The Role of Psychological Ownership in Community-based Piped Water Supply Infrastructure in Nepal and India

Inauguraldissertation

der Philosophisch-humanwissenschaftlichen Fakultät

der Universität Bern

zur Erlangung der Doktorwürde

vorgelegt von

Benjamin Adrian Ambühl

aus Sigriswil/BE

Von der philosophisch-humanwissenschaftlichen Fakultät der Universität Bern auf Antrag von Prof. Dr. Jennifer Inauen, Prof. Dr. et dipl.zool. Hans-Joachim Mosler angenommen.

Der Dekan: Prof. Dr. Stefan Troche

Bern, den 01.09.2022

The State shall, in particular, direct its policy towards securing-

(i) That the citizens, men and women equally, have the right to an adequate means of livelihood;

(ii) That the ownership and control of the material resources of the community are so distributed as best to subserve the common good;

Article 39, Constitution of India, 1949

Dominus illuminatio mea.

Abstract

Psychological ownership, the feeling that something is mine, is a diverse social construct on the individual level with a measurable core dimension of possessiveness. It can be fostered through participative elements in combination with behaviour change interventions. The concept originally stems from the organizational context, where antecedents leading to, and consequences of psychological ownership were vastly researched. Initial evidence of the application of the construct to shared targets such as the environment or common-pool resources, for instance community-based water infrastructure, yielded promising results. However, causal evidence is scarce and a holistic adaptation of the construct, tests of theory-based interventions concerning the routes, validation of the measurement scale, and a systematic investigation of the consequences of psychological ownership are lacking.

This dissertation presents findings from two community development programmes in Nepal and India, where psychological ownership for community-based water infrastructure was the subject of the research.

Our results are in-line with existing evidence from the organizational context and applications in other domains. First, we found qualitative evidence for the importance of the construct in the specific context of Nepal and India, and we validated the measurement for individual psychological ownership. Second, we found that interventions should be targeting the three routes substantially, e.g. by participatory activities. Community participation can be seen as a means of implementation and therefore needs to be combined with individual-level behaviour change and embedded in institutional interventions to cause greater psychological ownership. Third, the results show that psychological ownership fosters behavioural determinants and organizational citizenship behaviour, but not the functionality of safe water supply infrastructure.

This body of work provides various connecting factors for future research. Apart from changes towards an enabling environment, it is important to disentangle complex interaction of stakeholders. There is a need for experts to take care of key infrastructure. In turn, psychological ownership plays an important role in the acceptance, use and sustainability of community-based safe water supply.

Table of contents

Abbreviations

BCT	Behaviour change technique
CBPR	Community-based participatory research
c-RCT	Cluster-randomized controlled trial
IWRM	Integrated water resources management
NGO	Non-governmental organization
PACT	Participatory Action for Long-Term Safe Water
PAMSIMAS	Community-based drinking water supply and sanitation programme
PHED	Public Health Engineering Department
RANAS	Risks, Attitudes, Norms, Abilities and Self-regulation model
REACH	Global research programme to improve water security for the poor
SDG	Sustainable Development Goals
UN	United Nations
VMW	Village maintenance worker
WARM-P	Water Resource Management Programme
WaSH	Water, sanitation and hygiene
WHO	World Health Organization
WUMP	Water use master plan
WUSC	Water users' committee

List of figures

List of tables

Introduction

Although society agrees on a human right to water (Risse, 2015), not everyone on earth has access to safe drinking and cooking water (Martínez-Santos, 2017; WHO & Unicef, 2017). Access can be lacking for many reasons: absence of water supply infrastructure, broken water supply infrastructure, and contamination of water (Elimelech, 2006, WHO, 2011). Politicians and non-governmental organization (NGO) representatives design policies (e.g. Sustainable development goals, SDGs of the United Nations, UN), governments initiate programmes (e.g. Jal Jeevan and Har Ghar Nal Ka Jal mission in India), engineers install water treatment strategies (e.g. filters), and institutions improve their coordination (e.g. water safety planning, WSP, to run and guarantee proper functionality of water supply). They all strive to mitigate compromised water quality and to provide access to safe water for everyone. However, none of this helps unless people accept, maintain, and particularly use safe water sources.

In rural areas, an early trend to install new point-based mitigation infrastructure has shifted to a focus on system-based mitigation strategies (Hutchings et al., 2015, 2016; Prasain, 2003; Zuzani et al., 2013). The installation of new infrastructure is easy, but its operation and maintenance need to be improved to ensure its functionality. To prevent diseases that are caused by chronic consumption of unsafe water, water collection behaviour needs to be changed in the long term towards safe water sources (Bain et al., 2014). A psychological concept that influences a range of outcomes including behaviour at individual and community levels is psychological ownership. Psychological ownership theory has been extensively researched in organizational psychology (for a review, see Dawkins et al., 2017). First attempts to adapt the theory to the context of community-based safe water supply were successful (e.g., Contzen & Marks, 2018). Therefore, this dissertation further investigates the role of psychological ownership in community-based piped water supply infrastructure in two countries: Nepal and India.

In the first chapter, the theoretical foundations of psychological ownership in the organizational context and empirical evidence for it are briefly reviewed. This review is not intended to be systematic but to explain the theory-based foundations of the present research. In the second chapter, evidence of the application of psychological ownership theory in several domains, with a special focus on shared resources management and water infrastructure, is presented. The third chapter consists of the findings of our theory-based research into psychological ownership in community-based piped water supply infrastructure in Nepal and India. In the fourth chapter, the results are discussed. To conclude, the implications of this research, findings for practice and proposed topics for future research are presented.

Chapter 1: Psychological ownership

The concept of psychological ownership

Psychological ownership (or the sense of ownership, Vandewalle et al., 1995) is a representation of 'having the feeling that something is "mine" without actually owning it from a legal point of view' (Pierce et al., 2003, p. 26). This representation is multidimensional in nature but is experienced as possession (Pierce et al, 1991).

To grasp the manifold dimensions of this state, it is worth reading other schools' definitions of psychological ownership. In social psychology, psychological ownership is explained as a state in which the target of ownership becomes part of the psychological owner's identity (Dittmar, 1992). In cognitive psychology and the utilitarian school, Litwinski (1947) defines ownership as a state of socially and legally protecting possessions for future utility. The subjective psychologist Heider (1958) works from the principles of Gestalt psychology to postulate that property is a consensus on the object–owner liaison and ownership is a social cognition of coherent things. In developmental psychology, the concept of ownership is understood as an element in moral development that is adapted to favour collaborative interaction in groups (Furby, 1991; Rochat, 2011; Friedman & Neary, 2008; Kanngiesser et al., 2010; Rossano et al., 2011). In cross-cultural psychology, Rudmin (1994a) found lexical differences, with women describing targets of ownership more related to their extensive selves and men describing public places. Cree people emphasize connectedness more than western people, who emphasize the rights associated with the target of ownership (Rudmin, 1994b). Rudmin (1988) used archived social science data to show that property attitudes across cultures are predicted by motivational preferences for dominance and nonconformity. Within societies, these relationships were moderated by societal preferences for individual autonomy.

Overall, there is a common sense that psychological ownership is a cognitive state and an affection for a target that is inherent to human beings and exists because of social interactions. Cross-cultural research highlighted diverse motives for psychological ownership. Additionally, depending on the target of ownership and the social context, various forms of psychological ownership can be distinguished.

Psychological and legal ownership

Legal ownership is a separate concept from psychological ownership because it describes a nonconceptual representation of ownership (Morewedge, 2021). It is solely a collection of rights to use, possess, and give away tangible or intangible things. During the first 60 months of development after birth, children also come to understand different types of ownership (Rochat et al., 2014), reaching from explicit ownership (nonconceptual representation) towards implicit levels of ownership

(conceptual and metaconceptual representation). Thus, young children are already capable of differentiating the concepts of legal and psychological ownership (Cleroux et al., 2022).

Van Dyne and Pierce (2004) find a positive association between legal and psychological ownership. For example, psychological ownership was found to create a desire to own the target of ownership legally (Cocieru et al., 2019). Both concepts are linked through organizational justice (Chi & Han, 2008), which is a combination of distributive and procedural justice and represents the extent to which organizational procedures, interactions, and outcomes are perceived to be fair. Legal ownership paired with perceived organizational justice leads to a feeling of ownership.

Most recent psychological research aims at unifying both concepts using the framework of dual systems. Morewedge (2021) postulates a dual process model of ownership in which ownership is divided into an implicit psychological component and an explicit legal one. The latter part can have a corrective effect if legal ownership is not congruent with psychological ownership, and therefore psychological ownership can have effects on postulated outcomes (when congruent with legal ownership) or not (when not congruent with legal ownership), even though representation in the subject is the same.

Individual and collective psychological ownership

Collective psychological ownership is the feeling when a group collectively agrees that something is theirs (Druskat & Pescosolido, 2002); it is not an individual's feeling that something is 'ours'. Collective psychological ownership is theorized to be a group-level phenomenon (Pierce & Jussila, 2010) of individual psychological ownership, based on the presumption that individuals feel social identity (Rantanen & Jussila, 2011). Consequently, it can exist independently of individual psychological ownership (e.g. Henssen et al., 2014). Collective ownership is a core feature of the social organization of everyday life and the functioning of family businesses (Ikävalko & Jussila, 2006), communities, and societies (Jussila et al., 2007). It structures society, regulates social interactions through group-level thinking (Brown et al., 2014) and social identity (Tajfel, 1981), and defines rights and responsibilities (Verkuyten & Martinovic, 2017).

Targets of psychological ownership

Van Dyne and Pierce (2004) distinguish as targets of ownership jobs and organization, and Mayhew et al. (2007) have confirmed these targets as such through confirmatory factor analysis of measurement scales. They use factor analysis of cross-sectional data to show that distinct factors include organization-based psychological ownership, job-based psychological ownership, affective commitment to an organization, and continuing commitment to the organization. This differentiation

is particularly important because the outcomes change with the targets of psychological ownership. For example, job-based psychological ownership has the sole outcome of job satisfaction, whereas organization-based psychological ownership has possible outcomes of affective organizational commitment and job satisfaction (Mayhew et al., 2007).

Measurement of psychological ownership

Originally, Van Dyne and Pierce (2004) developed and validated a unidimensional measurement scale of psychological ownership and its possessive core (Table 1):

Table 1

Measurement scale for individual psychological ownership

Instructions: Think about the home, boat or cabin that you own or co-own with someone, and the experiences and feelings associated with the statement 'THIS IS MY (OUR) HOUSE!' The following questions deal with the 'sense of ownership' that you feel for the organisation that you work for. Indicate the degree to which you personally agree or disagree with the following statements.

Items

This is MY organisation.

I sense that this organisation is OUR company.

I feel a very high degree of personal ownership for this organisation.

I sense that this is MY company.

This is OUR company.

Most of the people that work for this organisation feel as though they own the company.

It is hard for me to think about this organisation as MINE (reversed).

Note. Source: Van Dyne & Pierce (2004)

In a review, Olckers and Zyl (2017) find that although various instruments exist to measure psychological ownership, their factor structures, item loadings, and reliability differ to suit their applications to diverse conceptualizations of psychological ownership and populations. Thus, using a different conceptualization of psychological ownership, Avey et al. (2009) suggested extending the measurement scale to a five-factorial measurement scale. In line with qualitative findings from cross-cultural research (Rudmin, 1994b) researchers have identified the need to develop new measurement scales for different cultures. In South Africa, Olckers (2013) developed a measurement scale for psychological ownership. Their measurement scale covers a four-dimensional concept of psychological ownership with 35 items. In India, Shukla and Singh (2015) developed a new three-dimensional measurement instrument consisting of 12 items.

A disjunct form of individual psychological ownership is collective psychological ownership. Therefore, Pierce et al. (2018) developed a unidimensional scale measuring collective psychological ownership with four items (Table 2). In contrast, Ng and Su (2018) developed a bifactorial scale with

seven items to assess collective psychological ownership in China. It remains unclear, whether these different measurement scales are valid, reliable and measuring the exact same conceptualization. Furthermore, no explanation has been found as of yet, why these measures produce inconsistent results across different cultures.

Table 2

Measurement scale for collective psychological ownership

Instructions: Think about the house, automobile, workspace, or some other item that you own or co-own with someone, and the the experiences and feelings associated with the statement 'THIS IS OURS!' The following questions deal with the 'sense of ownership' that you and your work team members feel for work that you do. Indicate the degree to which you personally agree or disagree with the following statements.
Items
We (my team members and I) collectively agree that this is OUR job.
We (my team members and I) collectively feel that this job belongs to US together.
We (my team members and I) feel a very high degree of collective (team) ownership for this job.
All of the members of my work team feel as though we own this job collectively.

Note. Dependent upon the group being studied the term 'work team' appearing in each of the items may need to be worded differently (e.g. crew, teammates), and the target of ownership is changeable. Scoring of collective psychological ownership is determined by calculating the team's mean score. Source: Pierce et al. (2017).

In scholarly literature, depending on the discipline of research, more intuitive terms such as 'ownership', 'feelings of ownership', 'sense of possession', and others are used as synonyms for psychological ownership. However, I am going to use the term psychological ownership exclusively and follow Pierce et al.'s (2017) definition of psychological ownership as a two-fold representation: a cognitive state of the mind with a core of possessiveness (Van Dyne & Pierce, 2004; Brown et al., 2005) accompanied by an attitude and emotional tie (Pierce et al., 2001) towards the target of ownership. Additionally, I understand psychological ownership as a socially constructed state (Gibson, 2001; Gibson & Earley, 2007) because it portrays the psychological relationship of an individual with the target of ownership. It is moderated by social relationships (Fiske, 1992) within their environment (e.g., an employees' psychological ownership for the organization has to be understood in the context of how the company is organized; Pierce et al., 1991). Moreover, ownership of an object is only meaningful to the extent that others recognize and respect it (Rudmin, 1991).

Psychological ownership is instilled because of several reasons (motives) and through various pathways (routes), which is explained in the next chapter.

Motives for psychological ownership

Children have an innate propensity to ownership (Rochat, 2009). This is why psychological ownership is seen as serving basic human needs by motivating behaviours to achieve the feeling of ownership (Pierce et al., 2003). Pierce et al. (2001) propose four such motives:

1) efficacy and effectance, based on the desire for control and the satisfaction of changing an outcome through one's own action (Furby, 1991)
2) self-identity, based on the sense of self in things that are connected with the self (Rousseau, 1998)
3) having a place, which satisfies the desire to belong (Baumeister & Leary, 2017)
4) a need for stimulation (Gardner & Cummings, 1988)

However, the motives are the causal reasons, why psychological ownership emerges, and they moderate the mechanism how psychological ownership evolves (Pierce et al., 2001) from routes.

Routes to psychological ownership

Pierce et al. (2001) theoretically link routes to psychological ownership to roots of psychological ownership: How psychological ownership is formed is determined by why individuals have the desire for ownership; without motives for ownership, routes remain empty.

In a qualitative free-recall study, Rudmin and Berry (1987) found various exemplars of characteristics of property: Control is expressed through possession, assertion, and territoriality and refers to the regulation of social access to the property; attachment is expressed through familiarity, knowledge, aesthetics, and utility and expresses the psychological proximity of the owner to the property; and consumption is expressed through purchase, history, and desire and is reflected in important purchases and special acquisitions such as gifts and crafting. From an intrapersonal perspective, psychological ownership was postulated to emerge only if the target of ownership can satisfy the motives for psychological ownership and the individuals have the capacity to meet the demand of the three routes postulated by Pierce et al. (2001): Coming to intimately know the target of ownership, investing the self in the target of ownership, and controlling the target of ownership. Thus, the target of ownership facilitates or impedes the routes through which psychological ownership emerges. When individuals overcome personal resistance by choosing an option that is incongruent with a nonconscious goal, they experience greater feelings of engagement, which in turn lead to enhanced feelings of psychological ownership of the chosen option (Kirk et al., 2015).

Intimately knowing

Coming to intimately know the target of psychological ownership is the association of oneself with the target of ownership (Beggan & Brown, 1994). Empirical research has found that developing an intimate comprehension gave rise to psychological ownership (Rantanen & Jussila, 2011). Brown et al. (2014) found a positive relationship between job complexity and job-based psychological ownership, in which job complexity also represents a certain familiarity with the job, which requires intimately knowing the job.

Investing the self

Creating a target of ownership is seen as beginning to feel that the target flows from the self (Csikszentmihalyi & Rochberg-Halton, 1981). This includes investment of energy, time, effort, and attention. In an exploratory study, Raffelsberger and Hallbom (2009) find qualitative evidence that a longer association with work and a longer investing of the self, is associated with higher feelings of ownership of the business. Quantitative research established that distributive justice rather than procedural justice (Sieger et al., 2013) and organizational identification (Knapp et al., 2014) heightened employees' organization-based psychological ownership. Active involvement and participation increase physicians' feelings of greater influence over the development process and thus develops their feelings of ownership of the clinical system (Paré et al., 2006). Poutsma and Kaarsemaker (2015) found that employees express psychological ownership when they participate financially.

Controlling

Having control of the target of ownership means being able to use and to control its use (Rudmin & Berry, 1987). Previous empirical research found in a cross-sectional design that the positive effects of having control through participative decision-making over some outcomes are mediated by psychological ownership (Han et al., 2010; Pierce et al., 2004). Mayhew et al. (2007) and Henssen et al. (2014) found that employee autonomy, as an operationalization of having control, predicted organization-based psychological ownership. Finally, researchers have found that employees' locus of control predicted their levels of psychological ownership (McIntyre et al., 2009).

The three routes to psychological ownership are activities performed by the subject. They are understood as an interaction of individuals with the environment (Figure 1). Consequently, also the environment influences psychological ownership. Kwon (2020) showed with an online survey that social distance from other users determined which routes are associated with psychological

ownership. Pierce et al. (2004) describe additional external factors that function as antecedents to psychological ownership: culture of participation (Dunford et al., 2009), work and environment structure (O'Driscoll et al. 2006), and contextual factors (Pierce et al., 2003).

Accountability

Avey et al. (2009) postulate a fourth route to psychological ownership: accountability. Accountability is defined as 'the implicit or explicit expectation that one may be called on to justify one's beliefs, feelings, and actions to others' (Lerner & Tetlock, 1999, p. 255). Avey et al. (2009) postulated that psychological ownership manifests when individuals feel accountable for the target of ownership. If accountability is understood as an intraindividual disposition or as a locus of control (McIntyre et al., 2009), it has been found to be positively related to the effectance motive. In contrast, Pierce et al. (2001) conceptualize accountability as the rights and responsibilities expected and presumed of psychological ownership. I follow the latter conceptualization and thus, accountability will be discussed in the following chapter as a consequence of psychological ownership.

Consequences of psychological ownership

Pierce et al. (2001) postulate that psychological ownership has several effects and consequences on the individual and also at the level of the organization. I group the individual-level consequences in six categories: rights and responsibilities, promotive consequences, preventive consequences, behavioural determinants, and behavioural consequences. All empirical evidence is summarized in Figure 1.

Rights and responsibilities

Psychological ownership entails a desire to have a right to information about and to have a voice in decisions (Kubzansky & Druskat, 1993; Pierce et al., 1991). Responsibilities include maintaining, protecting, and enhancing the target of ownership and can be subsumed under the concepts of stewardship (Henssen et al., 2014; Groesbeck, 2001), organizational citizenship behaviour and personal sacrifice (Pierce et al., 2001).

The feeling of responsibility was found to be associated with psychological ownership (Brown et al., 2014). A systematic literature review found psychological ownership to be positively related to employees' feelings of responsibility towards targets of ownership and to encourage stewardship behaviour (Olckers & Du Plessis, 2012). Psychological ownership causes people to value the target of ownership more (Shu & Peck, 2011) and take greater care of the target of ownership (Peck & Luangrath, 2018).

Accountability

Linking back to Avey et al.'s (2009) conceptualization of accountability: Accountability is a dimension of promotive psychological ownership. Hence, it is characterized by individuals 'feeling more efficacious about working with the target, experiencing a greater sense of belongingness to the target, and feeling a sense of personal identification with the target of ownership' (Avey et al., 2012, p. 24), and feeling more accountable for what happens with respect to the target,.

Organizational change

Individuals with high psychological ownership are likely to support change in the target of ownership if the change is self-initiated, evolutionary, and additive (Wang et al., 2019). Specifically, results indicate that people with a sense of ownership towards a set of ideas are less likely than those with limited ownership to adopt change that diminishes their ideas and more likely to adopt suggestions that expand them (Baer & Brown, 2012). Psychological ownership also positively influenced organization-based self-esteem (Pierce & Rodgers, 2004).

In turn, high psychological ownership can also affect negative consequences:

Territoriality

Brown et al. (2005, p. 578) defined territoriality as 'an individual's behavioural expression of his or her feelings of ownership towards a physical or social object', including 'behaviours for constructing, communicating, maintaining, and restoring territories around those objects in the organization towards which one feels proprietary attachment'. Territoriality is a preventive consequence of psychological ownership that can be associated with individuals becoming overly possessive and territorial about their organizational targets of ownership (Avey et al., 2009).

Resist sharing, deviant behaviours, negative feelings, and giving up support the organization (Robinson & Bennett, 1995; Bartunek et al., 2006; Cram & Paton, 1993) are examples of how territoriality manifests. Previous empirical research showed a reluctance to share ideas (Webster et al., 2008), reluctance to share knowledge (Ladan et al., 2017), rejection of new knowledge (Choi & Levine, 2004), and resistance to change (Baer & Brown, 2012) in individuals with psychological ownership for the organization. Kirk et al. (2018) highlight individuals' territorial responses according to the routes invested in targets of psychological ownership. Strong feelings of ownership evoke motivation to protect the target of ownership even when this is intangible (Menard et al., 2018). Power distance moderated the mediating role of psychological ownership (Liu et al., 2012). However, Brown and Zhu (2016) found in a field study that the effect of psychological ownership on territoriality are reduced in 'high trust environments'.

These findings combine theoretical conceptualization of psychological ownership with a sociocognitive core and a defensive feeling about possessions. Storz et al. (2020) even demonstrate that collective psychological ownership can cause a barrier in reconciliation in territorial conflicts or exclusionary attitudes in political behaviour (Nijs et al., 2021).

Behavioural determinants

Behavioural determinants are factors, including risk perceptions, attitudes, norms, abilities, and self-regulation, that are subsequently related to behaviour (Mosler, 2012). Empirical research has established that psychological ownership affects work attitudes (Knapp et al., 2014), job satisfaction (Groesbeck, 2001; Mayhew et al., 2007; Dunford et al., 2009; Brown et al., 2011), and organizational commitment (Olckers & Du Plessis, 2012; Van Dyne & Pierce, 2004; O'Driscoll et al., 2006, Mayhew et al., 2007; Han et al., 2010). Organizational commitment is the desire to perform, and an obligation to maintain membership in the organization (Meyer & Allen, 1991). Paré et al.'s (2006)

results demonstrate that psychological ownership is positively associated with physicians' perceptions of system utility and system user friendliness.

Prosocial behaviour

Psychological ownership is associated with increased prosocial behaviour (Jami et al., 2021). The authors examined materialism and mine-me sensitivity (an individual's tendency to align possessions with the concept of the self) as individual differences moderating the effect of psychological ownership on prosocial behaviour and found that the effect does not exist for individuals low on materialism and mine-me sensitivity. This is related to the roots that need to be satisfied to explain why psychological ownership emerges, which is not the case if individuals do not assign possessions to self-identity.

Behaviour

In their revision of the job characteristics model, Pierce et al. (2009) conceptualized psychological ownership as mediating the association between job characteristics and job outcomes (i.e. job performance as behaviour). However, evidence is mixed:

Van Dyne and Pierce (2004) found a significant correlation between employee performance and organization-based psychological ownership, which disappears when taking demographics into account. However, Bernhard and O'Driscoll (2011) found no support for a relationship between psychological ownership and helping or voice behaviour or extra role behaviour. Similarly, Wagner et al. (2003) found no significant enhancement of performance by psychological ownership. In a cross-sectional study Mayhew et al. (2007) found that psychological ownership predicted job satisfaction and organizational commitment and mediated the relationship between autonomy and these work attitudes, but there was no support for a relationship between psychological ownership and behavioural outcomes.

In contrast, Kaur et al. (2013) found psychological ownership for the job to be related directly to improved nursing behaviour. Similarly, De la Rosa et al. (2021) found psychological ownership as a successful social intervention to increase people's participation in government programmes (behaviour was defined as claiming interest in receiving government benefits). In another study, organizational commitment mediated the relationship between psychological ownership and knowledge-sharing behaviour (Li et al., 2015) and led also to less attempts to cheating behaviour (Viglia et al., 2019).

