0.007***
Distance to nearest project well (minutes)	Coeff	5.5	7.4	7.1	TD = pooled	0.010***
	s.e.	(0.5)	(0.6)	(0.6)	CP = pooled	0.137
	N		1927		RCP = pooled	0.339
Change in distance to nearest safe source (minutes)	Coeff	-2.0	-2.7	-2.4	TD = pooled	0.421
	s.e.	(0.4)	(0.8)	(0.8)	CP = pooled	0.606
	N		2064		RCP = pooled	0.899
Change in distance to main source (minutes)	Coeff	-0.5	0.1	0.1	TD = pooled	0.020**
	s.e.	(0.2)	(0.2)	(0.1)	CP = pooled	0.207
	N		2063		RCP = pooled	0.134
Change in distance to main source, if using unsafe water at baseline (minutes)	Coeff	0.3	0.7	0.6	TD = pooled	0.079*
	s.e.	(0.2)	(0.2)	(0.2)	CP = pooled	0.286
	N		846		RCP = pooled	0.685
Change in distance to main source, if using safe water at baseline (minutes)	Coeff	-1.0	-0.4	-0.4	TD = pooled	0.134
	s.e.	(0.31)	(0.36)	(0.13)	CP = pooled	0.490
	N		1217		RCP = pooled	0.249

Note: Outcome variable as listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the village when the outcome variable of interest is only measured at the village level. When the unit of analysis is the household, weights are applied so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values. *** p<0.01, ** p<0.05, * p<0.1.

Table 11a: Participation in process: Meeting attendance and contributions
Gopalganj

		TD	CP	RCP		p-value
Panel A: Participation in community meeting						
Number of meeting attendees	Coeff	30.2	31.0	34.4	TD = pooled	0.576
	s.e.	(3.3)	(2.2)	(5.2)	CP = pooled	0.734
	N		51		RCP = pooled	0.504
Fraction of meeting attendees with low socioeconomic status	Coeff	0.36	0.46	0.44	TD = pooled	0.172
	s.e.	(0.05)	(0.05)	(0.06)	CP = pooled	0.332
	N		50		RCP = pooled	0.685
Fraction of meeting attendees with less than primary education	Coeff	0.27	0.23	0.30	TD = pooled	0.893
	s.e.	(0.05)	(0.05)	(0.05)	CP = pooled	0.331
	N		50		RCP = pooled	0.417
Fraction of meeting attendees female	Coeff	0.19	0.20	0.22	TD = pooled	0.700
	s.e.	(0.05)	(0.04)	(0.04)	CP = pooled	0.949
	N		50		RCP = pooled	0.639
Panel B: Contributions						
Number of contributing households	Coeff	7.6	4.8	11.5	TD = pooled	0.889
	s.e.	(2.9)	(1.1)	(3.2)	CP = pooled	0.053*
	N		51		RCP = pooled	0.138
Fraction of villages with one household paying contribution per well	Coeff	0.75	0.71	0.50	TD = pooled	0.311
	s.e.	(0.11)	(0.11)	(0.13)	CP = pooled	0.574
	N		49		RCP = pooled	0.137

Note: Outcome variable as listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the village. Robust standard errors are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values.
** p<0.01, ** p<0.05, * p<0.1.

Table 11b: Participation in process: Meeting attendance and contributions
Matlab

		TD	CP	RCP		p-value
Panel A: Participation in community meeting						
Number of meeting attendees	Coeff	28.5	28.4	31.7	TD = pooled	0.548
	s.e.	(2.3)	(1.1)	(2.2)	CP = pooled	0.382
	N		57		RCP = pooled	0.195
Fraction of meeting attendees with low socioeconomic status	Coeff	0.38	0.48	0.46	TD = pooled	0.062*
	s.e.	(0.04)	(0.03)	(0.06)	CP = pooled	0.130
	N		53		RCP = pooled	0.648
Fraction of meeting attendees with less than primary education	Coeff	0.29	0.26	0.27	TD = pooled	0.449
	s.e.	(0.03)	(0.03)	(0.03)	CP = pooled	0.504
	N		56		RCP = pooled	0.903
Fraction of meeting attendees female	Coeff	0.27	0.36	0.44	TD = pooled	0.006***
	s.e.	(0.04)	(0.03)	(0.02)	CP = pooled	0.907
	N		56		RCP = pooled	0.000***
Panel B: Contributions						
Number of contributing households	Coeff	12.7	7.3	10.3	TD = pooled	0.121
	s.e.	(2.2)	(1.7)	(1.8)	CP = pooled	0.059*
	N		56		RCP = pooled	0.914
Fraction of villages with one household paying contribution per well	Coeff	0.17	0.35	0.17	TD = pooled	0.443
	s.e.	(0.09)	(0.12)	(0.09)	CP = pooled	0.171
	N		53		RCP = pooled	0.443

Note: Outcome variable as listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the village. Robust standard errors are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values.
** p<0.01, ** p<0.05, * p<0.1.

Table 12a: Project knowledge and perception
Gopalganj

		TD	CP	RCP		p-value
Has knowledge of NGO	Coeff	1.00	1.00	0.96	TD = pooled	0.343
Forum safe drinking water	s.e.	(0.00)	(0.00)	(0.04)	CP = pooled	0.342
program	N		1920		RCP = pooled	0.334
	Coeff	0.76	0.72	0.86	TD = pooled	0.665
Agreed with decisions taken	s.e.	(0.05)	(0.05)	(0.04)	CP = pooled	0.123
	N		1830		RCP = pooled	0.020**
Number of water sources too few	Coeff	0.09	0.16	0.09	TD = pooled	0.529
	s.e.	(0.04)	(0.04)	(0.03)	CP = pooled	0.157
	N		1829		RCP = pooled	0.379
Sources installed too far away from house	Coeff	0.12	0.12	0.03	TD = pooled	0.373
	s.e.	(0.04)	(0.04)	(0.01)	CP = pooled	0.241
	N		1829		RCP = pooled	0.004***

Note: Outcome variable as listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the village when the outcome variable of interest is only measured at the village level. When the unit of analysis is the household, weights are applied so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values. *** p<0.01, ** p<0.05, * p<0.1.

Table 12b: Project knowledge and perception
Matlab

		TD	CP	RCP		p-value
Has knowledge of NGO	Coeff	1.00	0.96	0.98	TD = pooled	0.114
Forum safe drinking water	s.e.	(0.00)	(0.03)	(0.01)	CP = pooled	0.326
program	N		2068		RCP = pooled	0.840
	Coeff	0.79	0.68	0.65	TD = pooled	0.001***
Agreed with decisions taken	s.e.	(0.02)	(0.04)	(0.03)	CP = pooled	0.345
	N		1892		RCP = pooled	0.033**
Number of water sources too few	Coeff	0.07	0.07	0.12	TD = pooled	0.174
	s.e.	(0.02)	(0.02)	(0.02)	CP = pooled	0.199
	N		1893		RCP = pooled	0.023**
Sources installed too far away from house	Coeff	0.08	0.12	0.16	TD = pooled	0.013**
	s.e.	(0.02)	(0.02)	(0.02)	CP = pooled	0.989
	N		1893		RCP = pooled	0.035**

Note: Outcome variable as listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the village when the outcome variable of interest is only measured at the village level. When the unit of analysis is the household, weights are applied so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values. *** p<0.01, ** p<0.05, * p<0.1.