Intra role behaviour

Intra role behaviour is all the behaviour that is part of the job and was found to be positively related to psychological ownership (Kostova, 1996; Brown et al., 2014). Psychological ownership was associated with being proud of (Mayhew et al., 2007), reported as motivating state for (Pierce et al., 2001), supported feelings of reciprocity associated with (Van Dyne & Pierce, 2004), and was linked to increased performance within (Meyer & Herscovitch, 2001) the job and its responsibilities. However, Mayhew et al.'s (2007) results did not support a relationship between in-role behaviour and job-based or organization-based psychological ownership.

Extra role behaviour

In contrast to intra role behaviour, extra role behaviour was found to be positively associated with psychological ownership (Vandewalle et al., 1995). Extra role behaviour can be helping behaviour (O'Driscoll et al., 2006), organizational citizenship behaviour (LePine et al., 2002; Ullah et al., 2021), or any other behaviour which is beneficial to the organization, but not directly recognized by the formal reward system. Willingness to pay for a service is also directly related to psychological ownership, but this relationship is influenced by the perceived risk of the investment (Lessard-Bonaventure & Chebat, 2015).

Organizational level

At the organizational level, psychological ownership is related to higher competitiveness (Brown et al. 1998) and improved cost-effectiveness (Jensen & Meckling, 1976). Sieger et al. (2013) showed that psychological ownership is positively related to company performance through the mediating effect of individual-level entrepreneurial behaviour. The authors also found that the effect is weaker for high levels of monitoring than low levels, hinting at the moderating effect of working-environment on the relationship of psychological ownership and outcomes.

Figure 1

Conceptualization of psychological ownership in the organizational context
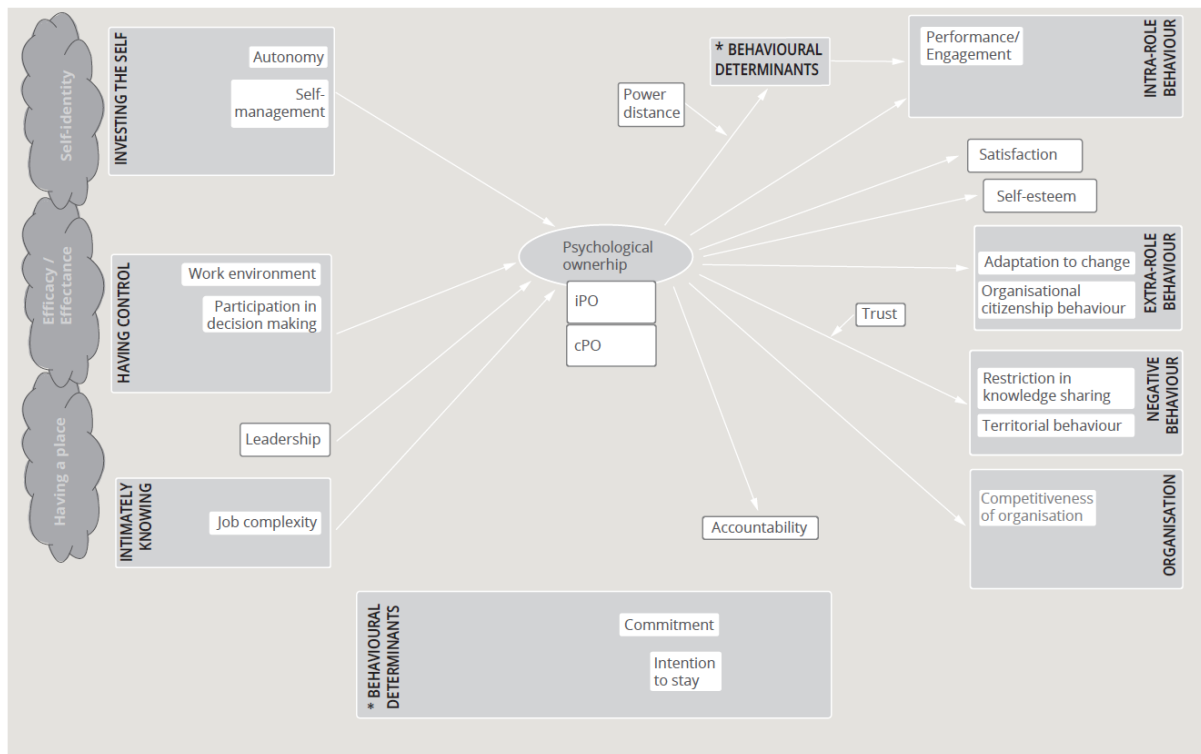
Note. This figure summarizes the conceptualization of psychological ownership in the organizational context based on empirical findings (in white) and theory (in grey). From left to right: Antecedents are motives (clouds) and route-blocks (boxes on the left) that lead to psychological ownership. Psychological ownership can be measured as individual or collective psychological ownership. Consequences of psychological ownership are intra role and extra role behaviour, negative behaviour, and consequences on the level of the organisation. Behavioural determinants mediate the effect of psychological ownership on intra role behaviour. Power distance and trust are moderating the effect of psychological ownership on behavioural determinants and negative behaviour respectively.

Chapter 2: Psychological ownership for shared resources

Because of its beneficial outcomes and proposed behavioural consequences, psychological ownership has been appraised as a concept and introduced in studies about behaviour for the conservation of nature. Recently, the concept and its potential application to shared resources such as community-based water supplies (Aga et al., 2018), shared use of mobility services (Paundra et al., 2017), and management of the commons (Peck et al., 2021) have been highlighted as potential solutions to global sustainability issues, such as mitigation of and adaptation to climate change, and compliance with initiatives for SDGs). One prominent example is improved water service levels that require shared infrastructure. Therefore, I use this example to focus on the role of psychological ownership for community-based shared safe water infrastructure to model the sense of ownership for a shared resource.

Known as the tragedy of the commons (Hardin, 1968), use of a shared resource always poses the risk of overexploitation if the use is not regulated well. Applying economic theory to natural resources, Gordon (1954) concluded that users of a commons are involved in a process that inevitably leads to the destruction of the resource on which they depend. This was used to legitimize 'central control of all common-pool resources and to paint a disempowering, pessimistic vision of the human prospect' (Ostrom et al., 1999, p. 278). However, psychological ownership and its beneficial outcomes offer an alternative to strict control and optimistic vision:

Ostrom et al. (1999) firstly find that participants are more likely to adopt effective rules in management and use of common-pool resources that facilitate their efforts than in ones that are implemented in a top-down manner. This finding relates to the first route of controlling in psychological ownership theory. Secondly, they find that the benefits of the welfare of the resource are easier to assess when users have accurate knowledge of external boundaries and internal microenvironments and have reliable and valid indicators of resource conditions, which relates to the second route of coming to intimately know the target of ownership. And thirdly, they report that in addition to facilitating local efforts, a call for incentives such as assigning individual rights or shares in the resource is also valuable because it allows users to invest in the resource instead of overexploiting it. This relates to the third route of investing the self in psychological ownership theory. Of course, whether people are able to self-organize and self-manage their control over common-pool resources also depends on the broader social setting and its norms and hierarchy. Thus, psychological ownership theory offers an alternative persepective, with interesting insights, theory-based opportunities for improving attitudes and behaviour, when applied to shared resources.

Psychological ownership and shared resources

Psychological ownership is a promising concept for supporting sustainable behaviour. Süssenbach and Kamleitner (2018) define several barriers to sustainable behaviour including lack of perceived efficacy, lack of perceived responsibility, lack of relevance and immediate benefits, and immediate costs. They find psychological ownership helps to remove these barriers. Recent research on psychological ownership has shown that people's perceptions of ownership can increase resource valuation, even for items not legally owned, and thus explain the psychological processes underlying the endowment effect (Shu & Peck, 2011).

In an explorative qualitative study of psychological ownership of natural resources, Matilainen et al. (2017) describe how various user groups, such as owners, hunters, and tourism entrepreneurs, conceptualize psychological ownership towards a single natural resource and legitimize their feelings with their relative benefits and goals. Such a differentiation was also found by Matilainen and Lähdesmäki (2021) to depend on social stratification: the more distinct and unrelated that social groups are, the less they are perceived to own a resource collectively. This does not forcibly correspond with physical distance or living distance between the users, only with proximity to and identity with a certain social group.

Psychological ownership was found to be ignited because of several reasons. Identity with a place was a route to psychological ownership for a public place (Liu et al., 2021). Peck et al. (2021) research psychological ownership to explain enhanced responsibility and stewardship behaviour for public goods in field experiments. They find that simple interventions such as letting participants assign a nickname for a lake or assign a public park through vignettes to a participant can target psychological ownership.

Tomberge et al. (2021) researched the role of psychological ownership for safe sanitation and open defecation behaviour. In their study, having control over the open defecation state of a community and participation in a sanitation planning meeting was found to be a route to individual and collective psychological ownership for the space used for open defecation. Participation in the meeting was found to be a route associated with lower individual and collective psychological ownership for the space. Investment of labour in the sanitation planning process were identified as routes to individual psychological ownership for the latrine.

In an online experimental study on the intention to select a shared or a private car, psychological ownership for the car had a moderating effect on the influence of price on the intention to select a shared car: With higher feelings of ownership, costs became less important (Paundra et al., 2017).

In sharing Airbnb apartments, the hosts' psychological ownership mediated the effects of attachment to Airbnb and to the place on citizenship behaviour (Lee et al., 2019). However, the

effects only indicate psychosocial determinants of behaviour, and almost no effects are reported for the actual behaviour.

As a consequence, in an experimental laboratory study, Preston and Gelman (2020) found that a framing suggesting psychological ownership elicited a more protective attitude towards the land and an attitude discouraging exploitation of the land than a vignette suggesting legal ownership. This hints at the strong connection and proximity of the feeling of ownership and behavioural determinants, whereas legal ownership is more an abstract feeling of control and territoriality but not of connectedness, familiarity, or self-identity.

For behavioural outcomes, psychological ownership affects stewardship behaviour, mediated by responsibility (Peck et al., 2021). This means that responsibility can actually dampen the effect of psychological ownership on stewardship outcomes, for instance by diffusion of responsibility over a group. However, most findings support a positive effect of the feeling of ownership. Psychological ownership was found to mediate the effect between ecological consciousness and sustainable consumption behaviour (Mishra et al., 2022) and to have a mediating role between perceived justice and the environmentally responsible behavioural intentions of residents in a touristic area (Liu et al., 2021; Kuo et al., 2021). These findings also suggest that ownership as social construct must be consensually established and recognized if it is to have any effects on the individual (Kalish & Anderson, 2011).

Tomberge et al. (2021) found higher individual psychological ownership for the open defecation space was associated with greater latrine construction and less open defecation. Conversely, higher collective psychological ownership for the open defecation space increased open defecation. For households with a latrine, higher individual psychological ownership for the latrine was associated with higher commitment to latrine use, but not with higher observed latrine use.

Psychological ownership and community-based shared water infrastructure

Psychological ownership has been researched not only in management issues and for shared resources but also in the context of water, sanitation, and hygiene (WaSH), where participative and demand-driven work has a long tradition. The three essential strategies for long-term success and sustainability of water supply systems were identified to be a (i) holistic approach to water management, (ii) direct community participation in resource management, and (iii) appropriate community institutional structures (Mohan, 2009). Ownership, situated in (ii), is capable of reallocating influence or direct authority over decision-making and the execution of actions, but only within the legal institutional structures that are powerful and guide planning processes (Lachapelle & McCool, 2005).

However, a psychological ownership framework has only been applied in part: in the tradition of the field of research, 'participation' (Whittington et al., 2009) and 'sense of ownership' (Marks & Davis, 2012) were the predominant terminologies. Here, I summarize the findings about psychological ownership in the water sector.

Concept and measurement

Fielmua (2020) describes a community-managed piped water system in Ghana and how the community perceives ownership and control of the water supply. Clearly, the community sees themselves as having the highest psychological ownership; however, only the management of the water system has control over it. Daniel et al. (2021) use the example of PAMSIMAS (Community-based Drinking Water Supply and Sanitation programme) in Indonesia to show how difficult it is to keep a community-based piped water supply scheme functional. For water systems, Marks and Davis (2012) develop the first specific measurement instrument of sense of ownership. Compared to established measures in the organizational context, it does not seem to be supported by sufficient theoretical conceptualization to provide a measure of psychological ownership as in its original sense in organizational psychology. However, evidence is converging on the routes to psychological ownership in the WaSH context:

Routes to psychological ownership

Investing the self

Marks and Davis' (2012) findings suggest that capital cost sharing policies are useful for instilling community sense of ownership for water supply infrastructure, but not when project rules require only small or 'token' contributions from households. Other forms of participation in water system planning also had variable associations with sense of ownership. Labour contributions were

significantly associated with moderate ownership expressions, but not with a high sense of ownership. A qualitative study (Kelly et al., 2017) has identified processes in which both – sense of ownership and social capital – facilitate community participation in water system operations and maintenance, implying an indirect relationship via participation. Although the study found no evidence that social capital and ownership were directly related nor directly affected one another, a relationship was found through community participation. These results suggest that while social capital and sense of ownership both facilitate community participation, community participation also strengthens sense of ownership and builds social capital.

Having control

By contrast, households' involvement in decisions about the level of service to be provided in their water project was a significant predictor of high sense of ownership, but was not significant for moderate to low ownership (Marks & Davis, 2012). Similarly, Handberg (2018) found no increase in psychological ownership when participants only participated weakly. Cleaver (1999) questions participatory approaches to development, because the reasons for participation and the benefits promised to individuals are not necessarily aligned, hinting at the differentiation of motives for and routes to psychological ownership. Contzen and Marks (2018) used a path analysis model on cross-sectional data to find that involvement was positively related with psychological ownership.

Intimately knowing

To the best of the author's knowledge, no empirical evidence has been published on intimate knowledge of the target of psychological ownership.

Consequences of psychological ownership

WaSH research into psychological ownership has mostly found its psychosocial consequences to be in line with results from organizational contexts, but evidence is mixed for behavioural outcomes.

Attitudes & behavioural determinants

Contzen and Marks (2018) modelled psychological ownership as a determinant of several psychosocial factors. Psychological ownership was positively related with attitudes such as increased perceived water quality and decreased perceived effortfulness, social norms, and self-efficacy. Further, these psychosocial factors were positively related to commitment and commitment was positively related to the use of the target of ownership, which led to the finding of psychological ownership as mediating construct between routes to and consequences of psychological ownership.

Similarly, in a computer experiment, Aga et al. (2018) found psychological ownership to be the mediator between participation and behavioural intentions for sustainability in development projects. Subsequently, I conclude that psychosocial factors are mediating the effect of psychological ownership on behaviour. For example, collective efficacy is fostered by participation and can be a means to achieve community-level safe WaSH outcomes (Salinger, 2020). These in turn can even have a beneficial effect on social outcomes (Malolo et al., 2021).

Functionality

Functionality is the consequence equivalent to the organizational-level outcomes of performance and cost-effectiveness. Marks et al. (2013) did one of the few studies investigating the relationship with psychological ownership in a cross-sectional way. They found that infrastructure condition of 50 rural communities with piped water supply in Ghana is positively associated with water committee members' sense of ownership, whereas users' confidence and system management are positively associated with households' sense of ownership.

Figure 2

Conceptualization of psychological ownership towards community-based shared water infrastructure
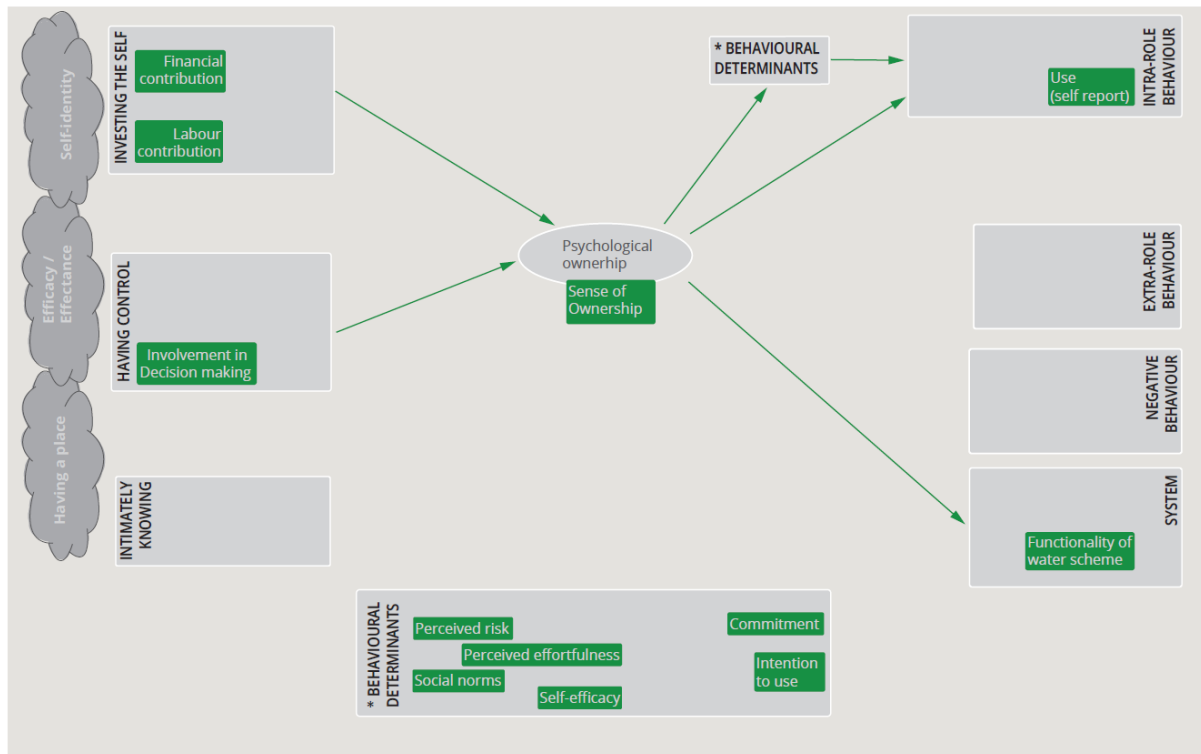
Note. This figure summarizes the conceptualization of psychological ownership of community-based shared water infrastructure based on empirical findings (in green) and theory (in grey). From left to right: Antecedents are motives (clouds) and route-blocks (boxes on the left) that lead to psychological ownership. Psychological ownership was measured as sense of ownership. Consequences of psychological ownership are intra role and also consequences on the level of the community (green). Behavioural determinants mediate the effect of psychological ownership on intra role behaviour.

Chapter 3: Research

Research gaps

So far, psychological ownership has mainly been researched by organizational psychologists in capitalist settings. First attempts to transfer the concept to community-based safe water infrastructure and to adapt the concept to other cultural contexts have been promising but not without barriers such as the lack of suitable measurement scales. Applications of the concept in marketing, natural resources management, and water system sustainability confirmed several effects found in organizational contexts, but especially effects on consequences were not only congruent.

However, in-depth research on adaptation of psychological ownership theory to community-based safe water infrastructure (including adapting measurement instruments), is lacking and hampers further application. For example, to the best of the author's knowledge, no one has yet investigated methodologically sound transfer of psychological ownership and its measurement to another cultural context. Especially in low- and middle-income countries, where the conceptualization of measurement instrument and measurement invariance (e.g., Paige et al., 2018; Sudbury-Riley et al., 2017) is a challenge, this may present a problem. Further, neither the transfer to a tangible target of ownership in a complex environment nor the assessments of antecedents and consequences of psychological ownership have been studied. And finally, so far no one has tested interventions on psychological ownership for community-based safe water infrastructure in systematic research.

Overall, theory-based application of the concept and its routes and consequences are lacking, and research to date has been only conducted with study designs that are correlational but not causal. This calls for theory-based, systematic research on psychological ownership in community-based shared safe water infrastructure.

Research question and hypotheses

In this dissertation, I aim to answer one overarching research question: What is the role of psychological ownership in community-based shared piped water supply infrastructure in Nepal and India? This implies several levels of analysis:

1. How can psychological ownership of shared infrastructure be conceptualized and reliably measured?

2. What is the relevance of psychological ownership to community-based shared safe water infrastructure?

3. A) What routes can foster psychological ownership community-based shared safe water infrastructure? B) What consequences are influenced by psychological ownership of community-based shared safe water infrastructure?

Figure 3

Conceptualization of psychological ownership and research questions
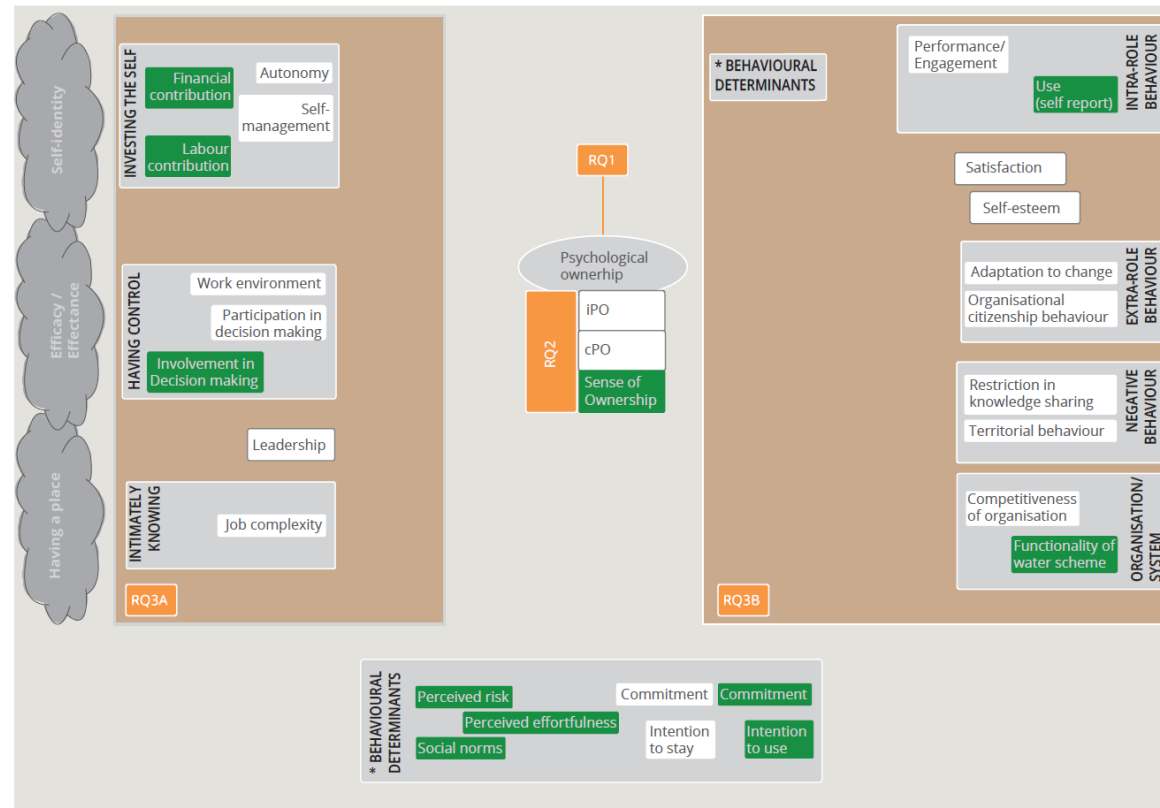
Note. This figure shows the discrepancies of empirical evidence of the concept of psychological ownership in the organizational context (white) and community-based water infrastructure (green) and highlights which gaps are targeted by the research questions (RQ, orange). RQ1 targets the understanding of psychological ownership in the water context. RQ2 targets the measurement scale used in the water context. RQ3A and RQ3B target route-blocks leading to, and consequences of psychological ownership.

Methods

To answer the research questions, we conducted several research studies in two research projects. Here, I describe briefly the two projects and our theory-based research methodology.

Project 1: REACH - water security for the poor

Safe and inclusive drinking and cooking water services for all is a key component of the larger water security challenge we are facing as humanity. Achieving inclusive services requires an intensive focus on rural communities, where access to safe drinking and cooking water supplies is lowest and water-related disease burden is greatest (WHO & UNICEF, 2017). REACH is a global research programme to improve water security for the poor. A critical example of this problem is found in rural areas of Mid-Western Nepal, where access to basic services has not kept pace with the rest of the country and the burden of respiratory and diarrheal diseases because of microbiological contamination of drinking and cooking water is greatest (IMHE, 2010).

In order to mitigate this threat, already existing drinking and cooking water supply infrastructure is upgraded in the government programme of integrated water resources management (IWRM) under the umbrella of the national water plan. At present, attempts to scale up local approaches to IWRM have not been successful, because of a lack of elected representatives in village development committees and district development committees, and the fact that the intended participation of the village development committees has not taken place. Further, the water safety strategy consists of water safety planning (WSP), which have been designed and implemented in rural communities throughout every region. Whereas the World Health Organization (WHO) provides valuable guidance for implementing risk-based water safety planning (Bartram et al., 2009), implementation as well as institutionalization of this framework in remote rural settings has been shown to be particularly challenging. Reasons for this are, that decision-making power is at the level of district government, and the lack of support on selection and implementation of the programme sites reflects the institutional barriers to effective, inclusive and accountable decision-making in water resource management (Suhardiman et al., 2015). However, if applied in detail, IWRM and WSP include all elements of psychological ownership theory and ways of implementing the programmes are hypothesized to strengthen the routes to and create psychological ownership within this context (Barrington et al., 2013).

Study area

The REACH project was situated under the broader framework of IWRM and set within Helvetas-Nepal's Water Resource Management Programme (WARM-P), which in recent decades has contributed to the dramatic increase in access to gravity-fed piped water supplies throughout the Mid-

Western Province of Nepal (Pant; 2014). The situation of water supply infrastructure is shown in figure 4, left. For a more detailed description of the study site please consult Daniel et al. (2020); Tosi-Robinson et al. (2018); and Bänziger et al. (2022).

Study design & interventions

The project placed a strong focus on drinking and cooking water security through source conservation practices and the establishment of a centralized resource and training centre. The goal of the REACH collaboration was to implement and evaluate a risk-based drinking and cooking water security strategy across five WARM-P working districts in the Mid-Western Region of Nepal, including targeted capacity building activities in support of institutionalization at the local, regional and national level.

We conducted a pre-post non-randomized study, resulting in a cross-sectional mixed-method analysis. The interventions in this project were an upgrade of community-based water supply infrastructure in 33 villages according to a risk-based assessment and the water safety planning framework (Charles, 2015), implemented with several participatory activites (for a detailed description, please see Article 3).

Project 2: PACT - participatory action for long-term safe water

In India, due to the geological characteristics of the country at the feet of the Himalayas, not only anthropogenic, but also geogenic contamination of the drinking and cooking water is a major threat for public health. In particular, arsenic in groundwater is not only a global threat (Podgorski & Berg, 2020), but especially a local threat in the Indo-Ganga-Brahmaputra plane (Kumar et al., 2021). Arsenic is an invisible, taste- and odourless poison in water and food, that not only affects health very severely in the long-term (e.g. cancer (Villanueva et al., 2014)), but as well in the short term (e.g. vomiting and diarrhoea (Singh et al., 2014)).

From a technical point of view arsenic removal sounds easy (Richards et al., 2022). The water plant has to filter arsenic fluoride and iron through adsorption filters and add a fixed dose of chlorine to the water before storing and supplying. Even though these low-cost arsenic-safe water collection plants have already been installed in some parts of the eastern Indian state of Bihar, Singh (2015) as well as Singh (2017) found, that they fail. This is not necessarily due to technical reasons but rather a lack of sense of ownership among local community. This restricts their participation in operation and maintenance of water sources, despite India's long tradition with community-based management of natural resources (Ormsby & Bhagwat, 2010).

Notwithstanding this long tradition, conventional water harvesting systems were gradually neglected and centralized water management was systematically promoted. The control and ownership shifted from people to government, reducing the communities as mere end-users. Central and state governments funded entire costs of water supply without any cost recovery from community (Black & Talbot, 2005). The supply-driven approach of water supply departments and inefficient management of key resources are resulting in poor service delivery. Re-emergence of water scarce habitations, a supply-driven approach in service delivery, the absence of community participation and cost recovery, and problems in scaling-up reforms are the primary issues identified.

Study area

In the PACT study area, these issues are well evident, as well as the struggle to provide the maintenance and major repairs required to keep water supply operational sustainably.

The settlement is sometimes caste based, but sometimes people of many castes are seen in same settlement. Where people reside, the same provision of schools, hospitals, electricity and drinking and cooking water is provided by the state government in the form of civic amenities. While financial constraints are perceived to be a significant barrier in the implementation of the actions, technical (such as scarcity of electricity) and natural (e.g. flooding during monsoon) hurdles are also identified. This demonstrates the need for integrated, contextual, and well-coordinated strategies and actions to ensure rural water security (Basu et al., 2021), especially because policy and traditionalist perspectives are too technologically deterministic to adequately account for the myriad challenges of delivering rural water supply. This emphasis on technology, rather than service levels, creates the conditions in which capability traps emerge in terms of service provision (Hutchings et al., 2016).

To tackle the above-mentioned problems and because only very few community-based piped water supplies are installed, the central government of India initiated the Jal Jeevan programme (Sarkar & Bharat, 2021; Kumar & Singh, 2020). The goal of this programme is to provide safe water facilities in rural areas and, going one step further, to supply every household in the country with piped water. The Jal Jeevan and Har Ghar Nal Ka Jal programme is a scheme of Department of Drinking Water and Sanitation of the Central Government of India and the State Government of Bihar (Basu et al., 2021). In some places the task to supply the piped water scheme has been given to the Panchayati Raj Institution. Where the groundwater is contaminated, this work has been carried out by the Public Health Engineering Department (PHED) of the State of Bihar.

The situation of water supply infrastructure is shown in figure 4, middle (intervention group) and right (control group).

Study design & interventions

In a 2x2 factorial cluster-randomized controlled trial, we tested the effectiveness of interventions on a social level (individual psychological ownership) and on an individual level (habit). We combined interventions to assess its impact for sustainable installation of new community-based piped water supply infrastructure in the Navgachia subdivision of the Bhagalpur district in Bihar, India, where community-based water supply infrastructure was installed in 64 villages. This is the state-of-the-art study design to investigate causality and effectiveness of interventions (Banerjee et al., 2016). For the psychological ownership interventions, we developed a set of theory-based interventions, targeting the three routes to psychological ownership and classified them in the behaviour change technique (BCT) taxonomy. For the habit intervention, we adapted evidence-based interventions from a previous study (Inauen and Mosler, 2014).

We selected 64 habitats of arsenic affected area for our research through baseline survey and divided those 64 habitats into four different intervention arms and did four different types of intervention work in them (control with no activities, psychological ownership, habit, combination of psychological ownership + habit). For a detailed overview over the interventions, please see Article 4.

Figure 4

Schematic overview over the water organisation in study villages
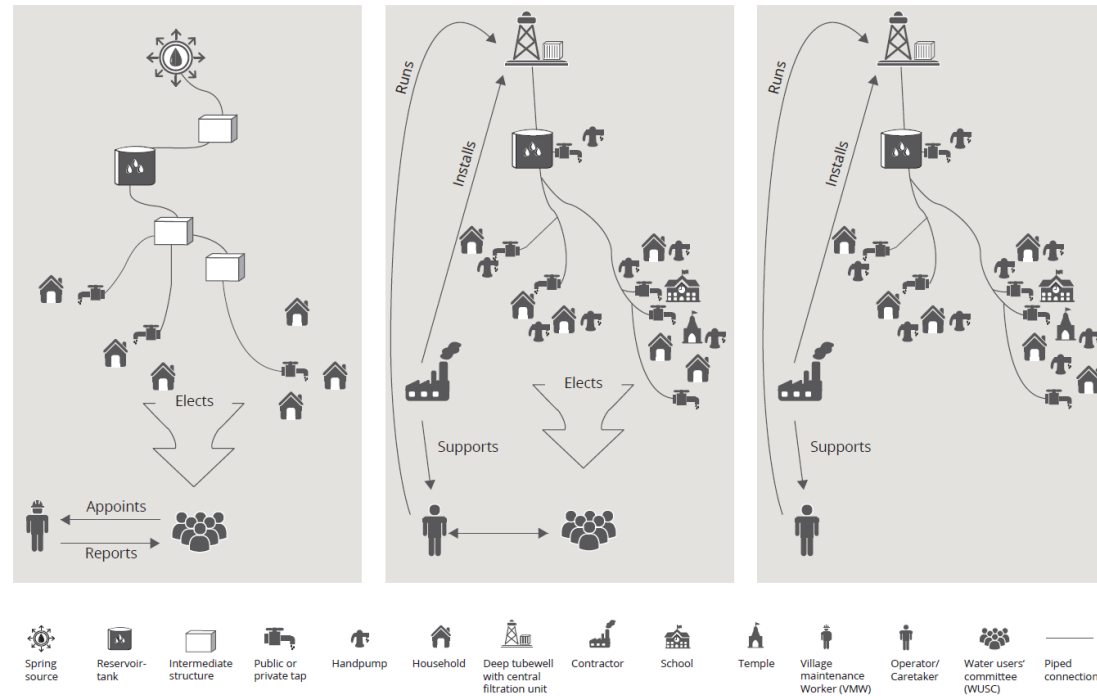
Note. Left: REACH study areas. All schemes are gravity-fed supply systems, either with community taps (n = 26) or private connections (n = 7). The water users' committee (WUSC) is elected by the community and oversees the overall management of the water scheme. The village maintenance worker (VMW) is appointed by the WUSC and is responsible for operation and maintenance, as well as collecting the water tariff. *Middle + right:* PACT study area. All schemes are deep borewells with a central filtration unit and piped water supply to community and private taps. In the psychological ownership intervention group, WUSC were established to connect the village and the operator / caretaker and include the village in decision-making, maintenance and repairing work, and exchange with the contractor.

Results

In the following I present the results structured in four Articles. Supplementary materials of the articles and original articles published can be found online: https://osf.io/kcf6j/

Article 1: The Role of Psychological Ownership in Safe Water Management: A Mixed-methods Study in Nepal

This article is published:

Ambuehl, B., Tomberge, V. M. J., Kunwar, B. M., Schertenleib, A., Marks, S. J., & Inauen, J. (2021). The role of psychological ownership in safe water management: A mixed-methods study in Nepal. *Water, 13*(5), 589.

The Role of Psychological Ownership in Safe Water Management: A Mixed-methods Study in Nepal

Benjamin Ambuehl 1, 2*, Vica Marie Jelena Tomberge 1*, Sara J. Marks 2, Madan Bhatta 3, Bal Mukunda Kunwar 3, Ariane Schertenleib 2, Jennifer Inauen 1

*These authors contributed equally and share first authorship.

1 Institute of Psychology, Department of Health Psychology & Behavioural Medicine, University of Bern, Bern, Switzerland

2 Eawag - Swiss Federal Institute of Aquatic Science and Technology, Duebendorf, Switzerland

3 Helvetas Swiss Intercooperation Nepal, Kathmandu, Nepal.

[+]Corresponding author

E-mail: benjamin.ambuehl@eawag.ch

Abstract

Long-term management and safe use of community-based water systems is essential to reduce health risks of drinking contaminated water. Water sector professionals frequently cite water users' psychological ownership (feeling that something is mine or ours) for the community-based water system as an essential element for its sustainable management and use. However, only a few studies from Africa have systematically examined the role of psychological ownership in community water system management and use. No study has yet investigated how psychological ownership emerges (routes) and how it contributes to safe water management outcomes (consequences) in the South Asian context, nor how psychological ownership is understood by local water users themselves. This mixed-methods study aims to provide the first in-depth insight into users' understanding of psychological ownership and safe water management processes in a low-income population in rural Nepal.

Our team conducted 22 semi-structured qualitative interviews with water system users and water committee members in five districts in the Karnali and Achham region of Sudur Paschim provinces of Nepal, where spring-fed piped supplies had been previously implemented through a demand-led, participatory planning approach. We analysed the transcripts by thematic analysis. Quantitative data were collected in structured interviews across 33 communities ($N = 493$). We performed generalized estimating equations for modelling routes to and consequences of psychological ownership.

Findings from qualitative and quantitative analyses converged to show that community members' involvement and feeling of influence in decision-making and investing labour and money as well as knowing about the water system was associated with greater psychological ownership for it. Greater psychological ownership, in turn, was related to greater acceptance of the water system, reported responsibility for its maintenance, greater confidence in system functionality, as well as more frequent repairing and use, but not to actual functionality.

Overall, the concept of psychological ownership is understood by people living in a low- and middle-income context, and ownership theory is applicable to the context of community-based water

systems. The results highlight the potential of psychological ownership and community participation for the longevity of communal infrastructure.

1. Introduction

2.2 billion people were without safely managed drinking water in 2017 (World Health Organization & United Nations Children's Fund, 2017). Water contaminated by pathogens can transmit various diseases and is estimated to cause 485 000 diarrhoeal deaths each year (World Health Organization, 2011; World Health Organization & United Nations Children's Fund, 2017). To reduce the risk of exposure to faecal contamination and thus improve public health, using and safely managing using and safely managing improved drinking water supply infrastructure is key (Baguma et al., 2010; Fay et al., 2005; Njonjo & Lane, 2002). For shared water supply systems and other collective resources (e.g. community forests), community-led management is a widespread approach in low- and middle-income countries (Bluffstone et al., 2020). However, for water systems, long-term functionality is often limited (Chowns, 2015).

Reasons for premature failure of water infrastructure include lack of local technical expertise, low access to spare parts, and failure of the government to provide post-construction support (Schouten & Moriarty, 2003), due to a lack of local stakeholders' use and engagement in planning and maintenance of drinking water systems (Butler & Adamowski, 2015; Carter et al., 1999; Njonjo & Lane, 2002), which is assumed to create a sense of ownership for communal infrastructure.

1.1 Psychological ownership for safe water related infrastructure

Numerous practitioners and researchers in the development sector underline the importance of stakeholders' "ownership" for communal infrastructure such as water systems to promote its sustainability (Carter et al., 1999; Kelly et al., 2017; Marks & Davis, 2012; Njonjo & Lane, 2002; Whittington et al., 2009). It is assumed that community members need to be involved in all steps of the decision-making process on planning and management of the infrastructure to develop ownership (Kelly et al., 2017; P. R. Lachapelle & McCool, 2005; Soste et al., 2015; Whittington et al., 2008; Wilson et al., 2018). Also, participation in decision-making and upfront contribution are supposed to have a direct relationship with several beneficial outcomes of functional water supply infrastructure (Prokopy, 2005). Consequently, greater "ownership" should lead to greater acceptance, use, and caretaking of the infrastructure, supporting its longevity. However while widely accepted by water

sector professionals, these assumptions are rarely empirically investigated (e.g., Lachapelle, 2008; Matilainen et al., 2018; Soste et al., 2015).

In organizational psychology, psychological ownership or ''the state in which individuals feel as though [a] target of ownership (…) is theirs'' (p. 299, (Pierce et al., 2001) indicates a feeling of possessiveness and attachment to an object thought to be their own. Investing the self, intimately knowing and having control over the target are theorized routes to psychological ownership (Pierce et al., 2003). The more psychological ownership individuals feel towards a target, the more responsibility they will feel for the target of ownership (Pierce et al., 2003). This may result in better acceptance, caretaking, and more long-term behaviour change towards the object of ownership (Avey et al., 2009; Pierce et al., 2003; Süssenbach & Kamleitner, 2018; Wilson et al., 2018).

1.2 Psychological ownership for water-related infrastructure

There are three previous studies on psychological ownership in the context of water-related infrastructure, and all are from Kenya (Contzen & Marks, 2018; Marks et al., 2013; Marks & Davis, 2012). Investment in terms of financial contribution or labour, intimate knowledge about water systems (having private vs. public water supply) and sense of control (being involved in decision-making in the planning process of water systems or shared water kiosks) were found to be associated with greater psychological ownership (Contzen & Marks, 2018; Marks & Davis, 2012). Further, psychological ownership for shared water systems were positively related to their acceptance and use (Contzen & Marks, 2018; Marks et al., 2013). Marks et al. (2013) revealed that psychological ownership for a water system is also associated with user confidence in water services and long-term water system management. However, they only found a relationship of water committee members' psychological ownership and the functionality of the water system, but not for end-users.

Even though previous studies gave a valuable insight into the potential importance of psychological ownership for safe water management in the low- and middle-income context, they provided little insight into how the psychological ownership phenomenon is understood by

stakeholders themselves. Seeing that culture influences all elements of the psychological ownership framework, e.g. the construct itself, routes, self-concept and processes (Pierce et al., 2003), cultural differences in the understanding of ownership need to be considered (Rudmin, 1992). The only existing qualitative study states that the feeling of ownership of water committee members has an impact on water system decision processes, physical labour, and resource mobilization (Kelly et al., 2017). Consistent with ownership theory, this was found to facilitate different forms of community participation (Kelly et al., 2017). However, Kelly et. al. focused on the perceptions of water committee members only. No qualitative research on the theoretical concept of psychological ownership of end-users exists. Further, the results from the Kelly et al. study do not allow generalizability due to their qualitative nature. Previous quantitative studies, in turn, were only conducted in Kenya. The generalizability of the importance of psychological ownership for safe water management is therefore still to be determined.

1.3 The present study

The present study aims to address the identified research gaps by answering the following research questions: How do end-users of safe water systems understand the concept of psychological ownership? What are the routes and consequences of psychological ownership for safe water systems? In line with ownership theory, we hypothesized that the theorized routes (having control, intimately knowing, investing the self, Pierce et al., 2003) are related to greater psychological ownership (H1) and that greater psychological ownership is related to more favourable consequences, i.e. functionality, acceptance/responsibility and use of safe water systems (H2).

This research will provide first in-depth knowledge on end-users' understanding of psychological ownership related to community-based water systems. We will conduct this research at the example of Nepal, where an estimated 75% of the rural population lacks access to safely managed drinking water (World Health Organization & UNICEF, 2017). Thereby, we will also extend research on psychological ownership and safe water systems to another continent.

2. Materials & Methods

We used a convergent parallel mixed-methods design (Creswell, 2015) to investigate the role of psychological ownership in safe water management in Nepal. The narrative structure of the qualitative data highlights the subjective perspective of Nepali water users' on their sensation of ownership for the water system, without superimposing the theory of psychological ownership, which emerged from a different context. The quantitative data, in turn, allows for a more generalizable first test of psychological ownership theory (Pierce et al., 2003) in the safe water management context in Nepal. We paired the results side by-side for comparison to identify areas that converged and diverged across the two different methodologies (Creswell, 2015). The results were iteratively discussed by the entire research team in order to validate them.

2.1 Research setting

In the hilly areas of Mid-Western Nepal up to 77% of drinking water samples are contaminated with coliforms (Shrestha et al., 2017). Following the WHO's Water Safety Plan recommendations, a comprehensive risk management strategy (monitoring of water quality, regular inspections and targeted upgrades of the water system combined with sanitary inspections to inform the potential sources of contamination to the water system) is needed for improving drinking water safety (Shrestha et al., 2017; Tosi Robinson et al., 2018). Community-led monitoring of the microbial water quality and the water system's sanitary status can improve drinking water safety (Tosi Robinson et al., 2018). Presuming the commitment of community members to safe water management for the success of these strategies, it is crucial to investigate the concept of psychological ownership in this context (Carter et al., 1999; Njonjo & Lane, 2002).

The study was carried out in five municipalities of the Karnali Province and Sudur Paschim Province of Nepal (Dailekh, Kalikot, Jajarkot Surkhet and Achham). In all but Surkhet, gravity-fed drinking water supply schemes were constructed between 2011 and 2017 by the Integrated Water

Resources Management Programme of Helvetas Nepal. In Surkhet, the water schemes were installed by another organisation.

In all schemes, a water users' committee (WUSC), selected by the community, is responsible for the coordination with various stakeholders, organize and participate in construction works and operation and maintenance of the scheme. A village maintenance worker (VMW), recruited by the users' committee, is responsible for the operation and maintenance, as well as collecting the tariff. Before the construction of the water schemes, communities are involved from the preparation period, where they present their water-related hardships among other communities and ensure a priority ranking in a list of schemes. Afterwards, they actively participate during the feasibility study and detail project survey. Communities are responsible to support the scheme construction in cash, labour works and arrangement of local materials, while the WUSC coordinates with various stakeholder's for financial and technical assistance. Site selection and constructions of structures are completed with the direct involvement of the community. Communities are further trained on governance and financial management for proper operation to promote transparency, accountability and participation practices for sustained water supply, sanitation and hygiene. The communities show usually a high involvement, presumably for two reasons: the past drinking water-related struggles and the participative approach of Helvetas. The selection of the water supply schemes for this study was based on geographical accessibility. In the quantitative study, only properly managed schemes were selected (i.e. active and skilled users' committee, regular collection of tariff, taps functionality) due to the inclusion criteria of a subsequent intervention study.

Ethical approval for this research was obtained from the institutional review board of Eawag. Written informed consent was obtained from each participant prior to data collection.

2.2 Qualitative methods

2.2.1 Sampling and Participants

Three villages were selected according to the status of their drinking water system: good (WS_good), intermediate (WS_intermd), or poor functionality (WS_poor). We categorized the functionality according to observations of the water systems in terms of the share of taps that were broken, discontinuity of water services and water quality (see detailed protocols in Annex A3).

Interviews were held with 16 women and 6 men who used the water system (Age: $M = 38.9$ years, $SD = 7.3$ Expenses: $M = 12523$ Nepalese rupee (~103 US $), $SD = 8170$; Ethnicity: 16 Janajati, 3 Dalit, 3 Brahmin / Chhetri / Thakuri). In WS_good, 4 users (3 women and 1 man) without special role were interviewed. In addition, the chairman of the WUSC, 1 female member and the female treasurer as well as the male (VMW) and the female community health worker were interviewed. In scheme WS_intermd, 6 women end-users without special role, the chairman of the WUSC and the female treasurer were interviewed. In water system WS_poor, 3 women end-users without special role as well as the chairman of the WUSC and the male VMW were interviewed.

2.2.2 Procedure

A psychology Master's student from Switzerland and a Nepali translator conducted 22 semi-structured qualitative interviews together. The translator simultaneously translated the interview questions and responses. The team audio-recorded the interviews, and the translator transcribed and translated them into English. The interview guideline can be found in Annex A2.

2.2.3 Data analysis

We used thematic analysis to analyse the qualitative data (Braun & Clarke, 2006). In a first step, the first authors read all interview transcripts. One interview was then partially excluded from analysis, because the translator appeared to be too suggestive. In a second step, one of the first authors

inductively coded subsets of sentences, full sentences or paragraphs related to ownership. In order to reflect different facets of ownership or associated themes, the same person grouped coding features of the text into themes in a third step. In a fourth step, the other first author read all the transcripts with initial coding. Themes appearing were then grouped in a fifth step, when the author agreed with the coding. If there was disagreement, both first authors discussed themes with the entire research group until reaching consensus.

2.3 Quantitative methods

A cross-sectional structured survey was conducted to quantitatively investigate the routes and consequences related to end-users' psychological ownership of safe water systems.

2.3.1 Participants and procedures

The quantitative data comprised a total sample size of $N = 493$ (15 randomly selected households for each of 33 water systems). This sample size was determined for a subsequent intervention study. Helvetas selected the communities according to the following criteria: a functioning piped water supply existent, road access from Helvetas headquarter's office within one day's travel time, organizational capacity to receive the planned water safety interventions (i.e., established administrative and technical management procedures), and the agreement of the community to participate. A psychology Master's student trained local data collectors in a 1-week workshop on the correct implementation of the survey. Surveys were conducted in Nepali and took approximately 30 minutes to complete. The interviews were supervised by Helvetas personnel and Master's students.

2.3.2 Measures

The survey instruments were translated and back translated from English to Nepali and pretested in one community not included in the analyses. The interviews assessed psychological

ownership, households' perceptions of and management practices for their main drinking water source and demographic measures. The data collectors used unipolar 5-point Likert scales for items measuring psychological ownership, supported by a visual scale of five dots of increasing size, ranging from "I do not at all agree" to "I agree very much" (Harter et al., 2020). To create composite scores for constructs (e.g. psychological ownership) we summed corresponding items. We normed all scores to values of 0-1, with higher values indicating a higher score on this construct. For binary items, 1 indicated the presence of an outcome. See Tables A1 in the Appendix for details on item wording.

Psychological Ownership. We adapted the validated individual psychological ownership scale to assess psychological ownership for the water system (Van Dyne & Pierce, 2004). The goal to use all seven items was deemed too onerous by the local partners. The nuances in psychological ownership items were difficult to translate to Nepali and caused a feeling of redundancy, which may also annoy participants (Heath, 2017). We retained five items with highest face validity in this cultural context. For the data analysis, we also removed one reverse-coded item from the scale, due to low items-total correlations. The final scale comprised four items (α = 0.56), e.g. *How much do you agree with the following statement? "This is MY water system."* 1= *agree not at all* to 5 = *agree very much*.