Table 13a: Heterogeneity in change in access
Gopalganj

		Change in access to safe drinking water TD	CP	RCP		p-value
All households	Coeff	0.17	0.15	0.38	TD = pooled	0.257
	s.e.	(0.06)	(0.05)	(0.07)	CP = pooled	0.103
	N		1912		RCP = pooled	0.012**
Poor or very poor households	Coeff	0.22	0.20	0.45	TD = pooled	0.316
	s.e.	(0.09)	(0.07)	(0.09)	CP = pooled	0.142
	N		704		RCP = pooled	0.027**
Low-income households	Coeff	0.16	0.14	0.35	TD = pooled	0.260
	s.e.	(0.05)	(0.06)	(0.07)	CP = pooled	0.156
	N		836		RCP = pooled	0.013**
Middle or high-income households	Coeff	0.09	0.08	0.28	TD = pooled	0.419
	s.e.	(0.08)	(0.04)	(0.11)	CP = pooled	0.235
	N		369		RCP = pooled	0.105
Households reporting use of program water sources at follow-up	Coeff	0.64	0.65	0.81	TD = pooled	0.385
	s.e.	(0.10)	(0.10)	(0.08)	CP = pooled	0.405
	N		567		RCP = pooled	0.128
Households reporting use of other water sources at follow-up	Coeff	0.00	-0.01	0.07	TD = pooled	0.598
	s.e.	(0.05)	(0.03)	(0.04)	CP = pooled	0.444
	N		1337		RCP = pooled	0.151

Note: Outcome variable is change in access to safe drinking water, for sample listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the household. Weights are applied so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 13b: Heterogeneity in change in access
Matlab

		Change in access to safe drinking water TD	CP	RCP		p-value
All households	Coeff	0.12	0.15	0.16	TD = pooled	0.607
	s.e.	(0.04)	(0.05)	(0.05)	CP = pooled	0.918
	N		2065		RCP = pooled	0.700
Poor or very poor households	Coeff	0.11	0.20	0.15	TD = pooled	0.399
	s.e.	(0.07)	(0.06)	(0.06)	CP = pooled	0.349
	N		492		RCP = pooled	0.944
Low-income households	Coeff	0.12	0.18	0.19	TD = pooled	0.308
	s.e.	(0.04)	(0.06)	(0.06)	CP = pooled	0.775
	N		735		RCP = pooled	0.504
Middle or high-income households	Coeff	0.13	0.09	0.16	TD = pooled	0.877
	s.e.	(0.06)	(0.07)	(0.07)	CP = pooled	0.521
	N		792		RCP = pooled	0.604
Households reporting use of program water sources at follow-up	Coeff	0.31	0.43	0.31	TD = pooled	0.578
	s.e.	(0.08)	(0.11)	(0.09)	CP = pooled	0.373
	N		474		RCP = pooled	0.612
Households reporting use of other water sources at follow-up	Coeff	0.06	0.06	0.13	TD = pooled	0.419
	s.e.	(0.04)	(0.03)	(0.05)	CP = pooled	0.465
	N		1560		RCP = pooled	0.232

Note: Outcome variable is change in access to safe drinking water, for sample listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the household. Weights are applied so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values. *** p<0.01, ** p<0.05, * p<0.1.

Table 14a: Well users
Gopalganj

		Fraction using project well				
		TD	CP	RCP		p-value
All households	Coeff	0.27	0.24	0.42	TD = pooled	0.481
	s.e.	(0.07)	(0.06)	(0.07)	CP = pooled	0.186
	N		1911		RCP = pooled	0.063*
Households using unsafe water at baseline	Coeff	0.25	0.23	0.41	TD = pooled	0.402
	s.e.	(0.08)	(0.06)	(0.07)	CP = pooled	0.220
	N		1396		RCP = pooled	0.065*
Households using safe water at baseline	Coeff	0.31	0.25	0.43	TD = pooled	0.938
	s.e.	(0.08)	(0.08)	(0.16)	CP = pooled	0.374
	N		508		RCP = pooled	0.378
Poor or very poor households	Coeff	0.25	0.29	0.47	TD = pooled	0.181
	s.e.	(0.08)	(0.07)	(0.10)	CP = pooled	0.449
	N		708		RCP = pooled	0.077*
Low-income households	Coeff	0.31	0.23	0.39	TD = pooled	0.973
	s.e.	(0.07)	(0.07)	(0.07)	CP = pooled	0.163
	N		833		RCP = pooled	0.148
Middle or high-income households	Coeff	0.21	0.17	0.38	TD = pooled	0.565
	s.e.	(0.08)	(0.04)	(0.10)	CP = pooled	0.092*
	N		367		RCP = pooled	0.068*

Note: Outcome variable is fraction using project well, for sample listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the household. Weights are applied so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values. *** p<0.01, ** p<0.05, * p<0.1.

Table 14b: Well users
Matlab

		Fraction using project well				
		TD	CP	RCP		p-value
All households	Coeff	0.27	0.24	0.18	TD = pooled	0.298
	s.e.	(0.05)	(0.05)	(0.04)	CP = pooled	0.788
	N		2038		RCP = pooled	0.156
Households using unsafe water at baseline	Coeff	0.25	0.26	0.12	TD = pooled	0.435
	s.e.	(0.07)	(0.06)	(0.03)	CP = pooled	0.264
	N		841		RCP = pooled	0.020**
Households using safe water at baseline	Coeff	0.29	0.23	0.23	TD = pooled	0.436
	s.e.	(0.06)	(0.06)	(0.06)	CP = pooled	0.675
	N		1193		RCP = pooled	0.651
Poor or very poor households	Coeff	0.36	0.25	0.18	TD = pooled	0.114
	s.e.	(0.08)	(0.05)	(0.05)	CP = pooled	0.836
	N		488		RCP = pooled	0.088*
Low-income households	Coeff	0.27	0.27	0.17	TD = pooled	0.434
	s.e.	(0.06)	(0.06)	(0.05)	CP = pooled	0.516
	N		731		RCP = pooled	0.124
Middle or high-income households	Coeff	0.23	0.22	0.14	TD = pooled	0.302
	s.e.	(0.04)	(0.05)	(0.03)	CP = pooled	0.591
	N		784		RCP = pooled	0.071*

Note: Outcome variable is fraction using project well, for sample listed in table. Results shown are for villages in which tubewells were feasible only. The unit of analysis is the household. Weights are applied so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. P-values reported test significance of the difference between means under one model, and the remainder of the treated villages. Asterisks reflect significance levels of reported p-values. *** p<0.01, ** p<0.05, * p<0.1.

Appendices
Not for publication

A Data

Variable Construction

We asked the households to list all the sources of water they used for drinking and cooking. In the analysis, we focus on the most important source of water for drinking and cooking, which we asked households to list first. We also asked households to report the percentage of water for drinking and cooking that they obtained from each source, but results based on the source from which households report drawing the largest percentage of water are unstable between baseline and followup, whereas the results based on the first-listed water source are more consistent. This may be attributable to slight differences in the way in which the question was asked as to whether the question referred to water used for drinking only or drinking and cooking.

Reports using safe drinking water If the household reports using a tubewell, we code the household as reporting using safe water if they report that the source is arsenic-safe, and reporting unsafe water if it is unsafe or if they don't know the source's safety. If the household reports using an unsafe source with respect to bacterial contamination (i.e. a dug well or surface water), we code the household as reporting using unsafe water. Some sources can be presumed to be safe from both bacterial and arsenic contamination (e.g. AIRPs, PSF, rainwater, deep-set tubewells). In these cases, we code the household as reporting using safe water unless the household reports that the water is unsafe. The numbers of households using these sources is small. If the household reports using any other source, we code the household as reporting using safe water if they report that the source is safe, and reporting unsafe water if it is unsafe or if they don't know the source's safety status.

Reports using verified safe drinking water Many tubewells in Bangladesh have been tested for arsenic safety in the past and marked with green (safe) or red (unsafe). If households reported using a tubewell, enumerators visited the tubewell to confirm whether it was marked safe, unsafe, or not marked, as long as the tubewell was less than 5 minutes walk away. However, an early version of the baseline survey used did not include this question, so this information is missing for some villages at baseline. We code this variable as follows. We always code households reporting an unsafe source as not using a verified source of safe drinking water. If the household reports using a source that can otherwise be presumed to be safe (i.e. rainwater), we code the household as using a verified source of safe drinking water, unless they report it to be unsafe. If they report using a tubewell, we code the house as using a verified source of safe drinking water if the source is verifiably safe, and not using a verified source of safe drinking water if the tubewell is either marked unsafe or can't be verified safe (either because it is too far, or because it is unmarked, or because the question wasn't asked in this village at baseline). If the household reports using any other source, we code the household as reporting using a verified source safe water if the enumerators recorded that the source could be verified safe, and reporting using an unverified or unsafe source if the source is unsafe or if it cannot be verified.

Combined measure We combine these measures by using the verified data, when the safety of the source could be verified, and the reported data, when the safety of the source could not be verified.

Construction of matched control groups in Gopalganj

Tubewells are not feasible where there is a rocky layer separating the surface from the arsenic-safe deep aquifer, which cannot be penetrated with local drilling technologies.[51] There is substantial

[51] This was only a problem in this study in Gopalgnaj, as tubewells of varying kinds were feasible in all villages in Matlab. The following discussion is therefore limited to Gopalganj.

spatial correlation in the location of these rocky layers.

In Gopalganj, there was no overall problem with random assignment to treatment. Appendix Table B3, columns 1, 2 and 3 confirm this; of 12 tests comparing treated to control villages in Gopalganj, only one shows statistically significant differences at the 10% level, which is approximately what we would expect due to chance. When we compare either the villages in which only AIRPs were feasible (columns 4 and 5) or the villages where tubewells were feasible (columns 6 and 7), to the full group of control villages, there is some evidence that feasible technology is correlated with other village level characteristics. In column 5, which compares AIRP villages to the full control group, one test shows statistically significant differences at the 5% level. In column 7, which compares tubewell villages to the full control group, two tests show statistically significant differences at the 5% level. To be conservative, we therefore construct matched control groups for the AIRP villages and tubewell villages, exploiting the spatial correlation in location of the rocky layer.

In Gopalganj, there are 18 unions (the smallest rural administrative and local government units in Bangladesh). In three of these unions, only AIRPs were feasible in all treated villages. In 4 unions, tubewells were feasible in all treated villages. We assign the five control villages in unions where only AIRPs were feasible to the AIRP-matched control group. We assign the 18 control villages in unions where tubewells were always feasible to the tubewell-matched control group. For the remainder of the unions — for which tubewells were feasible in a fraction of the villages — we randomly assign villages to either the AIRP-matched control groups or the tubewell-matched control groups at rates that reflect the proportion of treated villages in which only AIRPs were feasible.[52]

We repeat this random assignment 100 times, each time calculating a Hotelling's T-Squared test on the 12 variables on which we report baseline randomization checks. We then extract the matching assignment that gives the minimum sum of squared F-statistics for the comparison between tubewell and AIRP villages, and their respective matched control groups. This matching process performs better than other matching processes we tested, in terms of comparison on baseline characteristics. This process assigns a total of 13 villages to the AIRP-matched control group, and 37 villages to the tubewell-matched control group.

Appendix Table B3 shows baseline randomization checks that confirm that the villages in which only AIRP and tubewell villages are similar on baseline characteristics to their respective matched control groups. Column 1 repeats the mean of variables in the AIRP villages; column 2 shows the mean in the matched control group; and column 3 shows the regression-estimated difference between the two groups. Columns 4 to 6 repeat the same exercise for the tubewell and tubewell-matched villages. The only test that rejects equivalence between treated and control villages is the number of collective actions in AIRP communities. This is partly driven by a relatively skewed distribution on this variable, and also reflects the overall difference in means on this variable between treatment and control villages in Gopalganj as a whole. Hotelling's T-squared tests confirm that we cannot reject the null hypothesis that the treated and matched control groups are comparable on all 12 characteristics.[53]

In practice, the results are also not sensitive to the exact control group constructed. Appendix Figure B1 shows the distribution of point estimates for the effects within Gopalganj in AIRP and tubewell villages, relative to the matched control groups. The estimates for the AIRP villages

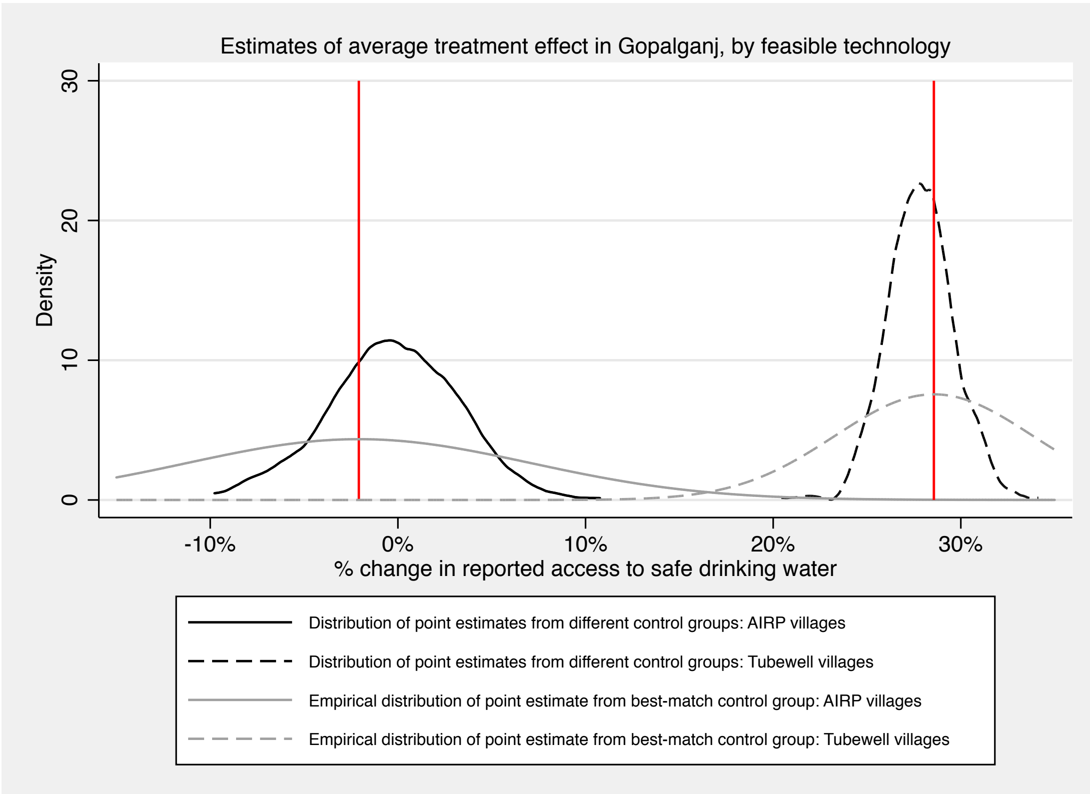
[52] An alternative approach would have been to use propensity score matching, but the relatively small number of villages (40), compared to the large number of unions with a mix of AIRP and tubewell villages (9) leads to overfitting of the propensity score index.