Routes to Psychological Ownership. Control was measured through participation in decision-making, whether anyone in this household had a special position in the water supply system, perceived influence during planning and construction, frequency of WUSC meeting to discuss the water system. Knowledge was assessed by asking whether participants knew that there was a village maintenance worker for the water system. For self-investment, participants were asked whether their family had contributed cash, labour, or materials, towards the construction of the water system. Please consult Table 1 for all codings of the responses.

Consequences of Psychological Ownership. We assessed self-reported functionality, expected functionality, interruption, confidence in reparation, perceived water taste and perceived safeness of main water source as well as behavioural consequences (exclusive use of water system, treatment after collection from water system).

2.3.3. Data analysis

For modelling the routes and consequences of psychological ownership, we performed generalized estimating equations (GEE) that account for the nested structure of the data (households nested in water systems) (Liang & Zeger, 1986). To identify the routes of psychological ownership, we computed one model with the routes as predictors and the outcome psychological ownership for the water system. For the consequences of psychological ownership, we fitted separate GEEs for continuous outcomes (confidence in reparation, perceived safeness) and dichotomous outcomes (self-reported functionality, expected functionality, interruption, perceived water taste, exclusive use and treatment after collection). We computed all analyses in IBM SPSS Statistics 23 version 24 (IBM Corp., Armonk, N.Y., USA). As effect size measures for the GEE models, we calculated odds ratios (*OR*s) with asymptotic Wald 95% confidence intervals (CIs). They are interpreted as the percentage increase (values >1) or decrease (values <1) in the outcome (e.g. exclusive use of the water system) for a unit increase in the predictor (Atkins et al., 2013).

3. Results

3.1 Qualitative Results

No differences in psychological ownership emerged between the three water systems. Therefore, we present the results without distinguishing between the water systems.

3.1.1 Psychological ownership in general

Interviewees reported a feeling of ownership for items **belonging** to them personally, their family or community. For example:

"[I feel ownership for] clothes, ornament, slippers that belong to me personally. I feel like these stuffs belong to me personally. (23f_user)"

Participants reported that the feeling of ownership refers to **regular personal use**:

"clothes [are] very much personal to me, I use it regularly. (4f_user)"

Or even to **exclusive use** of the target of ownership:

"and nobody is using my personal stuff that's why it leads to feeling like the cloth belong to me only. (4f_user)"

They explained, that a feeling of ownership emerges, when **investing** in something:

"For example if someone gives you something for free you don't really feel that this is your own thing. But if you buy something with your own money you will take care about it and feeling of ownership will arise. (7m_WUSC_chairperson)"

They also reported, that such a feeling of ownership can manifest in **different intensities**:

"[I feel ownership for] the one that I use very regularly like my clothes and my ornament that belongs to me only not even my family. The items which I get from my husband

house, I feel like it's not my own but the things which I get from my own house , I feel more ownership. (20f_user)"

And the feeling of ownership can even ***disappear***:

"[For] something like the domestic animal, we care them, love them, protect them but finally we sell them. Until the time they are in the house, [they are like] ours but the fact is we have to sell them later. (23f_user)"

3.1.2 Psychological ownership for the water system

For the water system, some persons reported to have a very strong ***individual feeling of ownership for the water system***: *"I don't have to think twice to feel like this water system is mine. It is the clearest thing that this system is mine. (8m_user)"*

Interviewees mentioned four themes, why they felt that they personally owned the water system: Regular use *("I am using [this system] regularly [...] that's why it is my system", 22f_user),* utility *("This system is providing me water [...] that's why it is my system.", 22f_user),* having influence *("[It is mostly true for me, that it is my water system], as I was the crucial part during the construction also", 10m_VMW),* and contributing labour and money *(e.g. "I wasted my sweat to built this [water system]. (...) and I also contribute money for this system. (...)This is why it is my water system. (8m_user).* Interviewees further mentioned having contributed equally to the water system: *"Probably, there are 200 families and all contributed the same amount of money" (3f_user).*

Psychological ownership differed depending on the position a person had in the village: For example, interviewees with a special role in the water system reported about the ***assignment of ownership***, because of their position:

"It is very true for me [that it is my water system], because I am the chairperson of the committee, if I didn't feel as mine then it would be a problem.
(12m_WUSC_chairperson)"

3.1.3 Organisation of the water system

The responsibility differed between individual and collective responsibility for different parts of the water system, e.g. sanitary structures: "*I feel responsible when the tap is broken and if the problem is occurring in the system, I would suggest all the members [= users] to fix it.*" *(21f_user)*.

For most interviewees, the feeling of ownership depended on the **organizational structure of the water system**, i.e. the presence of public tap vs. private taps.

> *"The earlier system had public taps, so when something happened with the water system we really didn't care. Now it is different. Since we have the private tap we care a lot about our system and I feel more ownership for this one as compared to the public tap.; Human nature is like that If something is being used by all the community together, the commitment from a single person is less. It doesn't feel very as you own it, because everyone is using it. The problem is then, that they don't maintain it or clean it. For the public tap we used to collect a tariff but not all the people were willing to pay this amount of money. Now as we have private taps this changed. We are all paying the tariff in time and it's literally not hard to think about this water system as mine. (7m_WUSC_chairperson)"*

Whereas some other interviewees reported no difference:

> *"I will feel equal ownership to both of the public and private tap. (11f_WUSC_treasurer)"*

A greater feeling in ownership lead to more **caretaking**:

> *Everyone was careless about the water system probably because they had only a public tap but now they care a lot more because they have their own tap. (5f_WUSC_member)*

Public taps represent the water system as a shared organizational structure, whereas private taps represent only individual parts of the water system. Accordingly, users can have **a co-existing feeling of ownership** for both: individual ownership for the private taps and collective ownership for the organisation of the water system:

"Everyone has contributed a lot, everyone pays money for the system and everyone in the community is facilitated with the system so that's why it is our community's water system. I think I own my personal tap. Maybe that's why I feel this is my water system and also everyone is using this water system in the community maybe that's why I feel this is our community's water system. (3f_user)

3.1.4 Safe water management roles

Perceived responsibility differed between **management roles**. For example, a member of the WUSC stated that there was a hierarchy regarding who had had greater responsibility.

"Yes, I am the member of the committee and I feel more ownership than others. As my responsibility is bigger than other people's responsibilities. (5f_WUSC_member)"

The roles in the management of the water system came with different attitudes and expectations for the water system. The chairperson urges people to **take care** (*"all the community owns it, all the community members must care it." (13f_user)*.

The chairperson with the top position in the hierarchy was seen as most **responsible**, followed by members of the WUSC and the VMW and then, all the people were perceived as equally responsible as they represented the bottom of the hierarchy:

"First of all the chairperson is responsible, then the committee members, and finally the people in the community are responsible that the system works properly or not. (4f_user)"

3.1.5 Collective Action

Interviewees emphasized the importance of collective action and collaboration to perform repairs and maintenance. However, collective action was also perceived as a **social dilemma**, i.e. a conflict between personal and collective interests (Van Lange et al., 2013).

"Personally, I feel very responsible. Only one person cannot do all the things [of maintenance work] so we need the unity but the problem is here is no unity at all. (17f_user)

Ownership also seemed to evoke a feeling of **territoriality** to defend and protect the water system:

"I will let everyone to use it because water is very important to everyone. This is for the whole water system. If somebody wants to use my personal tap I won't let them use. It is only for me and for [my] family. (5f_WUSC_member)"

3.2 Quantitative Results

As can be seen in the descriptive statistics in Table 1, 98% ($n = 484$) of the respondents used the water system as their main drinking water source, by either consuming water from their own household tap (27%, $n = 133$) or from a shared tap in the community (71%, $n =351$). 28% ($n = 138$) additionally used an unmanaged sources (e.g. river, open source). 51% ($n = 253$) treated their drinking water. Across the study communities psychological ownership for the water system was generally high.

Table 1: Sample characteristics and descriptive statistics.

	f	*f%*	*Coding for modelling*
Ethnicity			
Brahmin /Chhetri / Thakuri	331	67 %	
Dalit	108	22 %	
Janajati	51	10 %	
other	3	0.6 %	
Female respondents	326	67 %	
Main drinking water source (water system)			
Household tap (water system)	133	27 %	1
Village tap (water system)	351	71 %	1
Open source	3	0.6 %	0
Protected source	1	0.2 %	0
River	1	0.2 %	0
Unmanaged piped source	4	0.8 %	0
Unmanaged second source (multiple; % yes)	138	28 %	
Treating drinking water (boiling, chlorinating/ filtering water after collection; % yes)	253	51 %	
Outcome measures			
Routes			
Involvement HH in water supply system (% yes)			
Female community health volunteer	5	1 %	1
No	350	71 %	0
other	8	2 %	1
Village maintenance worker	3	2 %	1
Member of WSP[f] team	12	2 %	1
Member of WUSC[g]	115	23 %	1
Decision-making on level of service of the water system			
no	78	16 %	0
yes	394	80 %	1
Don't know	21	4%	0
Main perceived influence during planning and construction			
Donor or NGO[h]	8	2%	0

48

	f	f%	Coding for modelling
Local government	2	0.4%	0
Other	1	0.2%	0
Village leaders	30	6%	0
All users of the system	362	73%	1
Water committee	90	18%	0
Frequency WUSC meeting discussions on water system			
Bi-monthly	18	4%	0.66
Once every 3 months	35	7%	0.66
Once every 6 months	10	2%	0.66
As needed	110	22%	0.33
Never	96	19%	0
Don't know	43	9%	0
Once per year	15	3%	0.66
Monthly	166	34%	1
Existence of village maintenance worker (% yes)	416	84%	
Contribution cash (% yes)	124	75%	
Contribution labour (%yes)	462	94%	
Contribution materials (% yes)	91	19%	
Consequences			
Self-reported functionality			
No, not functioning	10	2%	0
Yes, functioning but not well	87	18%	0
Yes, functioning well	396	80%	1
Expected functionality one year from now (%yes)	395	80%	
Interruption in the last 6 months for more than one week (%yes)	77	16%	
Perceived water taste			
Good	455	92%	1
Rusty	2	0.4%	0
Salty	1	0.2%	0
soil	15	3%	0
Varies from rainy to dry month	20	4%	0
Exclusive use of water system			
Yes	353	72%	1

	f	f%	Coding for modelling
No, using unmanaged primary or secondary source	140	28%	0
Treatment after collection from water system [a]			
Yes, boiling, chlorinating/ filtering water	181	51%	1
No treatment	172	49%	0

	M	SD	Min	Max
Age	38.21	14.54	6	93
Income Nepali Rupees	10898 [b]	8173.75 [c]	000	36000
Household size	6.58	3.0		27
Outcome measures				
Psychological ownership for the water system	0.84	0.15		1
Confidence in reparation [d]	0.79	0.32		1
Perceived safeness of main water source [e]	-0.08	0.71	1	1

Note: N = 493, *f* = absolute frequency, *%f* = relative frequency, *n* = Total Sample size; *M* = Mean; *SD* = Standard deviation

[a] *n* = 140 missing (Do not have water system as exclusive source) [b] ≈ 106 US$ [c] 7 outliers < 36.000, set to 36.000

[d] *n* = 6 missing (no answer/ I don't know) [e] *n* = 2 missing (no answer)

[f] WSP team= water safety planning team

[g] WUSC = water users committee [h] NGO = non-governmental organization

The results on the routes to psychological ownership for the water system are presented in Table 2. As can be seen, psychological ownership for the water system was 5 to 7% higher when the influence on the water system during planning and construction of the water system was attributed mainly to the community members (rather than to other authorities, e.g. the local government, donor or village leaders) when WUSC members had regular meetings, and when respondents were aware of the presence of a village maintenance worker.

Table 2. Generalized estimating equations of psychological ownership for the water system

	B	SE	p	OR	CI for OR $_{95}$	
					LL	UL
Intercept	0.68	0.03	< 0.001	1.97	1.86	2.10
Involvement HH in water supply system	0.03	0.01	0.057	1.03	1.00	1.05
Decision-making on level of service	0.07	0.02	< 0.001	1.07	1.03	1.12
Perceived influence in planning and construction	0.07	0.02	0.001	1.08	1.03	1.12
WUSC meeting discussions on water system	0.05	0.02	0.005	1.05	1.02	1.09
Existence of village maintenance worker	0.06	0.01	< 0.001	1.07	1.03	1.10
Contribution cash	-0.03	0.02	0.118	0.97	0.94	1.01
Contribution labour	-0.04	0.02	0.079	0.96	0.93	1.00
Contribution materials	0.01	0.02	0.467	1.01	0.98	1.05

Note: N= 493, 33 systems, Dependent variable = Psychological ownership, HH = household, WSUC = water users committee, *B* = Parameter Estimates, *SE* = Standard error*, OR* = Odds Ratio, CI$_{95}$ =Confidence interval, LL/ UL= lower/ upper limit of the confidence interval. All *p*-values are two-tailed. Probability distribution: normal, link function: identity.

The results on the consequences of psychological ownership for the water system are presented in Table 3. Community members with higher psychological ownership for the water system, compared to community members with lower levels of psychological ownership had 12 times higher odds for reporting current, and 11 times higher odds for expected water system functionality, 0.2 times lower odds for interruptions in the water system and 71% greater confidence in repairing in case of interruption (see Table 3). They further had 19 times higher odds to use the water system exclusively, and 19 times higher odds to treat their water after collecting it from the water system.

1 **Table 3. Generalized estimating equations of different consequences of psychological ownership for the water system**

Psychological Ownership *Parameter*	Current self-reported functionality[a]	Expected functionality[a]	Interruption[a]	Confidence in reparation[b]	Perceived water taste[a]	Perceived safeness of main water source[b]	Exclusive use of water system[a]	Treatment after collection from water system[a]
Estimates	2.46	2.40	-1.69	0.71	2.03	-0.09	3.02	2.96
SE	0.71	0.86	0.68	0.12	1.36	0.15	0.87	0.83
p	0.001	0.005	0.013	< 0.001	0.137	0.550	0.001	< 0.001
OR	11.66	11.02	0.19	2.03	7.60	0.91	20.49	19.26
LL	2.88	2.05	0.05	1.61	0.52	0.68	3.74	3.81
UL	47.15	59.39	0.71	2.56	110.16	1.23	112.34	97.28

2   *Note: N=* 493, 33 systems, *SE* = Standard error*, OR* = Odds Ratio, CI$_{95}$ =Confidence interval, LL/ UL= lower/ upper limit of the 95% confidence
3 interval of OR. All *p*-values are two-tailed. [a] Probability distribution: binominal, link function: logit (dummy coded variables). [b] Probability distribution:
4 normal, link function: identit

4. Discussion

Indicating high convergence of qualitative and quantitative findings, our mixed-methods study in Nepal corroborated and extended earlier findings of the importance of psychological ownership in safe water system use and management. Qualitative findings contributed new understanding of contextual factors that accompany the emergence of psychological ownership. These findings deepened our interpretation of the quantitative results, and they extend ownership theory into new conceptual domains (e.g. theory of collective action, see Figure 1).
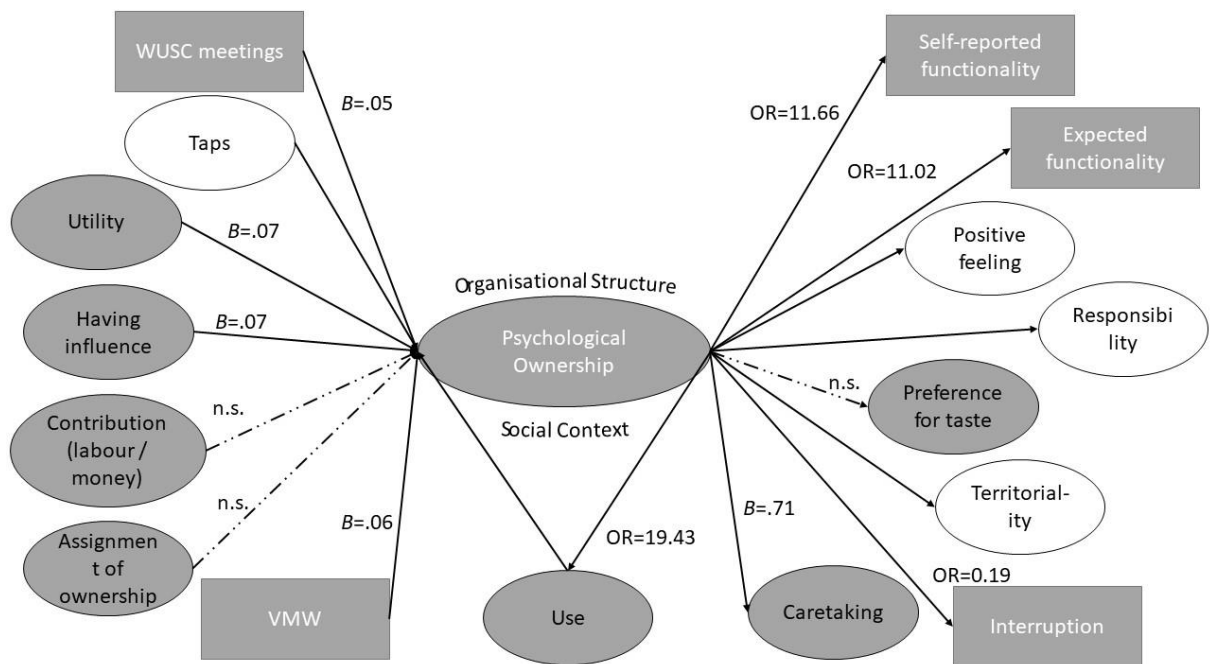
Figure 1. *Overview of qualitative and quantitative findings: Routes (left part) and consequences (right part) of psychological ownership for safe drinking water systems. Shapes and shading indicate which themes are supported by qualitative (oval, white), quantitative (squared, grey), or both qualitative and quantitative data (oval, grey). Arrows indicate the assumed causality derived from qualitative data, and strength of associations derived from the quantitative findings. Relationships without coefficients were not investigated in quantitative part. WSUC = Water System Users Committee, VMW = village maintenance worker, B = unstandardized regression coefficient, OR = odds ratio, n.s. = not significant.*

4.1 How is psychological ownership understood by end-users?

Our results indicated that the concept of psychological ownership for the communal water system is well understood by end-users in Nepal. Beyond possessiveness, end users relate a sense of belongingness and utility to psychological ownership for the water system. Psychological ownership is understood as social construct and thus related to other determinants for social phenomena in the community (Kelly et al., 2017). Such a vocabulary is also found in other samples to be categories of what can be owned (Csikszentmihalyi & Rochberg-Halton, 1981; Rudmin & Berry, 1987). The quantitative data indicates that psychological ownership for the water system was generally high among our study participants. This is consistent with ownership theory, considering the high involvement over the years of Helvetas within the study communities through the Integrated Water Resources Management Programme.

4.2 Which routes are associated with psychological ownership for the water system?

Our quantitative results showed that the theorized routes are significantly related to psychological ownership. Qualitative data corroborated the importance of control for fostering psychological ownership. This is in line with the previous findings (Contzen & Marks, 2018; Marks et al., 2013). Interestingly, control (e.g. involvement in decision-making) has been found to be the most dominant route to psychological ownership (Rudmin & Berry, 1987). These findings lend further empirical support for demand responsive planning, the sector's dominant approach for implementing rural water supplies since the 1990s (Whittington et al., 2009). Central features of the demand responsive approach include households choosing technology and management arrangements for the system, controlling key project-related decisions, and committing to covering a portion of the upfront capital costs and most (or all) of ongoing operational costs (Whittington et al, 1998).

In line with qualitative results, collective action and cooperative behaviour were also found to be key for the successful management of other collective resources (such as sustainable community foresting) (Bluffstone et al., 2020) .

Conversely to quantitative results but in-line with previous findings (Marks & Davis, 2012), qualitative findings indicated that water users' self-investment (labour and cash contributions) in the water system is related to their psychological ownership for it. This discrepancy in results may be explained by methodological artefacts in the quantitative analysis. If everyone contributes equally in the community, which was the case in our study, the variable will not contain any variance and therefore not explain variance in the dependent variable. Alternatively, a non-token level of financial contribution may be needed to increase psychological ownership (Marks & Davis, 2012), and the low fees in the present study may not have sufficed.

Extending ownership theory, our qualitative findings indicated that water system use, perceived utility, and assignment of ownership may be additional routes to psychological ownership. The former is conceptualized as a consequence of ownership (Contzen & Marks, 2018), which was predicted by psychological ownership in our quantitative analyses. Due the cross-sectional nature of our study design, however, causal direction cannot be ascertained. Possibly, regular use of the target of ownership may be both a route and a consequence of psychological ownership. Using a target of ownership may be understood as a form of control, which increases psychological ownership according to theory. Deriving utility from the water system or being assigned responsibility had no corresponding items in our quantitative analysis. Future studies should include these routes and test their generalizability.

4.3 Which consequences are associated with psychological ownership for the water system?

Our quantitative findings indicate that greater psychological ownership relates to greater self-reported and expected functionality, fewer interruptions, greater confidence in reparation, greater exclusive use of the water system, and more frequent water treatment after collection from water system. The majority of our findings corroborate earlier studies. However, no differences in psychological ownership emerged between the functional, intermediate, and non-functional water

systems in the qualitative part of our study. Future research should use observed functionality data in quantitative research on psychological ownership to shed further light on this issue.

For the relationship of interruptions and psychological ownership, there are at least two potential explanations. First, if people have high psychological ownership they are also more committed to the target of ownership (Davis et al., 1997; Meyer & Allen, 1997), manifesting in reporting interruptions, so that they can be repaired (i.e. stewardship behaviour). This is supported by the fact that confidence in reparation (also in qualitative data, and in line with Marks et al. (2013)) and exclusive use of water system are significantly associated (as they express also the reciprocal commitment to the water system). Another reason for higher reported interruptions could be that responsibility diffuses within the community. Caretaking and responsibility are reported to be highly pronounced in qualitative data of users and persons with a key role in the communities. The competing sense of ownership might be understood as social dilemma – where the extra role behaviour (LePine et al., 2002) is high (e.g. users with high psychological ownership might be more willing to pay fees or not to switch to another water source, even when water services are not perfect) and can also be counterproductive (Spector & Fox, 2010).

In addition to the theorized consequences of psychological ownership, territoriality emerged as a further consequence. This corroborates findings in a study on how psychological ownership leads to a series of territorial behaviours (i.e. behavioural expression of ownership towards a target) in organizations (Brown et al., 2005). This means, that users with high psychological ownership were more likely to report to protect the system and exclude outsiders from using it.

4.4 Strengths, Limitations, and Future Directions

A strength of our study is the convergent mixed methods approach, which allows for robust conclusions for convergent findings. Hence, we can strongly conclude that end-users of safe water systems understand the concept of psychological ownership, at least in Nepal, and potentially in similar contexts. Psychological ownership theory from organizational literature showed high

relevance to the safe water management context, and psychological ownership has high potential for the sustainable implementation of infrastructure.

As a limitation, we found low internal consistency of the validated psychological ownership scale (Van Dyne & Pierce, 2004), which was applied for the first time in this context. This is acceptable for early research on the topic (Peterson, 1994), but future studies must improve this. In our qualitative interviews we found, for example, that people perceived the possessive attributes "mine / my" as emphasizing too much individual psychological ownership and not enough collective psychological ownership of the community (Pierce & Jussila, 2009). A second reason for low internal consistency of the scale could be the organization of some of the water systems. Qualitative data indicated that respondents had both individual and collective feelings of ownership for the water system at the same time – depending on the part of the structure that was referred to as the target of ownership. There are structures of the water system that are community owned (pipelines, water source), and others are privately owned (e.g. private tap stands). Thus, we found evidence that conceptualizing collective psychological ownership as an extension of individual psychological ownership, when certain preconditions are fulfilled (Pierce & Jussila, 2009), is valid in the context of safe water infrastructure and recommended for future research in this domain.

A further limitation of our quantitative study is that due to the cross-sectional design, no conclusions can be drawn on the directionality of effects. This is mitigated to some extent by the qualitative results that indicated directionality of the results. However, randomized controlled trials are needed to determine whether the assumed routes can promote psychological ownership and consequences such as functionality of infrastructure.

5. Conclusion

The convergent findings of this mixed-method study lead us to conclude that psychological ownership (Pierce et al., 2009) can be transferred to the communal water supply context. Our study suggests that psychological ownership is a social construct that influences individual and collective

outcomes in community-based safe water management. Especially stakeholders' investment and control may be important levers to add to the sustainability of safe water infrastructure and other collective resources. Expanding the concept to safe water infrastructure, we conclude that psychological ownership is an important component contributing to the functionality of technological resources for chieving public health goals, such as the Sustainable Development Goals (SDGs) through a more participative process of development.