[53] For the tubewell villages, in particular, the Hotelling's T-squared test does not reject equality of means between the treated tubewell villages and *any* of the 100 randomly assigned matched control groups.

are centered around zero, and range between -10% and 10%, while the estimates for the tubewell villages all lie in relatively narrow range between 24% and 32%. The variation in the estimates generated by varying the control group is small relative to the size of the confidence intervals in the point estimates.

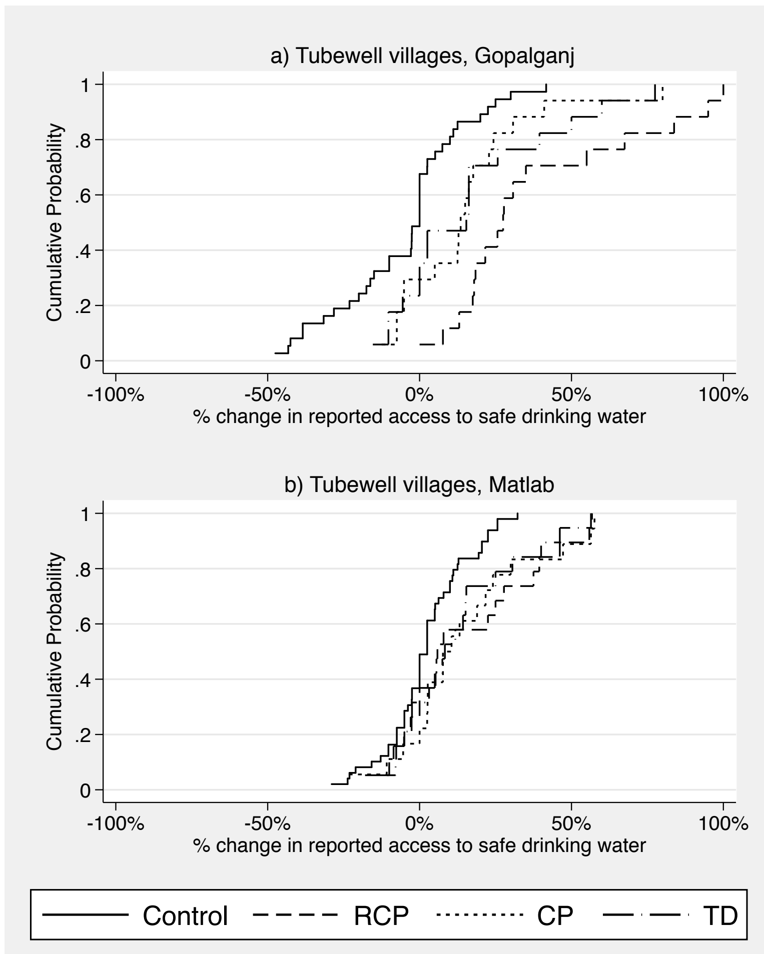
B Figures and Tables

Figure B1: Heterogeneity in estimated effect on access to safe drinking water by randomly selected matched control group



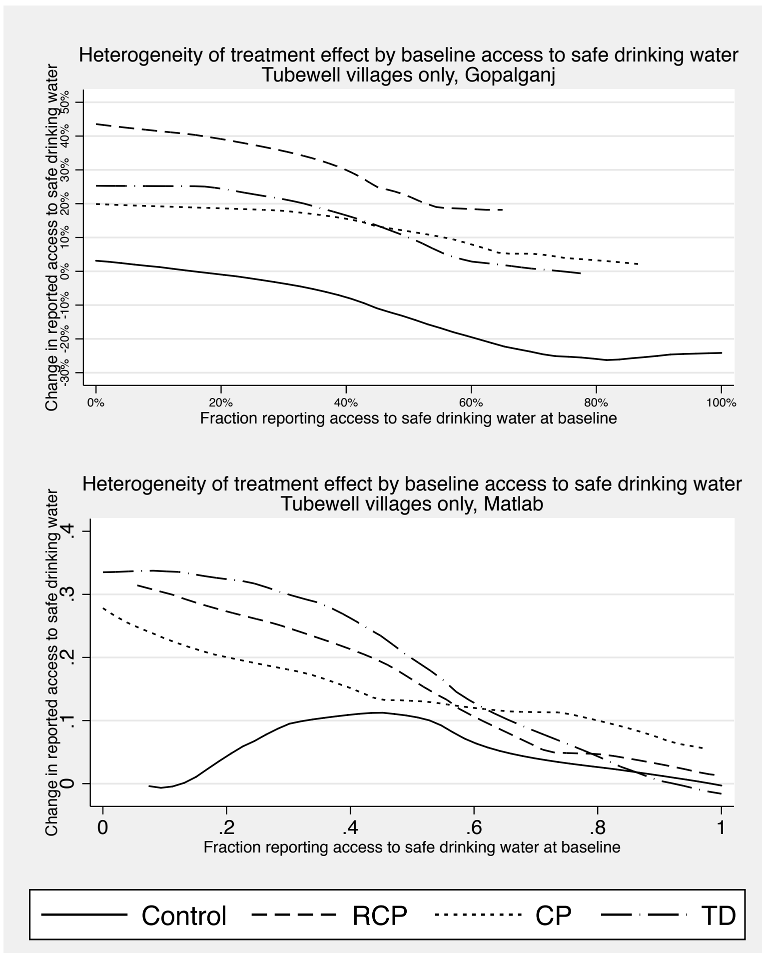
Graph shows distributions of point estimates of effect on access to safe drinking water in tubewell villages (dashed lines) and AIRP villages (solid lines). The distribution of point estimates following 100 draws of randomly selected control groups, selected based on union (district) level probabilities of treated villages being AIRP or tubewell villages respectively, are shown in black. The main point estimates are shown with a red vertical line., The empirically estimated distribution of the main point estimates are shown in grey, with robust standard errors.