6. Declaration of Interest

None. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

7. Funding

8. References

Atkins, D. C., Baldwin, S. A., Zheng, C., Gallop, R. J., & Neighbors, C. (2013). A tutorial on count regression and zero-altered count models for longitudinal substance use data. *Psychology of Addictive Behaviors*, *27*(1), 166–177. https://doi.org/10.1037/a0029508

Avey, J. B., Avolio, B. J., Crossley, C. D., & Luthans, F. (2009). Psychological ownership: Theoretical extensions, measurement and relation to work outcomes. *Journal of Organizational Behavior*, *30*(2), 173–191. https://doi.org/10.1002/job.583

Baguma, D., Loiskandl, W., & Jung, H. (2010). Water Management, Rainwater Harvesting and Predictive Variables in Rural Households. *Water Resources Management*, *24*(13), 3333–3348. https://doi.org/10.1007/s11269-010-9609-9

Bluffstone, R., Dannenberg, A., Martinsson, P., Jha, P., & Bista, R. (2020). Cooperative behavior and common pool resources: Experimental evidence from community forest user groups in Nepal. *World Development*, *129*, 104889. https://doi.org/10.1016/j.worlddev.2020.104889

Brown, G., Lawrence, T. B., & Robinson, S. L. (2005). Territoriality in Organizations. *Academy of Management Review*, *30*(3), 577–594. https://doi.org/10.5465/amr.2005.17293710

Butler, C., & Adamowski, J. (2015). Empowering marginalized communities in water resources management: Addressing inequitable practices in Participatory Model Building. *Journal of Environmental Management*, *153*, 153–162. https://doi.org/10.1016/j.jenvman.2015.02.010

Carter, R. C., Tyrrel, S. F., & Howsam, P. (1999). The Impact and Sustainability of Community Water Supply and Sanitation Programmes in Developing Countries. *Water and Environment Journal*, *13*(4), 292–296. https://doi.org/10.1111/j.1747-6593.1999.tb01050.x

Chowns, E. (2015). Is Community Management an Efficient and Effective Model of Public Service Delivery? Lessons from the Rural Water Supply Sector in Malawi: Is Community Management Efficient and Effective? *Public Administration and Development*, *35*(4), 263–276. https://doi.org/10.1002/pad.1737

Contzen, N., & Marks, S. J. (2018). Increasing the regular use of safe water kiosk through collective psychological ownership: A mediation analysis. *Journal of Environmental Psychology*, *57*, 45–52. https://doi.org/10.1016/j.jenvp.2018.06.008

Creswell, J. W. (2015). *A concise introduction to mixed methods research*. SAGE.

Davis, J. H., Schoorman, D. F., & Donaldson, L. (1997). *Toward a Stewardship Theory of Management*. *22*(1), 20–47.

Fay, M., Leipziger, D., Wodon, Q., & Yepes, T. (2005). Achieving child-health-related Millennium Development Goals: The role of infrastructure. *World Development*, *33*(8), 1267–1284. https://doi.org/10.1016/j.worlddev.2005.03.001

Harter, M., Inauen, J., & Mosler, H.-J. (2020). How does Community-Led Total Sanitation (CLTS) promote latrine construction, and can it be improved? A cluster-randomized controlled trial in Ghana. *Social Science & Medicine*, *245*, 112705. https://doi.org/10.1016/j.socscimed.2019.112705

Heath, W. (2017). *Psychology research methods: Connecting research to students' lives*. Cambridge University Press.

Kelly, E., Lee, K., Shields, K. F., Cronk, R., Behnke, N., Klug, T., & Bartram, J. (2017). The role of social capital and sense of ownership in rural community-managed water systems: Qualitative evidence from Ghana, Kenya, and Zambia. *Journal of Rural Studies*, *56*, 156–166. https://doi.org/10.1016/j.jrurstud.2017.08.021

Lachapelle, P. (2008). A Sense of Ownership in Community Development: Understanding the Potential for Participation in Community Planning Efforts. *Community Development*, *39*(2), 52–59. https://doi.org/10.1080/15575330809489730

Lachapelle, P. R., & McCool, S. F. (2005). Exploring the Concept of "Ownership" in Natural Resource Planning. *Society & Natural Resources*, *18*(3), 279–285. https://doi.org/10.1080/08941920590908141

LePine, J. A., Erez, A., & Johnson, D. E. (2002). The nature and dimensionality of organizational citizenship behavior: A critical review and meta-analysis. *Journal of Applied Psychology*, *87*(1), 52–65. https://doi.org/10.1037/0021-9010.87.1.52

Liang, K.-Y., & Zeger, S. L. (1986). Longitudinal data analysis using generalized linear models. *Biometrika*, *73*(1), 13–22. https://doi.org/10.1093/biomet/73.1.13

Marks, S. J., & Davis, J. (2012). Does User Participation Lead to Sense of Ownership for Rural Water Systems? Evidence from Kenya. *World Development*, *40*(8), 1569–1576. https://doi.org/10.1016/j.worlddev.2012.03.011

Marks, S. J., Onda, K., & Davis, J. (2013). Does sense of ownership matter for rural water system sustainability? Evidence from Kenya. *Journal of Water Sanitation and Hygiene for Development*, *3*(2), 122–133. https://doi.org/10.2166/washdev.2013.098

Matilainen, A., Suutari, T., Lähdesmäki, M., & Koski, P. (2018). Management by boundaries – Insights into the role of boundary objects in a community-based tourism development project. *Tourism Management*, *67*, 284–296. https://doi.org/10.1016/j.tourman.2018.02.003

Njonjo, A., & Lane, J. (2002). *Rural Piped Water Supplies in Ethiopia, Malawi and Kenya: Community management and Sustainability*. Water and Sanitation Program, Field Note 13.

Pierce, J. L., & Jussila, I. (2009). Collective psychological ownership within the work and organizational context: Construct introduction and elaboration. *Journal of Organizational Behavior*, *31*(6), 810–834. https://doi.org/10.1002/job.628

Pierce, J. L., Jussila, I., & Cummings, A. (2009). Psychological ownership within the job design context: Revision of the job characteristics model. *Journal of Organizational Behavior*, *30*(4), 477–496. https://doi.org/10.1002/job.550

Pierce, J. L., Kostova, T., & Dirks, K. T. (2001). Toward a Theory of Psychological Ownership in Organizations. *Academy of Management Review*, *26*(2), 298–310. https://doi.org/10.5465/amr.2001.4378028

Pierce, J. L., Kostova, T., & Dirks, K. T. (2003). The state of psychological ownership: Integrating and extending a century of research. *Review of General Psychology*, *7*(1), 84–107. https://doi.org/10.1037/1089-2680.7.1.84

Prokopy, L. S. (2005). The relationship between participation and project outcomes: Evidence from rural water supply projects in India. *World Development*, *33*(11), 1801–1819. https://doi.org/10.1016/j.worlddev.2005.07.002

Rudmin, F. W. (1992). Cross-Cultural Correlates of the Ownership of Private Property: A Look from Another Data Base. *Anthropologica*, *34*(1), 71. https://doi.org/10.2307/25605633

Rudmin, F. W., & Berry, J. W. (1987). *Semantics of Ownership: A Free-Recall Study of Property. 37*, 257–268.

Schouten, T., & Moriarty, P. B. (2003). *Community water, community management: From system to service in rural areas*. ITDG.

Shrestha, A., Sharma, S., Gerold, J., Erismann, S., Sagar, S., Koju, R., Schindler, C., Odermatt, P., Utzinger, J., & Cissé, G. (2017). Water Quality, Sanitation, and Hygiene Conditions in Schools and Households in Dolakha and Ramechhap Districts, Nepal: Results from A Cross-Sectional Survey. *International Journal of Environmental Research and Public Health*, *14*(1), 89. https://doi.org/10.3390/ijerph14010089

Soste, L., Wang, Q. J., Robertson, D., Chaffe, R., Handley, S., & Wei, Y. (2015). Engendering stakeholder ownership in scenario planning. *Technological Forecasting and Social Change*, *91*, 250–263. https://doi.org/10.1016/j.techfore.2014.03.002

Spector, P. E., & Fox, S. (2010). Counterproductive Work Behavior and Organisational Citizenship Behavior: Are They Opposite Forms of Active Behavior? *Applied Psychology*, *59*(1), 21–39. https://doi.org/10.1111/j.1464-0597.2009.00414.x

Süssenbach, S., & Kamleitner, B. (2018). Psychological Ownership as a Facilitator of Sustainable Behaviors. In J. Peck & S. B. Shu (Eds.), *Psychological Ownership and Consumer Behavior* (pp. 211–225). Springer International Publishing. https://doi.org/10.1007/978-3-319-77158-8_13

Tosi Robinson, D., Kunwar, B., Shrestha, R., Bhatta, M., Marks, S., & Marks, S. (2018). Assessing the Impact of a Risk-Based Intervention on Piped Water Quality in Rural Communities: The Case of Mid-Western Nepal. *International Journal of Environmental Research and Public Health*, *15*(8), 1616. https://doi.org/10.3390/ijerph15081616

Van Dyne, L., & Pierce, J. L. (2004). Psychological ownership and feelings of possession: Three field studies predicting employee attitudes and organizational citizenship behavior. *Journal of Organizational Behavior*, *25*(4), 439–459. https://doi.org/10.1002/job.249

Van Lange, P. A. M., Joireman, J., Parks, C. D., & Van Dijk, E. (2013). The psychology of social dilemmas: A review. *Organizational Behavior and Human Decision Processes*, *120*(2), 125–141. https://doi.org/10.1016/j.obhdp.2012.11.003

Whittington, D., Davis, J., Prokopy, L., Komives, K., Thorsten, R., Lukacs, H., Bakalian, A., & Wakeman, W. (2008). How Well is the Demand-Driven, Community Management Model for Rural Water Supply Systems Doing? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1265532

Wilson, N. J., Mutter, E., Inkster, J., & Satterfield, T. (2018). Community-Based Monitoring as the practice of Indigenous governance: A case study of Indigenous-led water quality monitoring in the Yukon River Basin. *Journal of Environmental Management*, *210*, 290–298. https://doi.org/10.1016/j.jenvman.2018.01.020

World Health Organization. (2011). *Guidelines for drinking-water quality*. WHO.

World Health Organization, & UNICEF. (2017). *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baseline*. UNICEF & World Health Organization.

Article 2: Contextualized Measurement Scale Adaptation: A 4-Step Tutorial for Health Psychology Research

This article is a preprint. The article has been submitted for publication and is under review at the International Journal of Environmental Research and Public Health.

Contextualized Measurement Scale Adaptation:

A 4-Step Tutorial for Health Psychology Research

Benjamin Ambuehl 1 2 *, Jennifer Inauen 2

1 Eawag- Swiss Federal Institute of Aquatic Science and Technology, Duebendorf,

Switzerland

2 Institute of Psychology, Department of Health Psychology & Behavioral Medicine,

University of Bern, Bern, Switzerland

*Corresponding author

E-mail: benjamin.ambuehl@eawag.ch

Author Note

Abstract

Health psychology research is inherently context specific: different health behaviours and different target groups (e.g. gender, age), influenced by social structures, culture, and environments. This asks for adaptation of research instruments to enhance specificity. For example, when using measurement scales in new contexts, the translation and psychometric validation of the instruments are necessary, but not sufficient if the validity of the psychological concept behind a measurement scale has not been researched. In this study, we build on existing guidelines of translation and psychometric validation and present four steps how to adapt measurement scales to a new context: Step 1 asks whether the psychological concept is found in the new context. Step 2 asks whether the measurement scale and its items are understood in the new context. Step 3 asks whether a measurement scale is valid and reliable. Step 4 asks how the items of the measurement scale perform individually. Following these 4 steps, measurement scales are carefully translated, adapted, and validated and can therefore be transferred to very different contexts.

Keywords (5): Context specificity; Scale adaptation; Cross-cultural psychology; Mixed methods; Measurement

Contextualized Measurement Scale Adaptation: A four-step Tutorial for Health Psychology Research

Explaining and changing health behaviour is a key area of health psychology. Behaviour is not only determined by the individual but is also influenced by various contextual factors (Campbell, & Murray, 2004; Maher et al., 2021) that need to be considered when measuring, explaining and changing behaviour. Measurement scales for behaviour and its determinants need to guarantee objective, reliable, and valid assessment of the measured construct (Dima, 2018). When using measurement scales in new contexts (e.g. different population or behaviour), the translation and psychometric validation of the instrument are necessary, but not sufficient if the validity of the psychological concept behind a measurement scale has not been researched (Myburgh et al., 2021). The present paper highlights this often-overlooked issue, and provides systematic guidance, how to tackle this in health psychology.

Context in health psychology

Context is the environment in which a subject acts. This can be social structures (Hogg & Smith, 2007; Tajfel, 1979), cultural scripts and behaviour (Kashima et al., 1992; Lamont et al., 2017; Wissing & Temane, 2008), and changes in the physical environment (Min & Lee, 2006). These contextual factors influence the subject, for example by shaping attitudes or other psychosocial determinants of behaviour. Also values, beliefs, cognition, norms, and personality are strongly influenced by context (Bandura, 2002). But also measurement is context specific: for example questionnaires used in the reasoned action approach include contextual factors (e.g. Connor, & Sparks 2015; Lo et al., 2014). Generally, context is very important to consider in research (Markus & Kitayama, 1998) and to be integrated in health psychology research for various reasons:

Firstly, context can facilitate the execution of an unhealthy behaviour, as was found, in research on habit formation (Gardner, 2015) and smoking abstinence (Gwaltney et al., 2001). Secondly, context not only influences behaviour directly but can also shape individual factors that

determine behaviour, such as personality traits (Markus & Kitayama, 1998), personal preferences, and response patterns (Tversky & Simonson, 1993). Thirdly, context is measurement specific and also influences measurement, especially when using questionnaires. This is crucial, because questionnaires are still one of the main methods for assessing target behaviour (Smith, 2011), and the reliability and validity of questionnaires is key in health psychology (Dima, 2018). Pomerance and Converse (2014) showed that context-specific questionnaires have higher predictive validity and accuracy than general questionnaires. Consequently, questionnaires need to be understood as context-specific measurement instruments. And measurement scales used in a new context, with a different population sample, require an adaptation of the scale and items to the new context (Ngwira et al., 2021) that goes beyond mere linguistic and psychometric adaptation.

Scale adaptation in health psychology

When established measurement scales are transferred to a different cultural context, Harkness et al. (2010) highlight three domains that should be considered when adapting survey instruments to a new context: language, culture, and measurement.

For language, researchers have focused on translation as an adaptation method, referring to linguistic translation of a scale in another language. The purpose of translation is to achieve semantic equivalence between measurement scales in both the original and new language. For example, a review by Van Widenfelt et al. (2005) identifies seven elements essential to good translation of a measurement scale to a new language: (1) creating a translation team; (2) balancing literal and specific translation; (3) using back-translations; (4) testing the questionnaire in the field; (5) identifying flawed items by statistical analyses; (6) establishing new reliability, validity, and norms; and (7) contacting original source authors. Similarly focusing solely on translation, Fenn, Tan, and George (2020) published a guideline for translating psychological tests. They recommend forward and backward translation and highlight that a check by a committee of experts may guarantee the accuracy

of a translation. Translation, however, is not sufficient to ensure conceptual equivalence of measurement scales in different contexts (Sousa, & Rojjanasrirat, 2010).

For cultural adaptation, Hall et al. (2018) extend translation as adaptation methodology by asking participants following their interviews for a cognitive debriefing or post-assessment discussion (Luszczynska et al., 2005) to find suggestions for improving accuracy of translation. For cross-cultural and multicultural surveys, good practice (as suggested by Acquadro et al., 2008; Harkness, 2003; Hambleton & Li, 2005, and Van Widenfelt et al. 2005), in turn, recommends a multistep approach. This includes pretesting translations of questionnaires qualitatively to ensure not only semantic, but also content equivalence (Prince, 2008; Hilton, 2017; used in Gjersing et al., 2010), and global validation to ensure conceptual equivalence (Fenn et al., 2020) when adapting the measurement scale. However, in many areas of health psychology, such as global health, this is not conducted in detail when doing cross-cultural comparative research (Prince, 2008).

For measurement adaptation, psychometric testing of a questionnaire is an extension to validate mathematical and statistical properties of the measurement scale (Dima, 2018), often through item-level analysis and subsequently refining it to improve its fit to the new context (e.g., Heeren et al., 2011; Guillemin et al. 1993; MacKenzie et al. 2011; Goncalves Silva, 2019). Because health psychology research uses measurement scales to fulfil several empirical quality criteria (Dima, 2018; Keszei et al., 2010), translation and validation might be sufficient for an established scale and can work to check adaptation for scales across similar cultural contexts.

However, adaptation of the measurement instruments to the specific context is often neglected or applied only in an exploratory way without actually translating or adapting the questionnaire to the new context (Arafat et al., 2016; Asatryan & Oh, 2008; Veronese et al. 2020). Researchers even use measurement instruments in entirely dissimilar contexts and for very specific target behaviours, without respecting demands of extensive adaptation of the measurement instruments. This can have many reasons; one is that a convergent guideline for cross-cultural adaptation and validation of measurement protocols is lacking (Epstein et al., 2015) and another is that the choice of methods depends on preference and logistics. In contrast, guidelines and reporting criteria (e.g., RECAPT,

Heim et al., 2021) have been established for adapting interventions to new contexts (Moore et al., 2021). In health psychology, to the best of the authors' knowledge, no protocols have been published for adapting a measurement scale to a new context.

Measurement scale adaptation and validation in new context: a four-step tutorial

To fill this gap, we developed the first comprehensive protocol for adaptation of measurement scales to a new context. Building on three domains to be adapted (Harkness et al., 2010), the tutorial comprises four steps for successful adaptation of a measurement scale to a new context: integrating and building on established protocols for conducting qualitative prestudies (Prince, 2008; Hilton, 2017; used in Gjersing et al., 2010), conceptual (Fenn et al., 2020) and in-detail psychometric validation (to ensure measurement equivalence) (Dima, 2018).

In this article, we present the adaptation of a measurement instrument in four steps (Harkness et al., 2010) using an explorative mixed-methods design (see Table 1). Steps 1 and 2 are qualitative steps for investigating the adaptation to the concept needed by the new context. Steps 3 and 4 are quantitative steps for validating the measurement instrument in the new context.

Table 1

Four-step protocol summary

Step	Research Questions	Method	Alternative procedure
1	Is the psychological concept found?	Qualitative interviews using grounded-theory approach.	If concept is not understood, has different dimensions: develop new items for potentially measuring these new dimensions
2	Are the measurement scale and its items understood?	Qualitative interviews using think aloud approach.	If items are not understood, reasoning does not match intended conceptualization: exclude items
3	Is the measurement scale valid and reliable?	Quantitative survey with two survey waves	If items do not fit in factor analysis; criterion validity; internal consistency; test–retest reliability, exclude items from scale
4	How do the items perform individually?	Quantitative survey with two survey waves	See Dima (2018)

Note. Four-step protocol summary with research questions for every step and proposed method to answer research question.

Example study: Psychological ownership of safe water infrastructure in India

We will exemplify the four-step protocol at a study of psychological ownership as it relates to safe water consumption for the prevention of water-borne diseases. Psychological ownership is defined as the sense of ownership, without necessarily legally owning the target of ownership (Pierce et al., 2003). Originally, psychological ownership was researched in the organizational context in the United States (Pierce, Kostova, & Dirks, 2001) and China (Peng & Pierce, 2015). Psychological ownership was later established in other areas as an important concept (Dawkins et al., 2017), for example in safe water. Psychological ownership was identified as factor related to the acceptance, use, and sustainability of safe drinking water infrastructure in various cultural contexts (Contzen & Marks, 2018; Marks, Onda, & Davis, 2013; Ambuehl et al., 2021). In India, Basu et al. (p. 1472, 2021) find 'a lack of sense of ownership among local community restricting their participation in operation and maintenance of water sources. The struggle to provide the maintenance and major repairs required to keep water supply operational sustainably are well evident'. For this reason, we proposed psychological ownership as a key target when improving the functionality of safe water infrastructure

in India. However, the concept stems originally from western and organizational contexts and has been used in other cultural contexts and to measure other targets without having been investigated or adapted. We use the example of measuring psychological ownership for safe drinking and cooking water infrastructure in Bihar, India to illustrate how to adapt a measurement scale in health psychology research to a new cultural context.

In Step 1, we investigate the understanding of the concept in Bihar, India in the context of safe water infrastructure. In Step 2, we research measurement of psychological ownership in a new context to determine whether the measurement scale for psychological ownership is understood by participants. In Step 3, we pretest and analyse the properties, test–retest reliability, and construct validity of the adapted scale to identify whether the measurement scale is valid in the new context and reliably measures psychological ownership of health-related infrastructure in India. In Step 4, we follow an established protocol for scale validation (Dima, 2018) to assess applicability of the psychological ownership measurement scale in-depth to identify whether particular scale items can be improved.

Step 1: Is the psychological concept found in the new context?

1.1 Introduction

In Step 1, we research the transfer of existing theory and empirical evidence to the new context and how the psychological concept is understood in the new context. In our example, Step 1 investigates the concept of psychological ownership of safe water infrastructure in Bihar, India and answers research question 1: How is psychological ownership understood in Bihar, India?

1.2 Method

We selected four villages with functional community-based piped water supply in rural Bhagalpur in the state of Bihar, India, as study area. Community-based piped water supply was installed by government or private trusts to supply communities with drinking and cooking water free from the naturally occurring arsenic. Groundwater is pumped to a central storage tank where arsenic is removed in a central filtration unit. Then, filtered water is pumped into an overhead tank and from there distributed by pipe to private or public collection taps.

Interviews were conducted according to a semistructured guideline following the grounded-theory approach (Belgrave & Seide, 2019), until no new information was gathered during interviews anymore. Grounded theory is a method for investigating the foundation of a construct (Jørgensen & Stedman, 2001) and is used here to investigate participants' understanding of the concepts of ownership, psychological ownership, and the water supply. Grounded theory emerges from the data bottom-up. We followed semistructured interview guidelines to cover all concepts and constructs. The translator simultaneously translated the interview questions and responses. The team audio-recorded the interviews, and the translator transcribed and translated them into English. Interview guidelines can be found in supplementary materials S1.

Participants

Qualitative interviews were held with 18 users, nonusers, and caretakers in six habitations (i.e. villages) with functional and nonfunctional safe water infrastructure.

Ethics and Registration

Ethical approval for this research was obtained from the institutional review board of Eawag. Written informed consent was obtained from each participant prior to data collection.

Analyses

The data were analysed by qualitative content analysis (Mayring, 2004). First, the first author read four interview transcripts and inductively coded phrases and clauses as thematic elements to assemble a coding system. Second, the coding system was discussed and validated with the last author. Third, it was used to code four further interviews and if necessary, complemented with additional codes. Fourth, the coded interviews and all remaining interviews were coded with the more elaborate and validated coding system.

1.3 Results

1.3.1 Psychological ownership and dimensionality of constructs

Villagers had several understandings of individual psychological ownership. One dimension is the understanding of psychological ownership as 'possession':

'ownership has two translations in Hindi (leadership = *svaamitv*; property/possession = *malikh*)'

'ownership has two meanings: 1) *hak* = what is in my hand (e.g., the working condition of a handpump) and 2) *malighkana* = head of something (e.g., family)'

And both translations have one meaning in common:

'I think that these are like personal things'

Additionally, this personal belonging was also seen by others in the community; it had a second, social dimension:

'It is known to everyone here that this cow belongs to me. The whole community here knows that this cow is mine so they will say accordingly.'

And as a third dimension, psychological ownership was also understood as an instrument of power:

'This feels like having the power over these things, having the full amount of control, like being a leader'

Villagers also distinguished individual psychological ownership and collective psychological ownership. They differentiated two forms of collective psychological ownership: by who the target of ownership benefits and by who invested in it:

[Collective ownership is when] 'their use can be shared'.

'The temple is for everyone, but this filter must belong to the person who gave their land for its installation'

'Everyone from the community can use it as they have contributed equally'.

However, the collectiveness was still sharply defined:

'This temple is for the whole community as they have contributed in its construction. Well only for the Hindu community.'

Collective psychological ownership was seen as a very elaborate and holistic perspective on how the community was responsible for the target of ownership:

[Collective psychological ownership depends on] 'mutual consent by the community and the whole community should be able to pay or contribute significantly to that. We may do our own boring then and subsequently will have our own connectivity. The caretaker will be from us and he/she will be responsible to look after the unit.'