Figure B2: Empirical cumulative distribution functions of change in access to safe drinking water
Results by upazila



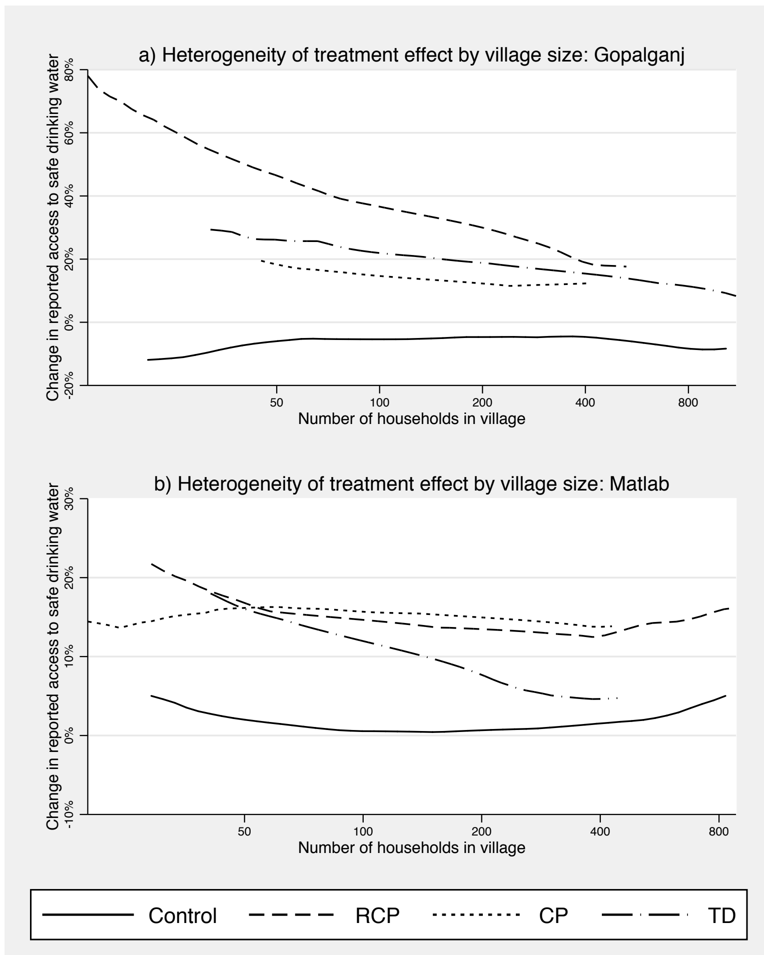
Graph shows empirical cumulative distribution functions of village-average change in reported access to safe drinking water for all villages in which tubewells were feasible and their matched control villages in Gopalganj in panel a) and Matlab in panel b) .

Figure B3: Non-parametric estimates of heterogeneity of treatment effect by baseline access to safe drinking water
Results by upazila



Graph shows results of a local linear regression plotting the change in access to safe drinking water against baseline access to safe drinking water for all villages in which tubewells were feasible and their matched control villages in Gopalganj in panel a) and Matlab in panel b). Bandwidth = 0.2.

Figure B4: Non-parametric estimates of heterogeneity of treatment effect by village size
Results by upazila



Graph shows results of a local linear regression plotting the change in access to safe drinking water against log village size for all villages in which tubewells were feasible and their matched control villages in Gopalganj in panel a) and Matlab in panel b). Bandwidth = 0.75.

Table B1: Number of water sources installed
Sub-sample estimates

		Gopalganj			Matlab		
		Max. possible no. sources	No. sources installed	Proportion installed	Max. possible no. sources	No. sources installed	Proportion installed
		(1)	(2)	(3)	(4)	(5)	(6)
All treated	Mean	3.00	2.38	0.79	2.82	2.51	0.89
	s.e.		(0.12)	(0.04)	(0.05)	(0.11)	(0.04)
TD	Mean	3.00	2.29	0.76	2.84	2.42	0.86
	s.e.		(0.24)	(0.08)	(0.09)	(0.21)	(0.07)
CP	Mean	3.00	2.65	0.88	2.79	2.42	0.86
	s.e.		(0.17)	(0.06)	(0.10)	(0.22)	(0.07)
RCP	Mean	3.00	2.22	0.74	2.84	2.68	0.95
	s.e.		(0.21)	(0.07)	(0.09)	(0.13)	(0.04)
RCP = CP	p-value		0.120	0.120	0.685	0.312	0.295
CP = TD	p-value		0.234	0.234	0.685	1.000	1.000
TD = RCP	p-value		0.821	0.821	1.000	0.290	0.271
TD = pooled	p-value		0.626	0.626	0.806	0.590	0.586
CP = pooled	p-value		0.096*	0.096*	0.642	0.603	0.599
RCP = pooled	p-value		0.331	0.331	0.806	0.194	0.168
	N	52	52	52	57	57	57

Note: Villages in which tubewells were feasible only. P-values test: (1) pairwise significance of the difference between the means across models indicated, from a regression of the outcome variable on indicators for the three types of treatment (with no constant); (2) significance of the difference between means under one model and the remainder of the treated villages. Robust standard errors shown in parentheses.

Table B2: Treated vs Control: Matlab
Baseline Randomization Checks

		Sample	Treatment - Control			
		(1)	(2)	(3)	(4)	(5)
No of households in village	Mean	198	-60*	-74	-44	-86
	s.e.	(16)	(32)	(33)	(32)	(62)
% of water sources arsenic contaminated	Mean	0.94	-0.01	0.01	-0.01	-0.01
	s.e.	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)
Reports using arsenic safe water	Mean	0.70	-0.26***	-0.03	0.01	0.02
	s.e.	(0.03)	(0.05)	(0.05)	(0.06)	(0.12)
Changed water source due to arsenic, last 5 years?	Mean	0.64	-0.26***	-0.03	0.00	0.00
	s.e.	(0.03)	(0.05)	(0.06)	(0.06)	(0.12)
Symptoms of arsenic poisoing, anyone in hh?	Mean	0.0100	0.0040	0.0033	0.0002	0.0004
	s.e.	(0.002)	(0.003)	(0.004)	(0.003)	(0.006)
Total value of household assets	Mean	631	-5	30	-6	-12
	s.e.	(29)	(58)	(79)	(58)	(114)
Access to electricity?	Mean	0.443	-0.056	-0.004	-0.018	-0.035
	s.e.	(0.03)	(0.06)	(0.08)	(0.06)	(0.12)
Household head literate	Mean	0.640	-0.036	-0.017	-0.020	-0.040
	s.e.	(0.011)	(0.022)	(0.031)	(0.022)	(0.044)
Household head Muslim	Mean	0.90	-0.03	-0.01	-0.05	-0.09
	s.e.	(0.02)	(0.04)	(0.05)	(0.04)	(0.09)
Household head farmer	Mean	0.38	0.00	0.00	-0.01	-0.01
	s.e.	(0.01)	(0.03)	(0.03)	(0.03)	(0.06)
Number of associations in community	Mean	5.68	0.12	-0.31	-0.07	-0.15
	s.e.	(0.09)	(0.17)	(0.20)	(0.17)	(0.34)
Number of collective actions in community	Mean	1.77	0.21**	-0.01	-0.13	-0.25
	s.e.	(0.05)	(0.10)	(0.10)	(0.11)	(0.24)
F-statistic from Hotelling's T-squared			2.61	0.72	0.45	
Number of villages			107	78	107	107
Number of households			4178	3043	4178	4178
Includes South Matlab?			Yes	No	Yes	Yes
Treatment variable?			Implemented	Implemented	Synthetic	Synthetic
Estimation			OLS	OLS	OLS	IV

Note: Column 1 shows the mean value across all villages in Matlab. Columns 2-5 show the regression-estimated difference between treatment and control villages in Matlab. Data in rows 1 and 2 comes from the Bangladesh Arsenic Mitigation Water Supply Project. All other data is from baseline household surveys. Data is collapsed to village-level means and standard errors (in parentheses) are robust. F-statistics from Hotelling's T-squared test equality of means between synthetic or implemented treated and control groups. Asterisks reflect regression-estimated significance of differences between groups. *** p<0.01, ** p<0.05, * p<0.1.