1.3.2 Antecedents to psychological ownership

When interviewing villagers about the antecedents of their feeling of ownership, an answer mentioned very frequently was about being the head or leader of something:

'When something is in his hands, he then is the head of something and therefore has the feeling of owning something.'
Or they reported having invested tokens, money or labour in installation and maintenance:

[It is ours, because….]
'we have spent Rs. 10,000 in its installation with the help of some labours having a depth of 50 feet. The labour cost Rs. 2000 each.'
'Ownership is not simply = costs, it is more that guarding leads to ownership'
'We have donated this land for the installation of the unit'
'If I am looking after the house and cattle, it is mine then.'

1.3.3 Consequences of psychological ownership

When reporting a sense of ownership, villagers referred to their unlimited use of the target of ownership:

'Only for me and related to mine and not to the others, there are no restrictions in use'
 'We did not prefer to go there because that source is someone else's and we don't like going there.'
However, it also involves a responsibility to look after the target of ownership, which was associated with psychological ownership:

'But no direct benefits, it depends on functionality (if there is benefit possible, owning is good) […]

looks after everything...'

'And the caretaking of the things is still a duty of the owner. So he feels a certain responsibility for the

things as well as no limits in using them. Considering other people using his things, he has a bit of an

unsafe feeling.'

In summary, the consequences of psychological ownership were understood as feelings of

power and control over the target of ownership:

'This feels like having the power over these things, having the full amount of control, like being a

leader'

1.4 Discussion

In Step 1, we found the concept of psychological ownership to be relevant and understandable

in the context of safe water supply and collection in India. However, we found that psychological

ownership in Bihar was understood as a multidimensional construct with the additional dimensions of

possession, social acknowledgment, and power. In literature, new scales developed to assess

psychological ownership are often multidimensional (Avey et al. 2009; Olckers, 2013; Shukla &

Singh, 2019). This was not the case in the original context (Pierce, Jussila, & Li, 2018; Van Dyne &

Pierce, 2004). Even so, in our data we found the original dimension, possession, to be present.

Antecedents, consequences, and differentiation between individual and collective psychological

ownership were found and align with previous findings (Dawkins et al., 2017; Pierce, & Jussila,

2011).

Next, we developed additional items to measure psychological ownership quantitatively and

three-dimensional. However, when testing for homogeneity of the measurement scale and criterion

validity, we did not identify a better model when including a three-dimensional measurement scale.

Overall, the three-dimensional scale did not fit the data well. Because of this and because qualitative

findings of Step 1 converge on the "possession" as central dimension, we continue this protocol by

reporting only on the measurement scale of the 'possessiveness' dimension. Overall fit indices of the

three-dimensional measurement scale can be found in supplementary materials S4.

Step 2: Are the measurement scale and its items understood in the new context?

After having found the concept and confirming that it was understood in the new context, we investigated participants' understanding of the items measuring psychological ownership. The aim of Step 2 is to identify misunderstandings and potential problems of interpretation in the items measuring the concept found in Step 1.

2.1 Introduction

Previous studies did not measure psychological ownership consistently. For safe water infrastructure, studies used singular items (Contzen & Marks, 2018; Marks, Onda, & Davis, 2013) or only the parts of established psychological ownership scales that reported highest face validity (Ambuehl et al., 2021). New measurement scales were even developed (Avey et al., 2009; Olckers, 2013; Shukla & Singh, 2015), covering a broader concept with potentially lower discriminant validity than theory-based psychological ownership. In India, a measurement scale for psychological ownership was developed and validated (Shukla & Singh, 2015). However, the authors did not conceptualize psychological ownership with a core of possessiveness as Pierce et al. (2003), calling into question the validity of that scale. None of the studies cited above adapted and validated measure of psychological ownership as understood by Pierce et al. (2003) to its new context. Therefore, we chose to adapt the original validated measurement scale of psychological ownership (Van Dyne, & Pierce, 2004). In this Step 2, we investigate how to best adapt the items of this measurement scale to our context by answering research question 2: How are the items that measure psychological ownership understood in Bihar, India?

2.2 Methods

Qualitative interviews following a structured guideline were held with participants, until no new information was gathered during interviews anymore. In total, 18 users, nonusers, and caretakers

in six habitations with functional and nonfunctional safe water infrastructure were interviewed following think-aloud reasoning (Collins, 2003; French et al., 2007). Think-aloud reasoning is a method used in health psychology that gives insights into participants' reasoning when answering questions and helps to observe whether they understand the question as intended. Further, it helps to identify problems when answering the questions and can uncover false reasoning or doubts when answering the questions. It is a method that lets participants verbalize their thoughts when choosing an answer for the items and thus helps to interpret the answer options in the intended way.

The original questionnaire for psychological ownership was translated into Hindi and double-checked by back-translating into English, following best practice (Fenn et al., 2020). Then, the questionnaire was pretested, and participants responded to the questions in a think-aloud way (Charters, 2003). The translator simultaneously translated the interview questions and responses. The team audio-recorded the interviews, and the translator transcribed and translated them into English verbatim. Interview guidelines can be found in supplementary materials S2.

Ethics and Registration

Ethical approval for this research was obtained from the institutional review board of Eawag. Written informed consent was obtained from each participant prior to data collection.

Participants

The same study sample was used as in Step 1.

Measures

The items of the original questionnaire for psychological ownership (Van Dyne & Pierce, 2004) were translated into Hindi by a committee of academics, ordinary working-class people, and older and younger people and double-checked by back-translating into English. If opinions diverged about a translation, it was discussed within the committee until everyone agreed on a solution. In the first phase of the interviews, no answer options were presented, as we were only interested in

respondents' reasoning. In a second phase, answer options were presented, and their interpretation was researched.

Analyses

Responses were analysed with qualitative content analysis (Mayring, 2004) at item level. First, the first authors read four interview transcripts and inductively coded phrases and clauses as thematic elements to assemble a coding system. Second, the coding system was discussed and validated with the last author. Third, it was used to code four further interviews and if necessary, complemented with additional codes. Fourth, the coded interviews and all remaining interviews were coded with the more elaborate and validated coding system.

2.3 Results

Examples for the psychological construct

When asking about examples of having the sense of ownership, villagers mentioned the following:

'I have this house, my vehicles and cattle, my agricultural land.'

'He owns the house, land, cows, a bike,'

'he owns cows (by buying), land, clothes, mobile, shoes, tractor, TV, motorbikes, knowledge, handpump'

'I have my house, my shop, my garden and agricultural land and one bicycle.'

'I am the head of my family'

Additionally, we asked about how they call the community's organization of the water supply and participants responded in agreement:

'Water scheme of the community. And privately, I also have a handpump.'

According to these results, we rephrased the introduction to the psychological ownership scale and reworded the target of ownership in the items (Table 02).

Table 2

Psychological ownership measurement scale

	Original Scale (Van Dyne, & Pierce, 2004)	Adapted Scale
Introduction	Think about the home or the boat or the cabin that you own and the experiences and feelings associated with the statement 'this is my (our) house!'. The following questions deal with the 'sense of ownership' that you feel for the organization that you work for. Indicate the degree to which you personally agree or disagree with the following statements:	Think about the home or ~~the boat or the cabin~~ *the cow or the bike or the mobile* that you own and the experiences and feelings associated with the statement ~~'this is my (our) house!'~~ *'this is my home!', 'this is my cow!'. 'this is my bike!', 'this is my mobile!'*. The following questions deal with the 'sense of ownership' that you feel for the ~~organization~~ *water scheme* that you ~~work for~~ *have in this community*. Indicate the degree to which you personally agree or disagree with the following statements:
PO_002*	This is my organization.	This is my ~~organization~~ *water scheme*.
PO_005*	I sense that this organization is our company.	I sense that this ~~organization~~ *water scheme* is our ~~company~~ *water scheme*.
PO_008	I feel a very high degree of personal ownership for this organization.	I feel a very high degree of personal ownership for this ~~organization~~ *water scheme*.
PO_011*	I sense that this is my company.	I sense that this is my ~~company~~ *water scheme*.
PO_014*	This is our company.	This is our ~~company~~ *water scheme*.
PO_017	It is hard for me to think about this organization as mine.	It is hard for me to think about this ~~organization~~ *water scheme* as mine.
PO_020	Most of the people that work for this organization feel as though they own the company.	Most of the people that ~~work for this organization~~ *live in this village* feel as though they own the ~~company~~ *water scheme*.

Note. Strikethrough font: original wording of scale (Context: Western; Target of ownership: organization) (Van Dyne, & Pierce, 2004). Italic font: Adapted wording of scale (Context: Indian; Target of ownership: community water supply scheme) used in Step 2. * These items form the definitve adapted measurement scale, after the entire adaptation and validation procedure.

Items that work as intended

When responding to the items by thinking aloud, respondents that perceived only community ownership for the safe water infrastructure agreed for example on the item 'This is our water scheme.':

'Yes it's for community – it is for the wellbeing of communities.'

'Yes, it is true'

They also agreed on the item 'Most of the people that live in this village feel as though they own the water scheme.':

'Yes. But this is a large village and the pipeline goes to which house at that lace people can use it. And the person who want this water they had the talk with the caretaker. The person who want this water can take this water – the households with taps can use the filtered water.'

'Yes, we feel so. Water is life after all. we would like to have a same filter scheme with HOUSEHOLD piped water from Ganga river that gives us hopes in the beginning for safe drinking water.'

Consistent with their reasoning that there is no personal ownership, they denied personal ownership when responding to the item 'This is my water scheme.':

'No, it is not true.'

Neither they agreed on the item 'I feel a very high degree of ownership for this water scheme'.

'No, I don't think so.'

For others, personal and community ownership can also go together. They responded to the item 'This is my water scheme' the following:

'Yes it is mine as well as for others till the time it is giving the waters to the community. It's never in my mind that this system is entirely mine.'

To the item 'This is our community water scheme.' they answered the following:

'I'm not saying that it is my personal unit, this is for whole community.'

And to the item 'Most of the people that live in this village feel as though they own the water scheme.' the following:

'Yes, they think like that. They have given their signature on the consent form in front of the Govt. officials.'

Item that caused confusion and was not understood

However, the inversely stated item 'It is hard for me to think about this water scheme as mine' caused problems when answering. Either respondents were confused:

'I don't understand. Because the filter is my own and the water belongs to everyone, because it makes them healthy.'

Or they did not understand what was being asked:

'I don't understand. if I want to get ownership, I am willing to pay for owning'

2.4 Discussion

The adapted questionnaire was pretested and understood by the villagers. The transfer from the nontangible original target of an organization to the tangible one of infrastructure was found to be easily possible, and corresponding terminology was found for the new target of ownership. Think-aloud reasoning about examples for psychological ownership highlighted which adaptations were necessary. By changing the introduction and examples provided according to the results of this step, we adapted the measurement scale minimally but still precisely for the new cultural context and target of ownership. Additionally, think-aloud responses also hinted at difficulties when the inversely stated item was misunderstood or not understood at all.

Previous studies (see 2.1) established new measurement scales and rejected the original scale. Often, they expanded conceptualization of the original scale and in turn, developed a new scale measuring psychological ownership as a multidimensional scale (as data structure indicated). However, when adapting the original single-factorial scale, we found such expansion to be unnecessary. As a result of this qualitative step, wording and examples in the introduction were adapted, and the measurement scale was cleared for pretesting in a quantitative study.

Step 3: Is the measurement scale valid and reliable in the new context?

In Step 2, we analysed the understanding of the measurement scale and its items. After we removed items that were misunderstood or caused problems (e.g. expressing thoughts that point towards not understanding the question correctly), the measurement scale was ready to be analysed in quantitative use.

3.1 Introduction

Once the concept and measurement scale were found to be relevant and understood, the question was whether the quantitative measurement instrument worked well. Psychometric properties and performance of the measurement scale are quantitative indices for a measurement scale and therefore key elements when validating a measurement scale (Prince, 2008). For this, we followed criteria for scale construction (John & Benet-Martinez, 2014) and analysed homogeneity, internal consistency, global fit, global misfit, and overall model fit of the measurement scale for psychological ownership. Therefore, the aim of the next step was to answer research question 3: Is the measurement scale valid and reliable for measuring psychological ownership of water infrastructure in Bihar, India?

3.2 Methods

For this 2-wave quantitative survey, we selected four villages with functional community-based piped water supply in rural Bhagalpur in the sate of Bihar, India, as study area. Community-based piped water supply was installed by government or private trusts to supply communities with arsenic-free drinking and cooking water. Approximately 30 households were randomly selected per village, and with the exception of one village, the caretakers of the infrastructure were also interviewed. The first survey wave was conducted in March 2019, followed by a 6-month time lag that included the monsoon, followed by the second survey wave in September.

Ethics and Registration

Ethical approval for this research was obtained from the institutional review board of the Eawag. Written informed consent was obtained from each participant prior to data collection.

Participants

Quantitative data was collected from total $N = 193$ participants, who categorized themselves as using the safe water infrastructure ($n = 111$), not using or using other water source as main source ($n = 79$), or as being the caretaker of the safe water infrastructure ($n = 3$) in four villages.

Measures

Besides psychological ownership, several theory-based psychosocial determinants and water collection behavioural practices, found to be related to psychological ownership in previous studies, were also assessed in these quantitative surveys. The precise questionnaire can be found in the supplementary materials S3.

Psychological ownership

We used the adapted individual psychological ownership scale (Van Dyne & Pierce, 2004) to assess psychological ownership of the water system in the Indian context (Table 2).

Routes to psychological ownership

Pierce, Kostova, & Dirks (2001) established three routes, how the sense of ownership evokes: by having control over the target of ownership, by being familiar with and having intimate knowledge about the target of ownership, and by investing the self into the target of ownership, These three routes were measured with multiple items each (see supplementary materials S3).

Water collection behavioural practices

As explained in the introduction, psychological ownership was found to have several effects on people's water collection behavioural practices. Some of the most important ones were included in

this survey: use (Marks & Onda, 2012), a proxy for behaviour: habit (Gardner et al. 2010), acceptance for infrastructure (Contzen & Marks, 2018), and commitment for caretaking (Basu et al., 2021).

Interviews were conducted with computer-assisted personal interviewing (CAPI) methods. Additionally, we used a visual answer scale (Harter, 2020) and a two-step question format in which respondents first either choose to agree, disagree, or neither agree nor disagree and only then report the intensity: strongly agree, slightly agree, strongly disagree, or slightly disagree.

Analyses

To validate the psychological ownership scale quantitatively, we examined the homogeneity and dimensionality of the ownership items. Subsequently, we tested the unidimensionality of the measurement scale with confirmatory factor analysis (CFA). CFA tests a hypothesized structure with model fit statistics and parameter estimates (Byrne, 2005). Model fit indices need to be judged against recommended thresholds: the Tucker-Lewis index (TLI) and the comparative fit index (CFI) > 0.95; root mean square error of approximation (RMSEA) < 0.06; and $\chi 2$ *p* value > .05 (Hu & Bentler, 1999; Jackson, Gillaspy, & Purc-Stephenson, 2009). To assess discriminant and criterion validity, we performed simple regression analyses for routes and continuous outcomes and logistic regression analyses for dichotomous outcomes, because our small sample size did not allow a nested data structure for generalized estimating equations (GEE) models.

3.3 Results

The original seven-item scale showed a significant chi-square ($\chi 2$ = 101.167, 14 d.f., *p* < 0.05), high RMSEA = 0.138, and low CFI = 0.871. Completely standardized factor loadings ranged from -0.017 to 0.784.

In the first iteration, we deleted two items (PO_017 and PO_020) with the lowest item-total correlation. The shortened 5-item model showed still a significant chi-square ($\chi 2$ = 69.532, 5 d.f., *p* <

0.05), high RMSEA = 0.198, and higher CFI = 0.899). Completely standardized factor loadings ranged from 0.592 to 0.780.

In the second iteration, we deleted one item with the lowest factor loading and allowed for covariances between items with similar wording. The shortened 4-item model (Figure 1) showed good fit indices: a nonsignificant chi-square ($\chi 2$ = 2.779, 1 d.f., p = .351), low RMSEA = 0.074 [.000; .183], and high CFI = 0.996. Completely standardized factor loadings ranged from 0.721 to 0.857 (Figure 1). With N = 193, we found internal consistency (Cronbach's α) to be high at both first measurement time point (Cronbach's $\alpha 1$ = .826) and at second measurement time point (Cronbach's $\alpha 2$ = .881). Test–retest reliability as ICC (Koo & Li, 2016) was moderate: .64 [.33; .81].

We found that the criterion validity of psychological ownership differs between users and nonusers of the water scheme and is correlated to certain routes and consequences (Figure 2). Routes and consequences were defined and conceptualized a priori from theory.

Figure 1

CFA model for 4-item measurement scale
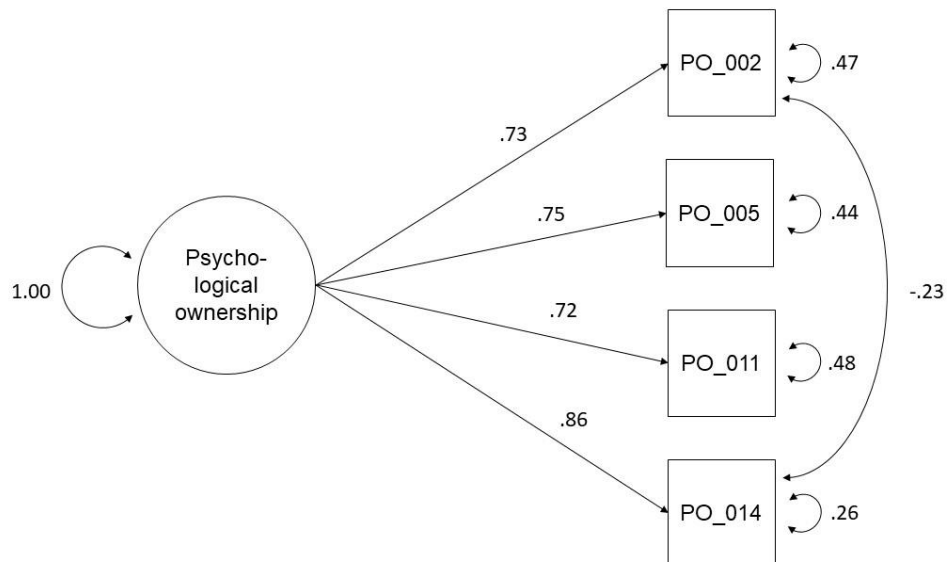
Note. 4-item psychological ownership measurement scale: a one-factor model that allows for covariances between items with similar wording (PO_002 and PO_014: 'This is _____ water scheme.').

Figure 2

Criterion validity of the psychological ownership scale
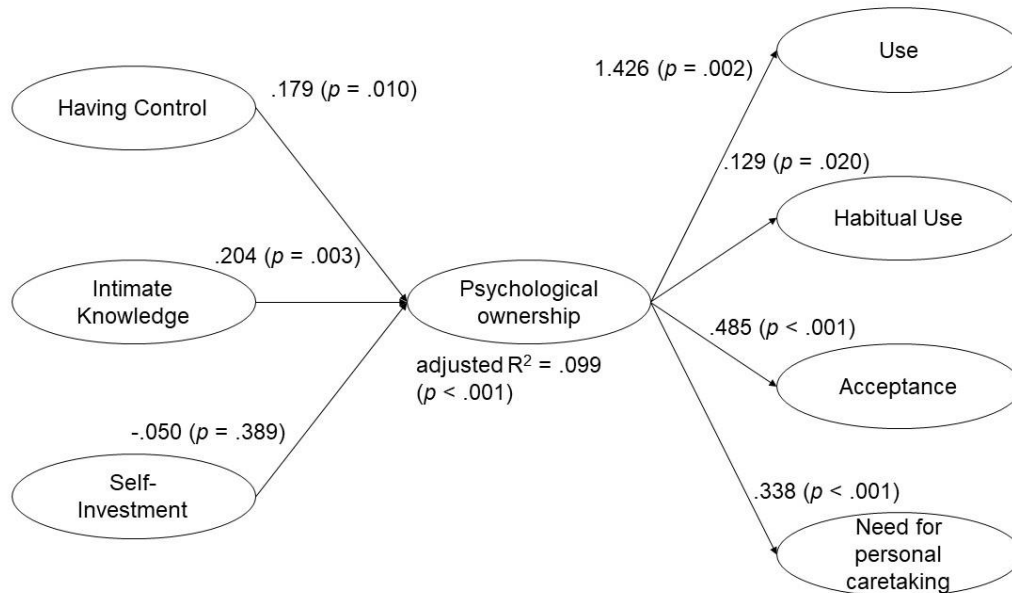
Note. A summary of multiple linear regressions and a logistic regression (use = 1; nonuse = 0). $N =$ 328. Highlighted with grey background, having control and intimate knowledge related significantly to psychological ownership as routes, whereas self-investment did not. Psychological ownership was related to the use of the water scheme, habitual use, its acceptance, and the perceived need to take care of the water scheme.

3.4 Discussion

The psychological ownership scale can be translated to a different context with a different target of ownership and also be measured with Van Dyne and Pierce's (2003) quantitative scale. After several iterations, good overall fit indices were found for a 4-item scale. The results from stepwise exclusion of items converge with the qualitative findings in Step 2, where the inversely stated item in particular was not understood: Internal consistency was increased when this item was deleted from the scale.

The shortened 4-item scale showed comparable fit indices to those of its old context ($N = 227$; internal consistency: $\alpha 1 = .93$, $\alpha 2 = .89$; $\chi 2 : 3.74$ (df = 2, $p > .05$); RMSEA: .06; CFI: .99; factor loadings: .73 - .93; apart from test-retest reliability, which was slightly lower in our study than in the original context (test–retest reliability: 3 month lag, r = .72). However, there are plausible explanations for this. Firstly, we tested the measurement scale in an unstable environment; the monsoon changes people's water collection practices, as they switch to water collection sources that are not flooded. Second, the test–retest lag was about 6 months, compared to 3 months in the old context. Therefore, we suggest that test–retest reliability be assessed again over a shorter time interval, during the dry season.

We found good criterion validity, differing between consequences of psychological ownership of the water scheme. Furthermore, we also found different theorized routes to be associated with psychological ownership. With that, we accepted the shortened scale for measurement of psychological ownership and analysed performance at item level in Step 4.

Step 4: How do the items perform individually in the new context?

4.1 Introduction

In Step 3, we assessed global fit indices for measuring psychological ownership in a new context and towards a new target of ownership. However, Dima (2018) urges the need to additionally validate measurement instruments at item level. In this Step 4, we followed Dima's (2018) six-step protocol to evaluate the core measurement properties of items in our measurement scale and answer research question 4: How do items perform individually in the new context?

4.2 Methods

In this step, the same study sample and measures was used as in Step 3.

Ethics & Registration

Ethical approval for this research was obtained from the institutional review board of Eawag. Written informed consent was obtained from each participant prior to data collection.

Participant & Measures

In this step, the same study sample and measures were used as in Step 3. However, the number of total participants was higher, as all participants of the first survey wave were included and not only participants who completed both survey waves. Additionally, for didactic purposes, we also use all items, including excluded ones, to underline the convergent findings of the four steps.

Analyses

We here present only results for our example measurement scale; for detailed description of the 6-step protocol, discussion, and interpretation of the results, we refer to Dima (2018).

4.3 Results

Step 4.1 – descriptive statistics

Descriptive analyses of all items included in the measurement scale are displayed in Table 3. Interitem correlation (Table 4) shows very low correlations of items PO_017 and PO_020 with the other items.