Table B3: Treated vs Control: Gopalganj
Baseline Randomization Checks

		Control (1)	Treated (2)	Treatment - Control (3)	AIRP (4)	AIRP - Control (5)	Tubewell (6)	Tubewell - Control (7)
No of households in village	Mean	265	257	8	328	71	244	-13
	s.e.	(27)	(33)	(43)	(69)	(75)	(28)	(43)
% of water sources arsenic contaminated	Mean	0.97	0.96	0.00	0.97	0.00	0.96	0.00
	s.e.	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Reports using arsenic safe water	Mean	0.26	0.26	-0.01	0.24	-0.02	0.26	0.00
	s.e.	(0.03)	(0.04)	(0.05)	(0.06)	(0.07)	(0.04)	(0.05)
Changed water source due to arsenic, last 5 years?	Mean	0.20	0.20	0.00	0.22	0.02	0.19	0.00
	s.e.	(0.03)	(0.03)	(0.04)	(0.05)	(0.06)	(0.03)	(0.04)
Symptoms of arsenic poisoing, anyone in hh?	Mean	0.0055	0.0094	-0.0038	0.0044	-0.0049	0.0059	-0.0035
	s.e.	(0.002)	(0.003)	(0.003)	(0.002)	(0.004)	(0.002)	(0.004)
Total value of household assets	Mean	469	512	-42	574	62	434	-77
	s.e.	(22)	(41)	(47)	(45)	(61)	(23)	(47)
Access to electricity?	Mean	0.376	0.447	-0.071	0.615	0.167**	0.296	-0.151**
	s.e.	(0.04)	(0.04)	(0.06)	(0.07)	(0.08)	(0.04)	(0.06)
Household head literate	Mean	0.582	0.558	0.023	0.550	-0.008	0.592	0.034
	s.e.	(0.026)	(0.037)	(0.045)	(0.062)	(0.072)	(0.027)	(0.046)
Household head Muslim	Mean	0.56	0.48	0.07	0.66	0.18	0.52	0.04
	s.e.	(0.05)	(0.06)	(0.08)	(0.10)	(0.12)	(0.06)	(0.09)
Household head farmer	Mean	0.50	0.46	0.04	0.44	-0.01	0.52	0.06**
	s.e.	(0.02)	(0.02)	(0.03)	(0.04)	(0.04)	(0.02)	(0.03)
Number of associations in community	Mean	6.73	6.86	-0.13	6.48	-0.38	6.80	-0.06
	s.e.	(0.24)	(0.23)	(0.33)	(0.38)	(0.44)	(0.29)	(0.37)
Number of collective actions in community	Mean	0.23	0.14	0.09*	0.25	0.11	0.22	0.08
	s.e.	(0.05)	(0.02)	(0.05)	(0.08)	(0.08)	(0.05)	(0.06)
F-statistic from Hotelling's T-squared				1.27		1.51		1.35
Number of villages		68	50		17		51	
Number of households		2664	1969		659		2005	

Note: Column 1 shows the mean value across all control villages in Gopalganj; column 2 shows the mean value across all treated villages in Gopalganj. Column 3 shows the regression-estimated difference between treatment and control villages in Gopalganj. Column 4 shows the mean value across all AIRP villages in Gopalganj, and column 5 shows the regression-estimated difference between these treated villages and the full pool of control villages. Column 6 shows the mean value across all tubewell villages in Gopalganj, and column 7 shows the regression-estimated difference between these treated villages and the full pool of control villages. Data in rows 1 and 2 comes from the Bangladesh Arsenic Mitigation Water Supply Project. All other data is from baseline household surveys. Data is collapsed to village-level means and standard errors (in parentheses) are robust. F-statistics from Hotelling's T-squared test equality of means between specified groups. Asterisks reflect regression-estimated significance of differences between groups. *** p<0.01, ** p<0.05, * p<0.1.

Table B4: Treated vs Matched Control: Gopalganj
Baseline Randomization Checks

		AIRP (1)	AIRP-Matched Control (2)	Difference (3)	Tubewell (4)	Tubewell-Matched Control (5)	Difference (6)
No of households in village	Mean	328	291	49	244	244	
	s.e.	(69)	(40)	(79)	(28)	(43)	(51)
% of water sources arsenic contaminated	Mean	0.97	0.97	0.00	0.96	0.96	0.00
	s.e.	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Reports using arsenic safe water	Mean	0.24	0.22	0.02	0.26	0.28	-0.01
	s.e.	(0.06)	(0.05)	(0.08)	(0.04)	(0.05)	(0.06)
Changed water source due to arsenic, last 5 years?	Mean	0.22	0.18	0.04	0.19	0.20	-0.01
	s.e.	(0.05)	(0.04)	(0.07)	(0.03)	(0.04)	(0.05)
Symptoms of arsenic poisoing, anyone in hh?	Mean	0.004	0.014	-0.009	0.006	0.008	-0.002
	s.e.	(0.002)	(0.008)	(0.009)	(0.002)	(0.003)	(0.003)
Total value of household assets	Mean	574	648	-74	434	464	-30
	s.e.	(45)	(138)	(144)	(23)	(25)	(34)
Access to electricity?	Mean	0.61	0.64	-0.03	0.30	0.38	-0.08
	s.e.	(0.07)	(0.03)	(0.07)	(0.04)	(0.05)	(0.07)
Household head literate	Mean	0.55	0.48	0.07	0.59	0.59	0.00
	s.e.	(0.06)	(0.07)	(0.10)	(0.03)	(0.04)	(0.05)
Household head Muslim	Mean	0.66	0.65	0.01	0.52	0.42	0.10
	s.e.	(0.10)	(0.11)	(0.15)	(0.06)	(0.07)	(0.09)
Household head farmer	Mean	0.44	0.34	0.10*	0.52	0.50	0.02
	s.e.	(0.04)	(0.04)	(0.06)	(0.02)	(0.02)	(0.03)
Number of associations in community	Mean	6.48	7.05	-0.57	6.80	6.79	0.01
	s.e.	(0.38)	(0.47)	(0.61)	(0.29)	(0.26)	(0.39)
Number of collective actions in community	Mean	0.25	0.16	0.09	0.22	0.13	0.09
	s.e.	(0.08)	(0.06)	(0.10)	(0.05)	(0.02)	(0.06)
F-statistic from Hotelling's T-squared				0.77			0.69
Number of villages		17	13		51	37	

Note: Column 1 shows mean values in villages in which only AIRPs were feasible in Gopalganj. Column 2 shows mean values in a matched control group. Column 3 shows the regression-estimated difference between villages in which only AIRPs were feasible and their matched control group in Gopalganj. Columns 4 to 6 repeat the same exercise for villages in which tubewells were feasible. Data in rows 1 and 2 comes from the Bangladesh Arsenic Mitigation Water Supply Project. All other data is from baseline household surveys. Data is collapsed to village-level means and standard errors (in parentheses) are robust. F-statistics from Hotelling's T-squared test equality of means between specified treated groups and the matched control groups. Asterisks reflect regression-estimated significance of differences between treated group described, and the matched control groups. *** p<0.01, ** p<0.05, * p<0.1.

Table B5: Treated vs Control
Baseline Randomization Checks
Tubewell villages only

		Sample	Treatment - Control			
		(1)	(2)	(3)	(4)	(5)
No of households in village	Mean	219	-35	-35	-26	-36
	s.e.	(14)	(29)	(32)	(29)	(40)
% of water sources arsenic contaminated	Mean	0.95	0.00	0.01	0.00	0.00
	s.e.	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Reports using arsenic safe water	Mean	0.50	-0.15***	-0.02	0.00	0.00
	s.e.	(0.03)	(0.04)	(0.04)	(0.04)	(0.06)
Changed water source due to arsenic, last 5 years?	Mean	0.44	-0.15***	-0.02	0.00	0.00
	s.e.	(0.03)	(0.04)	(0.04)	(0.04)	(0.05)
Symptoms of arsenic poisoing, anyone in hh?	Mean	0.0085	0.0013	0.0004	-0.0008	-0.0011
	s.e.	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)
Total value of household assets	Mean	547	-16	-3	-17	-23
	s.e.	(19)	(35)	(40)	(35)	(48)
Access to electricity?	Mean	0.392	-0.068	-0.048	-0.047	-0.065
	s.e.	(0.02)	(0.05)	(0.05)	(0.05)	(0.06)
Household head literate	Mean	0.617	-0.018	-0.005	-0.009	-0.012
	s.e.	(0.012)	(0.026)	(0.031)	(0.026)	(0.035)
Household head Muslim	Mean	0.71	0.03	0.05	0.02	0.03
	s.e.	(0.03)	(0.05)	(0.06)	(0.05)	(0.07)
Household head farmer	Mean	0.44	0.01	0.01	0.01	0.01
	s.e.	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
Number of associations in community	Mean	6.19	0.07	-0.13	-0.03	-0.05
	s.e.	(0.11)	(0.20)	(0.23)	(0.20)	(0.27)
Number of collective actions in community	Mean	1.05	0.15**	0.04	-0.03	-0.04
	s.e.	(0.07)	(0.06)	(0.05)	(0.07)	(0.09)
F-statistic from Hotelling's T-squared			2.07	0.90	0.35	
Number of villages			194	165	194	194
Includes South Matlab?			Yes	No	Yes	Yes
Treatment variable?			Implemented	Implemented	Synthetic	Synthetic
Estimation			OLS	OLS	OLS	IV

Note: Table refers throughout to tubewell and matched control villages only. Column 1 shows the mean value across all sample villages. Columns 2-5 show the regression-estimated difference between treatment and control villages, controlling for upazila-level stratification (an indicator for Gopalganj). Data in rows 1 and 2 comes from the Bangladesh Arsenic Mitigation Water Supply Project. All other data is from baseline household surveys. Data is collapsed to village-level means and standard errors (in parentheses) are robust. F-statistics from Hotelling's T-squared test equality of means between synthetic or implemented treated and control groups, and do not account for stratification by upazila, which may overreject the null hypothesis of no difference between groups. Asterisks reflect regression-estimated significance of differences between groups. *** p<0.01, ** p<0.05, * p<0.1.

Table B6: Assignment to decision-making structure
Baseline Summary Statistics and Randomization Checks
Tubewell villages only

		TD (1)	CP (2)	RCP (3)
Proportion of villages in Gopalganj	Mean	0.47	0.47	0.47
	s.e.	(0.08)	(0.08)	(0.08)
Proportion of villages in South Matlab	Mean	0.28	0.25	0.28
	s.e.	(0.07)	(0.07)	(0.07)
No of households in village	Mean	244	198	173
	s.e.	(37)	(20)	(27)
% of water sources arsenic contaminated	Mean	0.95	0.95	0.96
	s.e.	(0.01)	(0.01)	(0.01)
Reports using arsenic safe water	Mean	0.48	0.44	0.37
	s.e.	(0.06)	(0.06)	(0.06)
Changed water source due to arsenic, last 5 years?	Mean	0.40	0.37	0.33
	s.e.	(0.05)	(0.05)	(0.05)
Symptoms of arsenic poisoning, anyone in hh?	Mean	0.012	0.010	0.005**
	s.e.	(0.003)	(0.003)	(0.002)
Total value of household assets (in thousand BDT)	Mean	522	547	539
	s.e.	(33)	(48)	(46)
Access to electricity?	Mean	0.39	0.36	0.33
	s.e.	(0.06)	(0.05)	(0.06)
Household head literate	Mean	0.61	0.61	0.61
	s.e.	(0.02)	(0.03)	(0.02)
Household head Muslim	Mean	0.73	0.74	0.68
	s.e.	(0.07)	(0.06)	(0.07)
Household head farmer	Mean	0.43	0.45	0.45
	s.e.	(0.03)	(0.02)	(0.03)
Number of associations in community	Mean	6.44	5.96	6.32
	s.e.	(0.35)	(0.20)	(0.26)
Number of collective actions in community	Mean	1.13	1.13	0.99
	s.e.	(0.17)	(0.17)	(0.15)
F-statistic from Hotelling's T-squared		0.43	0.24	0.68
Number of villages		36	36	36

Note: Table shows village means of baseline variable in treated villages in which tubewells were feasible. Data from household surveys except rows 1), 2) and 5) which come from project records and rows 3) and 4) which come from the Bangladesh Arsenic Mitigation Water Supply Project. Standard errors (in parentheses) are robust. Asterisks reflect regression-estimated significance of differences between villages treated under one model and the pooled remaining treated villages. F-statistics from Hotelling's T-squared test equality of means on all variables between villages treated under one model and the remaining treated villages. Pairwise Hotelling's T-squared tests yield F-statistics as follows: RCP = TD 0.69; CP = RCP 0.57; TD = CP 0.24. *** p<0.01, ** p<0.05, * p<0.1.