Table 3

Descriptive statistics of all items

	M	SD	f	f%	Coding
Psychological ownership for the water system at baseline					
This is my water scheme. (PO_002)	3.45	1.26	328	100	1-5
I strongly disagree.			49	14.94	1
I disagree a little.			33	10.06	2
I neither agree nor disagree.			5	1.52	3
I agree a little.			204	62.20	4
I strongly agree.			37	11.28	5
I sense that this water scheme is our water scheme. (PO_005)	3.38	1.26	328	100	1-5
I strongly disagree.			52	15.85	1
I disagree a little.			34	10.37	2
I neither agree nor disagree.			13	3.96	3
I agree a little.			197	60.06	4
I strongly agree.			32	9.76	5
I feel a very high degree of personal ownership for this water scheme. (PO_008)	3.06	1.42	328	100	1-5
I strongly disagree.			85	25.91	1
I disagree a little.			31	9.45	2
I neither agree nor disagree.			25	7.62	3
I agree a little.			152	46.34	4
I strongly agree.			35	10.67	5

	M	SD	f	f%	Scale
I sense that this is my water scheme. (PO_011)	3.17	1.34	328	100	1-5
I strongly disagree.			70	21.34	1
I disagree a little.			32	9.76	2
I neither agree nor disagree.			25	7.62	3
I agree a little.			174	53.05	4
I strongly agree.			27	8.23	5
This is our water scheme. (PO_014)	3.31	1.3	328	100	1-5
I strongly disagree.			55	16.77	1
I disagree a little.			41	12.50	2
I neither agree nor disagree.			15	4.57	3
I agree a little.			182	55.49	4
I strongly agree.			35	10.67	5
It is hard for me to think about this water scheme as mine. (PO_017)	3.09	0.97	328	100	1-5
I strongly disagree.			0	0.00	5
I disagree a little.			139	42.38	4
I neither agree nor disagree.			20	6.10	3
I agree a little.			169	51.52	2
I strongly agree.			0	0.00	1
Most of the people that live in this village feel as though they own the water scheme. (PO_020)	2.71	1.5	328	100	1-5
I strongly disagree.			117	35.67	1
I disagree a little.			43	13.11	2
I neither agree nor disagree.			25	7.62	3
I agree a little.			105	32.01	4
I strongly agree.			38	11.59	5

Note: N = 328. f = absolute frequency. f% = relative frequency. M = Mean; SD = Standard deviation.

Table 4

Interitem correlations

	PO_002	PO_005	PO_008	PO_011	PO_014	PO_017	PO_020
PO_002	1.00						
PO_005	0.50	1.00					
PO_008	0.44	0.33	1.00				
PO_011	0.43	0.49	0.46	1.00			
PO_014	0.34	0.56	0.28	0.61	1.00		
PO_017	0.12	-0.07	0.05	-0.02	-0.03	1.00	
PO_020	0.10	0.14	0.27	0.20	0.11	0.06	1.00

Note: N = 328. Spearman correlations. Abbreviations: none.

Analysis for multivariate outliers by plotting a Mahalanobis D2 (Figure 3) found no unusually responding participants that would warrant exclusion.

Figure 3

Multivariate outliers in item set
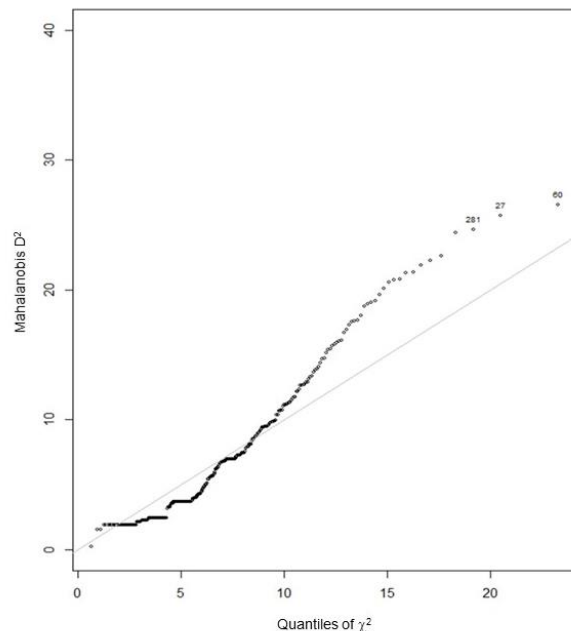
Note. This plot of Mahalanobis D2 vs. quantiles of Chi2 shows an upward bending on the left side and a downward bending on the right side. This indicates possible outliers at the top end. However, as they are not found to be extremely unlikely, they were left in the sample size.

Step 4.2 – nonparametric item response theory (IRT)

Homogeneity, indicating whether the items are scalable and measuring the same construct as the scale, is displayed in Table 5. For two items (PO_017 & PO_020), homogeneity was below .3, indicating problematic item performance.

Table 5

Homogeneity values of all items

	Scale		Item	
	H	*SE*	*H*	*SE*
Psychological ownership for the water system at baseline	0.34	0.03		
This is my water scheme. (PO_002)			0.44	-0.04
I sense that this water scheme is our water scheme. (PO_005)			0.43	-0.04
I feel a very high degree of personal ownership for this water scheme. (PO_008)			0.39	-0.04
I sense that this is my water scheme. (PO_011)			0.45	-0.03
This is our water scheme. (PO_014)			0.39	-0.04
It is hard for me to think about this water scheme as mine. (PO_017)			0.01	-0.05
Most of the people that live in this village feel as though they own the water scheme. (PO_020)			0.19	-0.04

Note. N = 328. The complete item set has a homogeneity value *H*(*SE*) = 0.34. (0.03). None of the items failed to meet the local independence criterion; *SE* = standard error.

In turn, analysis of the person-fit (by distribution of Guttman errors) is shown in Figure 4.

Figure 4

Histogram of Guttman errors for all item set
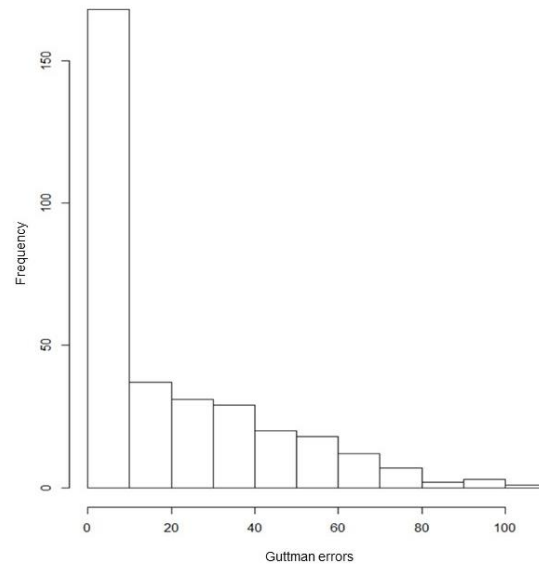
Note. Evaluation of Guttman errors of every item for participants. This evaluation flags aberrant response data. Counting the number of Guttman errors is an alternative to more complex statistics for determining nonfitting item score patterns (Meijer, 1994). Low numbers of Guttman errors are therefore a sign of well performing items.

To test unidimensionality, the results of an automated item selection procedure (AISP) with all items are shown in Table 6. Cell values of 0 indicate poor item performance and items classified as unscalable (items PO_017 & PO_020).

Table 6

Automated item selection procedure (AISP) for increasing homogeneity (H) thresholds (c)

Item	Homogeneity threshold levels											
	c=0.05	c=0.10	c=0.15	c=0.20	c=0.25	c=0.30	c=0.35	c=0.40	c=0.45	c=0.50	c=0.55	c=0.60
This is my water scheme. (PO_002)	1	1	1	1	1	1	1	1	1	1	2	0
I sense that this water scheme is our water scheme. (PO_005)	1	1	1	1	1	1	1	1	1	1	1	1
I feel a very high degree of personal ownership for this water scheme. (PO_008)	1	1	1	1	1	1	1	1	1	0	2	0
I sense that this is my water scheme. (PO_011)	1	1	1	1	1	1	1	1	1	1	1	1
This is our water scheme. (PO_014)	1	1	1	1	1	1	1	1	1	1	1	1
It is hard for me to think about this water scheme as mine. (PO_017)	0	0	0	0	0	0	0	0	0	0	0	0
Most of the people that live in this village feel as though they own the water scheme. (PO_020)	1	1	1	1	0	0	0	0	0	0	0	0

Note: $N = 328$. Based on the AISP table. Items 17 & 20 are excluded from the scale by selecting the remaining items that show unidimensionality at a threshold level of .30. Numbers represent which subscale the item belongs to; 0 indicates the item is unscalable at that homogeneity level. No multidimensional solution is apparent from this table: no groups of items identified as 'leaving to form another scale' at the same homogeneity threshold. Abbreviations: AISP = automatic item selection procedure; H = homogeneity.

Based on the assumption that latent variables are interval variables, monotonicity assesses whether item difficulty increases for every item.

Monotonicity is shown in Table 7. It highlights that none of the items has a critical value (crit) > .8 that would warrant exclusion.

Table 7

Monotonicity with default minimum size of a rest score group n = N/5

	ItemH	#ac	#vi	#vi/#ac	maxvi	sum	sum/#ac	zmax	#zsig	crit
This is my water scheme. (PO_002)	0.53	21	2	0.10	0.05	0.09	0.00	0.80	0.00	15.00
I sense that this water scheme is our water scheme. (PO_005)	0.56	21	3	0.14	0.15	0.29	0.01	2.60	1.00	64.00
I feel a very high degree of personal ownership for this water scheme. (PO_008)	0.48	12	1	0.08	0.06	0.06	0.01	1.07	0.00	19.00
I sense that this is my water scheme. (PO_011)	0.57	12	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
This is our water scheme. (PO_014)	0.52	21	2	0.10	0.05	0.09	0.00	0.71	0.00	15.00

Note: $N = 328$. No significant violations were identified. Abbreviations: ItemH = ; #ac = number of active pairs; #vi = number of violations; #vi/#ac = average number of violations per active pair; maxvi = largest violation of manifest monotonicity; sum = sum of violations of manifest monotonicity; sum/#ac = average violation per active pair; zmax = maximum z-value; #zsig = number of significant z-values; crit = crit value.

In IRT, easy items are usually presented at the beginning, and items gradually become more difficult. Invariant item ordering (IIO) assesses whether items retain the same order of difficulty over all levels of latent variable. Table 8a shows that some items have very high critical values. One by one, each item with the highest value is excluded. After item PO_008, has been excluded, the IIO is displayed in Table 8b.

Table 8a

Invariant item ordering (IIO) tests with default minimum size of a rest score group n = N/5

	ItemH	#ac	#vi	#vi/#ac	maxvi	sum	sum/#ac	zmax	#zsig	crit
This is my water scheme. (PO_002)	0.53	11.00	1.00	0.09	0.19	0.19	0.02	0.65	0.00	42.00
I sense that this water scheme is our water scheme. (PO_005)	0.56	10.00	2.00	0.20	0.26	0.45	0.04	0.89	0.00	90.00
I feel a very high degree of personal ownership for this water scheme. (PO_008)	0.48	8.00	1.00	0.12	0.51	0.51	0.06	1.90	1.00	158.00
I sense that this is my water scheme. (PO_011)	0.57	9.00	2.00	0.22	0.51	0.57	0.06	1.90	1.00	161.00
This is our water scheme. (PO_014)	0.52	10.00	2.00	0.20	0.26	0.32	0.03	0.89	0.00	78.00

Note: N = 328. No significant violations were identified. Abbreviations: ItemH = scalability coefficient; #ac = number of active pairs; #vi = number of violations; #vi/#ac = average number of violations per active pair; maxvi = largest violation of manifest monotonicity; sum = sum of violations of manifest monotonicity; sum/#ac = average violation per active pair; zmax = maximum z-value; #zsig = number of significant z-values; crit = crit value.

Table 8b

Invariant item ordering (IIO) tests with default minimum size of a rest score group n = N/5 after deletion of most critical item (PO_008).

	ItemH	#ac	#vi	#vi/#ac	maxvi	sum	sum/#ac	zmax	#zsig	crit
This is my water scheme. (PO_002)	0.51	6.00	1.00	0.17	0.06	0.06	0.01	0.24	0.00	25.00
I sense that this water scheme is our water scheme. (PO_005)	0.60	6.00	3.00	0.50	0.19	0.43	0.07	0.86	0.00	138.00
I sense that this is my water scheme. (PO_011)	0.59	5.00	1.00	0.20	0.18	0.18	0.04	0.86	0.00	69.00
This is our water scheme. (PO_014)	0.57	5.00	1.00	0.20	0.19	0.19	0.04	0.75	0.00	72.00

Note: N = 328. No significant violations were identified. Abbreviations: ItemH = scalability coefficient; #ac = number of active pairs; #vi = number of violations; #vi/#ac = average number of violations per active pair; maxvi = largest violation of manifest monotonicity; sum = sum of violations of manifest monotonicity; sum/#ac = average violation per active pair; zmax = maximum z-value; #zsig = number of significant z-values; crit = crit value.

Step 4.3 parametric item response theory (IRT)

As our scale and items did not measure all levels of the latent continuum proportionally, we decided to run nonparametric IRT in Step 4.2, and thus Step 4.3 was not conducted.

Step 4.4 – Factor analysis

See Step 3 above.

Step 4.5 – classical test theory

Classical test theory includes a variety of analyses. A range of indicators of internal consistency and reliability are displayed in Table 9. Descriptive statistics of a shorter scale than the original is reported in Table 10, and the histogram comparing the variance of the two is displayed in Figure 5.

Table 9

Reliability indicators for all items

	Cronbach's α [lower CI – upper CI]	Cronbach's α raw. if item dropped	McDonald's Ω [lower CI – upper CI]	Revelle's Ω	GLB	Lambda
Psychological ownership for the water system at baseline	0.83 [0.8 – 0.86]		0.83 [0.8 – 0.86]	0.89	0.89	0.83
This is my water scheme. (PO_002)		0.82				
I sense that this water scheme is our water scheme. (PO_005)		0.76				
I sense that this is my water scheme. (PO_011)		0.77				
This is our water scheme. (PO_014)		0.77				

Note: $N = 328$.; Abbreviations: CI = confidence interval; GLB = greatest lower bound.

Table 10

Descriptive statistics of original and shortened scales at measurement time point 1

	M	SD	f	f%	Coding
Psychological ownership for the water system at baseline (7 items. original)	3.49	1.04			
Psychological ownership for the water system at baseline (4 items)	3.17	0.82			1-5
			18	5.49	1
			6	1.83	1.25
			8	2.44	1.5
			14	4.27	1.75
			16	4.88	2
			9	2.74	2.25
			14	4.27	2.5
			13	3.96	2.75
			14	4.27	3
			10	3.05	3.25
			16	4.88	3.5
			7	2.13	3.75
			148	45.12	4
			16	4.88	4.25
			10	3.05	4.5
			4	1.22	4.75
			5	1.52	5

Note: N = 328. f = absolute frequency. f% = relative frequency. M = Mean; SD = standard deviation.

1 **Figure 5**

2 *Histogram of original scale (left) and shortened scale (right) at measurement time point 1*

3
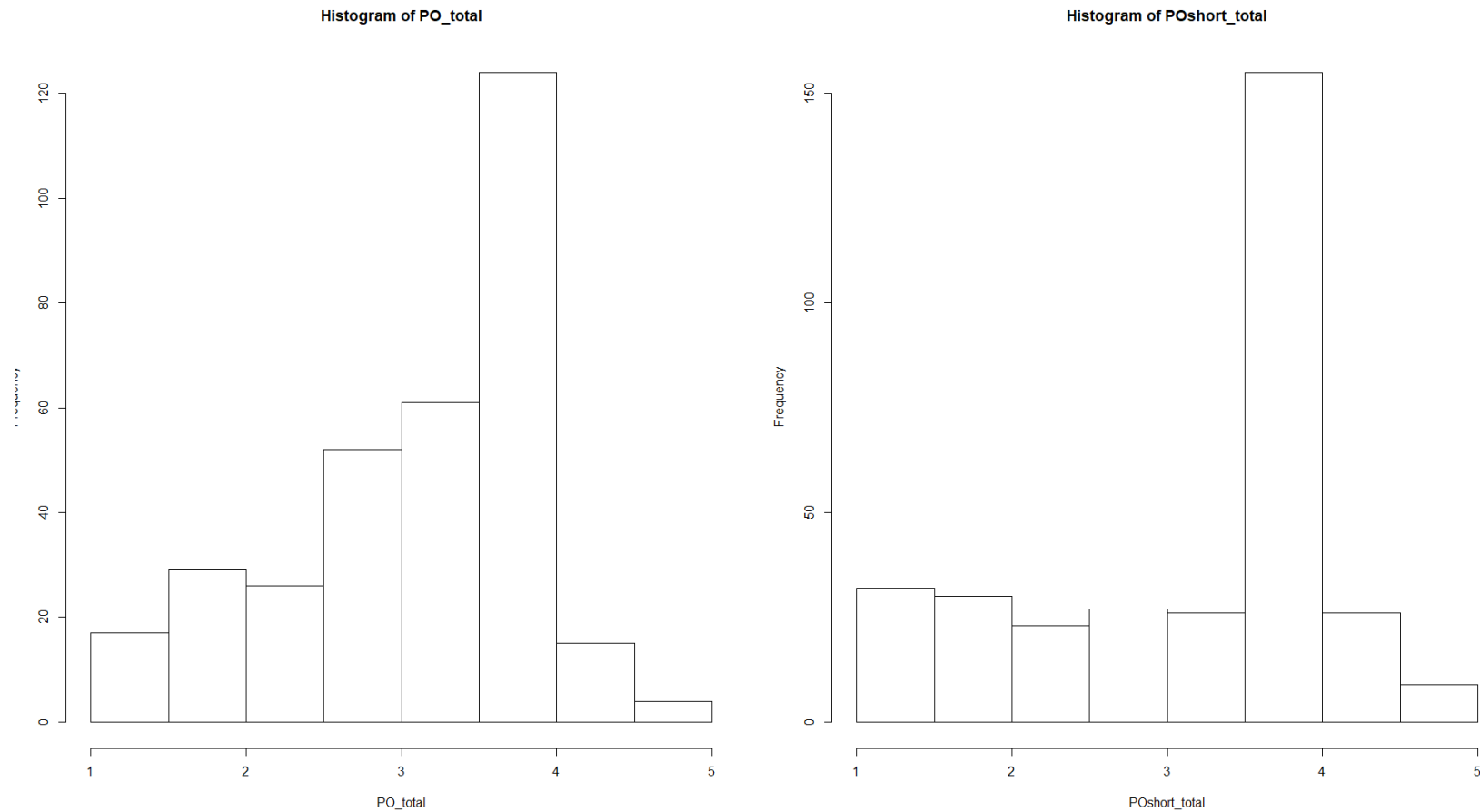
4

5 *Note.* Correlation of the two scales is *r* = 0.84. Abbreviations: PO_total = original seven-item scale measuring psychological ownership; POshort_total =
6 shortened 4-item scale measuring psychological ownership.

4.4 Discussion

In-depth psychometric analysis at item level converged with findings from Steps 2 and 3, where we already identified one question as performing poorly: the inversely stated item caused reasonable problems for respondents and did not fit the CFA model. Interitem correlation showed that one particular item, PO_017, does not correlate with the other items of the measurement scale. Additionally, homogeneity analyses revealed that item PO_017 does not have scalable properties. Overall, these analyses corroborated previous findings and therefore strongly suggest the need to exclude this item from the measurement scale. In invariant item ordering, further two items were identified as not meeting the criteria for monotonicity. Thus, to achieve a scale measuring a single construct and so that differences between respondents are appropriately represented in their sum and average scores, two items were excluded from the scale, resulting in a definitive scale of four items measuring psychological ownership..

General discussion

In this article, we introduced a comprehensive four-step protocol to adapt psychological measurement instruments to a new context. The example analysis performed on the psychological ownership measurement scale illustrates that it is not always necessary to develop a measurement instrument in a new context from scratch, instead, careful adaptation and validation procedures allow existing measurement scales to be transferred successfully to new contexts. In Step 1 of our protocol, using the grounded theory approach, we confirmed the understanding and relevance of the construct in the new context, and revealed examples with which to frame the introduction to the questionnaire (Step 1). In Step 2, think-aloud interviews helped identify respondents' difficulties and reasoning processes when answering the questions of the psychological ownership scale. Then, the quantitative analyses of the psychometric properties at scale and items levels in Steps 3 and 4 confirmed the validity and reliability of the scale in the new context. The comparison of the qualitative and quantitative findings also showed convergence: difficulties reported when understanding or answering items in the think-aloud paradigm aligned with impaired psychometric properties of the same items. This provides strong evidence that such items have to be excluded from the measurement scale to ensure that the measurement instrument is valid and reliable.

Previous adaptation protocols predominantly focused on translation. Our four-step protocol significantly expands adaptation practices to reflect the three domains recommended to be considered when adapting a measurement instrument to a new context: culture, language, and measurement (Harkness et al., 2010). In particular, our protocol combines an initial qualitative investigation of the concept behind the measurement scale with in-depth quantitative psychometric analysis of the scale and items.

We targeted culture in qualitative Step 1: we adapted the introduction by changing the examples of psychological ownership and by identifying whether the concept was understood in the new context. Perhaps cultural differences in other cases require more profound adaptation, and thus integration of qualitative and quantitative findings may cause problems (Borgstede, & Scholz, 2021). We targeted language in qualitative Step 2: we adapted comprehensibility and language by using

words and sentence structures corresponding to the local language (Van de Vijver & Leung. 2011).

This pragmatic-driven adaptation recognizes that language is used in a social context. And lastly, in

measurement, we adapted the questions' familiarity by introducing the question format with an

example. We adapted the question format by introducing a two-step sequential question style and by

providing a visual answer scale.

Qualitative and quantitative approaches combined present a robust approach to adapting

measurement instruments to new contexts. However, such a mixed-methods approach to conceptual

adaptation is only appropriate when context differs substantially, because it is a resource- and time-

intensive process. It may not be worthwhile when measurement instruments are adapted to new

contexts or targets that are similar or closely related to the originals. If no qualitative investigation of

the topic is necessary, we suggest using think-aloud methods as described in Step 2 and validating the

questionnaire with steps 3 and 4.

It is a common process to shape a measurement scale when pilot-testing it. This increases its

efficiency, validity, and reliability in future applications. However, it needs to be done carefully to

avoid impairing criterion validity (Raykov. 2008). In our case, evidence from qualitative and

quantitative assessment and global and item-level assessments are used, and only if findings converge

are adjustments made to the measurement scales.

The main limitation of this mixed-methods approach is the amount of work required to adapt

a scale to a new context. As the example showed, an entire prestudy is needed for a first adaptation of

a scale to a new context. However, our Step 4 showed that such a protocol is only worthwhile when a

scale of several items is adapted and tested, as several items may not match the criteria and need to be

excluded to produce a well-functioning measurement scale. Nevertheless, we advocate the necessity

of such extensive adaptation procedures, as only through these can reliable and valid measurement

scales of psychological concepts be guaranteed to fit specific contexts. Furthermore, contextual

adaptation frameworks may even be used to adapt intervention protocols. It is particularly important

that intervention activities are tailored to their contexts because precise mechanisms of action are

necessary to unfold effectiveness (Lal et al., 2018). Such tailoring can also be achieved by conducting

qualitative steps to assess the relevance (Freudberg et al., 2018), difficulties, and understandability of intervention activities, for example in a person-based approach (Muller et al., 2019). We conclude from following this four-step adaptation approach that carefully translated, adapted, and validated psychological questionnaires can be transferred to very different contexts.

References

Acquadro, C., Conway, K., Hareendran, A., Aaronson, N., & European Regulatory Issues and Quality of Life Assessment (ERIQA) Group. (2008). Literature review of methods to translate health-related quality of life questionnaires for use in multinational clinical trials. *Value in Health, 11*(3), 509-521.

Ambuehl, B., Tomberge, V. M. J., Kunwar, B. M., Schertenleib, A., Marks, S. J., & Inauen, J. (2021). The role of psychological ownership in safe water management: A mixed-methods study in Nepal. *Water, 13*(5), 589.

Arafat, S. Y., Chowdhury, H. R., Qusar, M. M. A. S., & Hafez, M. A. (2016). Cross cultural adaptation & psychometric validation of research instruments: A methodological review. *Journal of Behavioral Health, 5*(3), 129-136.

Asatryan, V. S., & Oh, H. (2008). Psychological ownership theory: An exploratory application in the restaurant industry. Journal of Hospitality & Tourism Research, 32(3), 363-386.

Avey, J. B., Luthans, F., & Jensen, S. M. (2009). Psychological capital: A positive resource for combating employee stress and turnover. *Human resource management, 48*(5), 677-693.

Bandura, A. (2002). Social cognitive theory in cultural context. Applied psychology, 51(2), 269-290.

Basu, M., DasGupta, R., Hashimoto, S., & Hoshino, S. (2021). A multi-actor and bottom-up perspective on attaining rural water security: qualitative evidence from India. *Environment, Development and Sustainability, 23*(2), 1461-1484.

Belgrave, L. L., & Seide, K. (2019). Grounded theory methodology: principles and practices. In Handbook of research methods in health social sciences (pp. 299-316). Springer Singapore.

Borgstede, M., & Scholz, M. (2021). Quantitative and Qualitative Approaches to Generalization and Replication–A Representationalist View. *Frontiers in psychology*, 117.

Byrne, B. M. (2005). Factor analytic models: Viewing the structure of an assessment instrument from three perspectives. *Journal of personality assessment, 85*(1), 17-32.