Table B7: Estimates of average treatment effect
Robustness checks

		Change in access to safe drinking water					
		OLS	OLS	OLS	OLS	OLS	OLS
		(1)	(2)	(3)	(4)	(5)	(6)
Treated	Coeff.	0.195***	0.195***	0.196***	0.195***	0.193***	0.198***
	s.e.	(0.031)	(0.031)	(0.031)	(0.030)	(0.034)	(0.033)
	N	193	7257	193	193	193	206
	Observation	Village mean	Household	Village mean	Village mean	Village mean	Village mean
	Upazila control	Yes	Yes	No	Saturated	Yes	Yes
	Measure of access	Reported	Reported	Reported	Reported	Combined	Reported
	Control villages	Matched	Matched	Matched	Matched	Matched	All

Note: Results from OLS regressions on a treatment dummy and upazila control when specified, for villages in which tubewells were feasible and the specified control groups. Outcome variable is change in access to safe drinking water between baseline and follow-up. Regressions are on village-level means except in column 2, when the regression is on household-level observations. In column 2, weights are applied so that each village receives equal weight in the analysis. In column 4, the reported coefficient is the combined effect from estimating a saturated regression with an upazila control and treatment-upazila interaction, and combing the two to recover the population-average treatment effect. In column 5, we use a measure of change in access to safe drinking water that uses verified data where available. In column 6, we use the full control group rather than the matched control group. Robust or clustered (column 2) standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table B8: Estimates of average treatment effect
Sub-sample estimates

		Change in access to safe drinking water				
		OLS	OLS	OLS	OLS	OLS
		(1)	(2)	(3)	(4)	(5)
Treated	Coeff.	0.21***	0.29***	0.12***	0.20***	0.06
	s.e.	(0.05)	(0.05)	(0.03)	(0.04)	(0.04)
Constant	Coeff.	-0.05	-0.05	0.02		0.02
	s.e.	(0.03)	(0.03)	(0.02)		(0.02)
	N	118	88	105	29	76
	Feasible technology	All	Tubewell	Tubewell	Tubewell	Tubewell
	Sample	Gopalganj	Gopalganj	Matlab	S. Matlab	N. Matlab
	Control villages	All	Matched	All	All	All

Note: Outcome variable is change in reported access to safe drinking water between baseline and follow-up. Data is collapsed to village level means and robust standard errors are in parentheses. In column 2 the control group is matched to the subset of treated villages. *** p<0.01, ** p<0.05, * p<0.1.

Table B9: Comparison of access to safe drinking water by decision-making mode
Cross-sectional comparison at follow-up

		Followup (1)	Followup (2)	Followup (3)
TD	Coefficient	0.56***	0.62***	0.19**
	s.e.	(0.05)	(0.05)	(0.08)
CP	Coefficient	0.55***	0.59***	0.28**
	s.e.	(0.05)	(0.05)	(0.13)
RCP	Coefficient	0.56***	0.63***	0.06*
	s.e.	(0.05)	(0.05)	(0.03)
	RCP = CP	0.829	0.555	0.111
	CP = TD	0.841	0.650	0.545
	TD = RCP	0.983	0.887	0.161
	TD = pooled	0.914	0.844	0.948
	CP = pooled	0.811	0.555	0.269
	RCP = pooled	0.889	0.659	0.044**
	N	125	108	17
	Feasible technology	All	Tubewell	AIRP

Note: Outcome variable is reported access to safe drinking water at follow-up. Data is collapsed to village level means and robust standard errors are in parentheses. Regressions on treated villages only. P-values reported test i) pairwise significance of the difference between the means across models indicated, from a regression of the outcome variable on indicators for the three types of treatment (with no constant) ii) significance of the difference between means under one model and the remainder of the treated villages. *** p<0.01, ** p<0.05, * p<0.1.

Table B10: Comparison of access to safe drinking water by decision-making model
All treated villages

		Change in access to safe drinking water					
		OLS	OLS	OLS	IV	OLS	OLS
		(1)	(2)	(3)	(4)	(5)	(6)
TD	Coefficient	0.12	0.12	0.13	0.14	0.12	0.12
	s.e.	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
CP	Coefficient	0.12	0.12	0.14	0.13	0.13	0.13
	s.e.	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
RCP	Coefficient	0.21	0.21	0.23	0.21	0.21	0.25
	s.e.	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)
Constant	Coefficient			-0.01	-0.01		
	s.e.			(0.02)	(0.02)		
	RCP = CP	0.157	0.155	0.155	0.227	0.194	0.059*
	CP = TD	0.934	0.946	0.934	0.788	0.888	0.871
	TD = RCP	0.131	0.131	0.128	0.330	0.146	0.038**
	TD = pooled	0.319	0.331	0.318	0.646	0.331	0.156
	CP = pooled	0.406	0.406	0.405	0.370	0.475	0.269
	RCP = pooled	0.102	0.102	0.101	0.227	0.120	0.028**
	SW First stage F-stat: TD				259		
	SW First stage F-stat: CP				281		
	SW First stage F-stat: RCP				251		
	Hausman test p-value				0.47		
	N	124	4620	223	223	124	124
	Unit of analysis	Village	Household	Village	Village	Village	Village
	Includes control group	No	No	Yes	Yes	No	No
	Fully saturated	No	No	No	No	Yes	No
	Measure of access	Reported	Reported	Reported	Reported	Reported	Combined

Note: Outcome variable is change in reported access to safe drinking water. Data is collapsed to village level-means except in column 2, where the unit of analysis is the household. Results shown are for the full sample. Weights are applied in column 2 so that each village counts equally in the analysis. Robust standard errors, or standard errors clustered by village, are in parentheses. In column 4, the instruments for treatment under a given decision-making model are the synthetic treatment dummy interacted with decision-making model assignment. In column 5, we show the point estimate obtained by estimating a fully saturated model with decision-making model - upazila interactions, and aggregating the estimated average population effected across the treated population. P-values reported test: i) pairwise significance of the difference between the means across models indicated, from a regression of the outcome variable on indicators for the three types of treatment (and a constant, when the control group is included) ii) significance of the difference between means under one model and the remainder of the treated villages. *** p<0.01, ** p<0.05, * p<0.1.

Table B11: Comparison of access to safe drinking water by decision-making model
Alternative household-level specifications

		Change in access to safe drinking water		Changes to safe water		No change in access		Changes to unsafe water	
		OLS (1)	MLOGIT (2)	OLS (3)	PROBIT (4)	OLS (5)	PROBIT (6)	OLS (6)	PROBIT (6)
TD	Coefficient	0.16	0.17	0.13	0.14	-0.11	-0.11	-0.02	-0.02
	s.e.	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.02)	(0.02)
CP	Coefficient	0.16	0.17	0.13	0.14	-0.10	-0.10	-0.03	-0.03
	s.e.	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
RCP	Coefficient	0.27	0.26	0.22	0.21	-0.17	-0.16	-0.05	-0.06
	s.e.	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.02)	(0.02)
Constant	Coefficient	-0.01		0.10		0.78	0.11		
	s.e.	(0.02)		(0.01)		(0.02)	(0.01)		
	RCP = CP	0.059*	0.055*	0.079*	0.075*	0.160	0.156	0.199	0.197
	CP = TD	0.954	0.931	0.961	0.960	0.856	0.856	0.768	0.768
	TD = RCP	0.056*	0.043**	0.098*	0.095*	0.232	0.229	0.091*	0.094*
	TD = pooled	0.219	0.203	0.299	0.305	0.495	0.497	0.262	0.251
	CP = pooled	0.256	0.276	0.250	0.255	0.313	0.314	0.587	0.581
	RCP = pooled	0.034**	0.024**	0.060*	0.051*	0.154	0.146	0.080*	0.094*
	N	7257	7257	7257	7257	7257	7257	7257	7257

Note: Outcome variable and analysis method are as specified in the table. Unit of analysis is the household. Villages in which tubewells were feasible and matched control villages only. Survey weights are applied so that each village counts equally in the analysis. In columns 2, 4, 6 and 8, we report average marginal effects. Standard errors (in parentheses) are clustered at the village level.
*** p<0.01, ** p<0.05, * p<0.1.