Campbell, C., & Murray, M. (2004). Community health psychology: Promoting analysis and action for social change. *Journal of health psychology, 9*(2), 187-195.

Charters, E. (2003). The use of think-aloud methods in qualitative research an introduction to think-aloud methods. *Brock Education Journal, 12*(2).

Collins, D. (2003). Pretesting survey instruments: an overview of cognitive methods. *Quality of life research, 12*(3), 229-238.

Conner, M., & Sparks, P. (2015). Theory of planned behaviour and the reasoned action approach. Predicting and changing health behaviour: *Research and practice with social cognition models, 3*, 142-188.

Contzen, N., & Marks, S. J. (2018). Increasing the regular use of safe water kiosk through collective psychological ownership: A mediation analysis. *Journal of Environmental Psychology, 57*, 45-52.

Dawkins, S., Tian, A. W., Newman, A., & Martin, A. (2017). Psychological ownership: A review and research agenda. Journal of Organizational Behavior, 38(2), 163-183.

Dima, A. L. (2018). Scale validation in applied health research: Tutorial for a 6-step R-based psychometrics protocol. *Health Psychology and Behavioral Medicine, 6*(1), 136-161.

Epstein, J., Santo, R. M., & Guillemin, F. (2015). A review of guidelines for cross-cultural adaptation of questionnaires could not bring out a consensus. *Journal of clinical epidemiology, 68*(4), 435-441.

Fenn, J., Tan C. S., & George, S. (2020). Development, validation and translation of psychological tests. *BJPsych Advances, 26*(5), 306-315.

French, D. P., Cooke, R., Mclean, N., Williams, M., & Sutton, S. (2007). What do people think about when they answer Theory of Planned Behaviour questionnaires? Athink aloud'study. *Journal of health psychology, 12*(4), 672-687.

Freudberg, H., Contractor, S., Das, A., Kemp, C. G., Nevin, P. E., Phadiyal, A., Lal, J., & Rao, D. (2018). Process and impact evaluation of a community gender equality intervention with young men in Rajasthan, India. *Culture, Health & Sexuality, 20*(11), 1214-1229.

Gardner, B. (2015). A review and analysis of the use of 'habit' in understanding, predicting and influencing health-related behaviour. *Health psychology review, 9*(3), 277-295.

Gardner, B., Rebar, A. L., & Lally, P. (2019). A matter of habit: Recognizing the multiple roles of habit in health behaviour. *British journal of health psychology, 24*(2), 241-249.

Gjersing, L., Caplehorn, J. R., & Clausen, T. (2010). Cross-cultural adaptation of research instruments: language, setting, time and statistical considerations. *BMC medical research methodology, 10*(1), 1-10.

Guillemin, F., Bombardier, C., & Beaton, D. (1993). Cross-cultural adaptation of health-related quality of life measures: literature review and proposed guidelines. *Journal of clinical epidemiology, 46*(12), 1417-1432.

Gwaltney, C. J., Shiffman, S., Normal, G. J., Paty, J. A., Kassel, J. D., Gnys, M., ... & Balabanis, M. (2001). Does smoking abstinence self-efficacy vary across situations? Identifying context-specificity within the Relapse Situation Efficacy Questionnaire. *Journal of Consulting and Clinical Psychology, 69*(3), 516.

Hall, D. A., Zaragoza Domingo, S., Hamdache, L. Z., Manchaiah, V., Thammaiah, S., Evans, C., ... & International Collegium of Rehabilitative Audiology and TINnitus Research NETwork. (2018). A good practice guide for translating and adapting hearing-related questionnaires for different languages and cultures. *International Journal of Audiology, 57*(3), 161-175.

Hambleton, R. K., & Li, S. (2005). *Translation and Adaptation Issues and Methods for Educational and Psychological Tests.* In C. L. Frisby & C. R. Reynolds (Eds.), Comprehensive handbook of multicultural school psychology (pp. 881–903). John Wiley & Sons, Inc..

Harkness, J. A., Van de Vijver, F. J., Mohler, P. P., & Wiley, J. (Eds.). (2003). *Cross-cultural survey methods* (Vol. 325). Hoboken, NJ: Wiley-Interscience.

Harkness, J. A., Villar, A., & Edwards, B. (2010). Translation, adaptation, and design. *Survey methods in multinational, multiregional, and multicultural contexts,* 115-140.

Harter, M., Inauen, J., & Mosler, H. J. (2020). How does Community-Led Total Sanitation (CLTS) promote latrine construction, and can it be improved? A cluster-randomized controlled trial in Ghana. *Social science & medicine, 245*, 112705.

Heeren, A., Douilliez, C., Peschard, V., Debrauwere, L., & Philippot, P. (2011). Cross-cultural validity of the Five Facets Mindfulness Questionnaire: Adaptation and validation in a French-speaking sample. *European Review of Applied Psychology, 61*(3), 147-151.

Heim, E., & Knaevelsrud, C. (2021). Standardised research methods and documentation in cultural adaptation: The need, the potential and future steps. *Clinical Psychology in Europe, 3*, 1-15.

Heim, E., Mewes, R., Abi Ramia, J., Glaesmer, H., Hall, B., Shehadeh, M. H., ... & Knaevelsrud, C. (2021). Reporting Cultural Adaptation in Psychological Trials–The RECAPT criteria. *Clinical Psychology in Europe, 3*, 1-25.

Hilton, C. E. (2017). The importance of pretesting questionnaires: a field research example of cognitive pretesting the Exercise referral Quality of Life Scale (ER-QLS). *International Journal of Social Research Methodology, 20*(1), 21-34.

Hogg, M. A., & Smith, J. R. (2007). Attitudes in social context: A social identity perspective. *European Review of Social Psychology, 18*(1), 89-131.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal, 6*(1), 1-55.

Jackson, D. L., Gillaspy Jr, J. A., & Purc-Stephenson, R. (2009). Reporting practices in confirmatory factor analysis: an overview and some recommendations. *Psychological methods, 14*(1), 6.

John, O. P., & Benet-Martínez, V. (2014). *Measurement: Reliability, construct validation, and scale construction.* In H. T. Reis & C. M. Judd (Eds.), Handbook of research methods in social and personality psychology (pp. 473–503). Cambridge University Press.

Jorgensen, B. S., & Stedman, R. C. (2001). Sense of place as an attitude: Lakeshore owners attitudes toward their properties. *Journal of environmental psychology, 21*(3), 233-248.

Kashima, Y., Siegal, M., Tanaka, K., & Kashima, E. S. (1992). Do people believe behaviours are consistent with attitudes? Towards a cultural psychology of attribution processes. *British Journal of Social Psychology, 31*(2), 111-124.

Keszei, A. P., Novak, M., & Streiner, D. L. (2010). Introduction to health measurement scales. *Journal of psychosomatic research, 68*(4), 319-323.

Lal, S., Gleeson, J., Malla, A., Rivard, L., Joober, R., Chandrasena, R., & Alvarez-Jimenez, M. (2018). Cultural and contextual adaptation of an ehealth intervention for youth receiving services for first-episode psychosis: adaptation framework and protocol for Horyzons-Canada phase 1. *JMIR Research Protocols, 7*(4), e8810.

Lamont, M., Adler, L., Park, B. Y., & Xiang, X. (2017). Bridging cultural sociology and cognitive psychology in three contemporary research programmes. *Nature Human Behaviour, 1*(12), 866-872.

Lo, S. H., Peters, G. J. Y., van Breukelen, G. J., & Kok, G. (2014). Only reasoned action? An interorganizational study of energy-saving behaviors in office buildings. *Energy efficiency, 7*(5), 761-775.

Luszczynska, A., Scholz, U., & Schwarzer, R. (2005). The general self-efficacy scale: multicultural validation studies. *The Journal of psychology, 139*(5), 439-457.

MacKenzie, S. B., Podsakoff, P. M., & Podsakoff, N. P. (2011). Construct measurement and validation procedures in MIS and behavioral research: Integrating new and existing techniques. *MIS quarterly*, 293-334.

Maher, J. P., Rebar, A. L., & Dunton, G. F. (2021). The influence of context stability on physical activity and sedentary behaviour habit and behaviour: An ecological momentary assessment study. *British Journal of Health Psychology, 26*(3), 861-881.

Marks, S. J., Onda, K., & Davis, J. (2013). Does sense of ownership matter for rural water system sustainability? Evidence from Kenya. *Journal of Water, Sanitation and Hygiene for Development, 3*(2), 122-133.

Marks, S. J., Onda, K., & Davis, J. (2013). Does sense of ownership matter for rural water system sustainability? Evidence from Kenya. *Journal of Water, Sanitation and Hygiene for Development, 3*(2), 122-133.

Markus, H. R., & Kitayama, S. (1998). The cultural psychology of personality. *Journal of cross-cultural psychology, 29*(1), 63-87.

Mayring, P. (2004). Qualitative content analysis. *A companion to qualitative research, 1*(2), 159-176.

Meijer, R. R. (1994). The number of Guttman errors as a simple and powerful person-fit statistic. *Applied Psychological Measurement, 18*(4), 311-314.

Min, B., & Lee, J. (2006). Children's neighborhood place as a psychological and behavioral domain. *Journal of environmental psychology, 26*(1), 51-71.

Moore, G., Campbell, M., Copeland, L., Craig, P., Movsisyan, A., Hoddinott, P., ... & Evans, R. (2021). Adapting interventions to new contexts—the ADAPT guidance. *bmj*, 374.

Muller, I., Santer, M., Morrison, L., Morton, K., Roberts, A., Rice, C., Williams, M., & Yardley, L. (2019). Combining qualitative research with PPI: reflections on using the person-based

approach for developing behavioural interventions. *Research Involvement and Engagement,*
5(1), 1-8.

Myburgh, N., Loxton, H., & Engels, R. C. (2021). Cross-cultural adaptation of an anxiety measure in
a disadvantaged South African community context: *Methodological processes and findings.*
Transcultural Psychiatry, 58(6), 759-771.

Ngwira, L. G., Khan, K., Maheswaran, H., Sande, L., Nyondo-Mipando, L., Smith, S. C., ... &
Niessen, L. (2021). A systematic literature review of preference-based health-related quality-
of-life measures applied and validated for use in childhood and adolescent populations in sub-
Saharan Africa. *Value in Health Regional Issues, 25*, 37-47.

Olckers, C. (2013). Psychological ownership: Development of an instrument. *SA Journal of Industrial*
Psychology, 39(2), 1-13.

Peng, H., & Pierce, J. (2015). Job- and organization-based psychological ownership: Relationship and
outcomes. *Journal of Managerial Psychology, 30*(2), 151–168.

Pierce, J. L., & Jussila, I. (2011). *Psychological ownership and the organizational context: Theory,*
research evidence, and application. Edward Elgar Publishing.

Pierce, J. L., Jussila, I., & Li, D. (2018). Development and validation of an instrument for assessing
collective psychological ownership in organizational field settings. *Journal of Management &*
Organization, 24(6), 776-792.

Pierce, J. L., Kostova, T., & Dirks, K. T. (2001). Toward a theory of psychological ownership in
organizations. *Academy of management review, 26*(2), 298-310.

Pierce, J. L., Kostova, T., & Dirks, K. T. (2003). The state of psychological ownership: Integrating
and extending a century of research. *Review of general psychology, 7*(1), 84-107.

Pomerance, M. H., & Converse, P. D. (2014). Investigating context specificity, self-schema
characteristics, and personality test validity. *Personality and Individual Differences, 58*, 54-
59.

Prince, S. A., Adamo, K. B., Hamel, M. E., Hardt, J., Gorber, S. C., & Tremblay, M. (2008). A
comparison of direct versus self-report measures for assessing physical activity in adults: a
systematic review. *International journal of behavioral nutrition and physical activity, 5*(1), 1-
24.

Raykov, T. (2008). Alpha if item deleted: A note on loss of criterion validity in scale development if
maximizing coefficient alpha. *British Journal of Mathematical and Statistical Psychology,*
61(2), 275-285.

Shukla, A., & Singh, S. (2015). Psychological ownership: scale development and validation in the
Indian context. *International Journal of Indian Culture and Business Management, 10*(2),
230-251.

Silva, F. G., Oliveira, C. B., Hisamatsu, T. M., Negrão Filho, R. F., Rodrigues, C. R. D., Franco, M.
R., & Pinto, R. Z. (2020). Critical evaluation of physical activity questionnaires translated to

Brazilian-Portuguese: a systematic review on cross-cultural adaptation and measurements properties. *Brazilian journal of physical therapy, 24*(3), 187-218.

Smith, T. W. (2007). *Measurement in Health Psychology Research*. In H. S. Friedman & R. C. Silver (Eds.), Foundations of health psychology (pp. 19–51). Oxford University Press.

Sousa, V. D., & Rojjanasrirat, W. (2011). Translation, adaptation and validation of instruments or scales for use in cross-cultural health care research: a clear and user-friendly guideline. *Journal of evaluation in clinical practice, 17*(2), 268-274.

Tajfel, H. (1979). Individuals and groups in social psychology. *British Journal of social and clinical psychology, 18*(2), 183-190.

Tversky, A., & Simonson, I. (1993). Context-dependent preferences. *Management science, 39*(10), 1179-1189.

Van de Vijver, F. J. R., & Leung, K. (2011). *Equivalence and bias: A review of concepts, models, and data analytic procedures.* In D. Matsumoto & F. J. R. van de Vijver (Eds.), Cross-cultural research methods in psychology (pp. 17–45). Cambridge University Press.

Van Dyne, L., & Pierce, J. L. (2004). Psychological ownership and feelings of possession: Three field studies predicting employee attitudes and organizational citizenship behavior. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior, 25*(4), 439-459.

Van Widenfelt, B. M., Treffers, P. D., De Beurs, E., Siebelink, B. M., & Koudijs, E. (2005). Translation and cross-cultural adaptation of assessment instruments used in psychological research with children and families. *Clinical child and family psychology review, 8*(2), 135-147.

Veronese, G., & Pepe, A. (2020). Cross-cultural adaptation, psychometric proprieties and factor structure of the Multidimensional Student Life Satisfaction Scale (MSLSS): A study with Palestinian children living in refugee camps. *Current Psychology, 39*(5), 1853-1862.

Wissing, M. P., & Temane, Q. M. (2008). The structure of psychological well-being in cultural context: Towards a hierarchical model of psychological health. *Journal of Psychology in Africa, 18*(1), 45-55.

Article 3: Can Participation Promote Psychological Ownership of a Shared Resource?
An Intervention Study of Community-Based Safe Water Infrastructure.

This article is published:

Ambuehl, B., Kunwar, B. M., Schertenleib, A., Marks, S. J., & Inauen, J. (2022). Can participation promote psychological ownership of a shared resource? An intervention study of community-based safe water infrastructure. *Journal of Environmental Psychology, 81*, 101818.

Can Participation Promote Psychological Ownership of a Shared Resource?

An Intervention Study of Community-based Safe Water infrastructure

Benjamin Ambuehl 1, 3*, Bal Mukund Kunwar 2, Ariane Schertenleib 1,

Sara J. Marks 1, Jennifer Inauen 3

1 Eawag: Swiss Federal Institute of Aquatic Science and Technology, Duebendorf,

Switzerland

2 Helvetas Swiss Intercooperation, Kathmandu, Nepal

3 University of Bern, Institute of Psychology, Bern, Switzerland

*Corresponding author

E-mail: benjamin.ambuehl@eawag.ch

Disclosure

Acknowledgments

Abstract

Previous research suggests that community-based participation, a process through which beneficiaries can actively influence and define the direction and execution of development programmes, can promote long-term uptake, use, and management of shared resources, such as community-based safe water infrastructure. However, results are heterogeneous. Psychological ownership theory and initial evidence suggests that participation promotes positive outcomes for shared resources by fostering sense of ownership through three routes: having control, intimate knowledge, and investing the self. This study used community-based safe water infrastructure as an example to investigate how various forms of participation affect acceptance, use, and functionality of a shared resource and whether this effect is mediated by psychological ownership. We conducted a nonrandomized cluster-based controlled trial with pre–post intervention assessment (N = 369) in 33 villages in rural Nepal, where safe water infrastructure is shared. Participatory intervention activities (e.g., influence in decision-making, contributing materials and labour) favourably affected self-reported outcomes and use of the water supply infrastructure but not observed functionality or drinking water quality. In conclusion, this study supports the assumption that participation can foster psychological ownership, which in turn can support successful management of a shared resource.

Keywords: Psychological ownership, Participation, Water, Sustainable development, Environmental Contamination, Resource management, Longitudinal intervention study, Dilemma of the commons

Highlights

1 – Participation leads to increased acceptance, use, and improved management of community-based safe water infrastructure.

2 – Psychological ownership partially mediates the effects of some forms of participation on some outcomes.

3 – Psychological ownership is an additional factor that supports successful management of shared resources.

118

Can participation promote psychological ownership of a shared resource? An intervention study of community-based safe water infrastructure.

Our individual human behaviour plays a key role in protecting and restoring the shared natural environment, which is under pressure due to climate change, decreasing biodiversity, and other factors (Inauen et al., 2021). But personal and collective goals often clash when using environmental resources (Sloot et al., 2018). One of the environmental resources most under pressure due to human behaviour is water (Steg & Vlek, 2009; Vlek & Steg, 2007): More than a quarter of the world's population cannot access safe drinking and cooking water (Bain et al., 2018). Anthropogenic contamination, especially faecal contamination of water, is a leading cause of diarrhoeal diseases globally (Prüss-Ustün et al., 2019). In Nepal, for example, up to 77% of drinking water samples are faecally contaminated (Shrestha et al., 2017).

Shared resources, such as safe water infrastructure, have the potential to decrease human impact on the environment and prevent adverse health impacts. In recent decades, the water sector has therefore increased efforts around the world to install new and rehabilitate existing community-based safe water infrastructure, including rural piped water supplies (WHO/UNICEF, 2021). However, ensuring sustainable safe water supply infrastructure in low- and middle-income countries remains a challenge (Fischer et al., 2020; Harvey & Reed, 2007). In particular, safe water infrastructure fails due to negligent operation and maintenance (Kabir & Howard, 2007, Naiga et al., 2015). This is often attributed to how water users and operation and maintenance teams interact (Khwaja, 2009). The participation of communities in planning, installing, and managing shared resources has been suggested as one solution to ensure long-term functionality and access to shared resources (Prokopy, 2005).

Participation and management of shared resources

In the context of international development, participation has been defined as a process through which beneficiaries can actively influence and define the direction and execution of

119

community development, in contrast to processes where they are only the recipients of shared resources (Abbott, 1995). The United Nations' Sustainable Development Goal (SDG) 6b, for example, specifies participation as a critical means of ensuring sustainable safe water access. In rural water supply planning, participation has been targeted through involvement of communities in decision-making, promoting attendance to community meetings, and asking the community to make cash, in-kind, or labour contributions to water infrastructure community development projects (Bisung et al., 2014; Whittington et al., 2007; Woolcock & Narayan, 2000).

Participation has been identified as an instrument central to sustainable management of shared resources (Agrawal & Gupta, 2005; Adhikari et al., 2014). Certain limitations have been identified, especially when focusing solely on voluntary action (Murty, 1994), but in general, participation is seen as a very important contribution to common property resource management (Sahoo & Swain, 2013). For example, enhancing participation was found to increase care for a lake (Peck et al., 2021), and shared management improved the maintenance of solar energy systems (Jenny et al., 2007). Participation was identified as a key step in developing a shared vision for successful planning of water resource management (Palmer et al., 2013). A concept that has been theorized to link participation to resource management is psychological ownership. For example, participation was linked to a sense of ownership over shared IT infrastructure (Kwon, 2020), and in development projects, project beneficiary participation predicted via psychological ownership how sustainable a project was (Aga et al., 2018). However, how different forms of participation influence psychological ownership has not been distinguished.

Psychological ownership

Psychological ownership is a theory that combines individual and social aspects (Rudmin & Berry, 1987). Psychological ownership is defined as "the state wherein a person or community feels as though a target of ownership is his/hers or theirs" (Pierce et al., 2001,

p.299). It is conceptualized as both a cognitive state and affect towards a target of ownership. This means that the individual can articulate the concept intellectually but also has a feeling of ownership. According to theory, psychological ownership serves to satisfy various basic motives (e.g., efficacy). It manifests as having a close connection between the target of ownership and the extended self (Jo et al., 2021). The concept is distinct from legal ownership, as the latter exists beyond the individual and in reality. By contrast, psychological ownership does not necessarily correspond with legal ownership: it is perceived.

Routes to psychological ownership

Psychological ownership is hypothesized to be evoked through three routes: (a) getting to know the target of ownership, for instance by experiencing the object); (b) investing the self in the target of ownership, for example by contributing effort; and (c) having control over the target of ownership, for instanced by being involved in decision-making (Pierce et al., 2003; Pierce & Jussila, 2010). Several cross-sectional survey studies in organizational contexts support these hypothesized routes to ownership (e.g., Han et al., 2010; Liu et al., 2012).

Routes to psychological ownership can be manipulated by involving stakeholders: by fostering participation. For example, correlational evidence suggests that psychological ownership of latrines relates to safe sanitation in community-led safe sanitation programmes (Tomberge et al., 2021). Further, one experimental study showed that psychological ownership of public goods can be increased by manipulating routes to psychological ownership; for example, screening a video increases intimate knowledge and psychological ownership of a beach (Peck et al., 2021). However, not all forms of participation seem to evoke psychological ownership equally (Aga et al., 2018; George et al., 2015; Marks et al., 2014; Tomberge et al., 2021). Studies involving safe water infrastructure have provided evidence that inviting community members to participate in decision-making (Ambuehl et al., 2021; Contzen & Marks, 2018; Marks & Davis, 2012) and upfront investment in the system (Marks & Davis,

2012) relate to increased psychological ownership. In turn, neither token nor small cash payments effectively enhanced ownership (Madajewicz et al., 2021; Marks & Davis, 2012). No further routes to psychological ownership have been investigated so far. Prospective studies investigating routes to psychological ownership are completely lacking.

Consequences of psychological ownership

Psychological ownership is assumed to relate to positive outcomes, for example by shaping individual and collective attitudes and behaviour (van Dyne & Pierce, 2004). For example, it increases individuals' willingness to protect natural resources and engage in pro-environmental behaviour (Preston & Gelman, 2020). Psychological ownership was also found to enhance positive attitudes, commitment, and stewardship behaviour with natural goods (Peck et al., 2021) and with shared services in society (Paundra et al., 2017). Compared to legal ownership, psychological ownership leads to reduced exploitation of a natural environment (Jiang et al., 2019) and fosters other sustainable behaviours (Suessenbach & Kamleitner, 2018). However, territorial behaviour—protective behaviour towards the target of ownership—can occur (Brown & Zhu, 2016).

The consequences of psychological ownership for safe drinking water infrastructure have received little empirical attention. Marks et al., (2013) found psychological ownership to be associated with confidence in water system functionality, better management practices, and improved infrastructure condition in Kenya. Cross-sectional mixed-methods research on safe water supply in Nepal suggests that increased psychological ownership relates to greater acceptance of and responsibility for maintenance and use of the shared infrastructure. It also increases confidence in the functionality of the water system, but it does not actually increase functionality (Ambuehl et al., 2021). Nevertheless, no longitudinal intervention study has been conducted on the routes to psychological ownership of safe water infrastructure or its consequences.

Participation and psychological ownership of shared safe water resources

In summary, previous observational research suggests that community participation may foster psychological ownership in line with the routes to psychological ownership specified in theory. Consequently, participation may enhance the long-term management of shared resources. However, previous studies have predominantly relied on cross-sectional designs to investigate these questions. What are lacking are longitudinal and experimental studies that test whether participation promotes positive outcomes by enhancing psychological ownership, which would help understand how participatory interventions work (Michie et al., 2013). Such studies can provide important insights into improving interventions (Inauen et al., 2020) and thus to promoting long-term successful and sustainable management of commons and pro-environmental behaviour.

In this study, we provide a first prospective test of these assumptions in the domain of safe water management. The study investigated the effects of a participatory intervention on the acceptance, use, and management of community-based safe water infrastructure in rural Nepal and the mediating role of psychological ownership. We extend Contzen and Marks's (2018) model and postulate that participation in the water safety programme increases psychological ownership of the shared infrastructure, which in turn influences acceptance, maintenance, use, negative behaviour (e.g. overuse), and the functionality of the target. On the basis of previous findings in published literature, we hypothesized that participation promotes the following safe water outcomes: (1a) greater acceptance, such as a positive attitude towards the infrastructure; (1b) greater preparatory behaviour, such as maintenance of infrastructure; (1c) greater use of infrastructure; (1d) lower negative behaviour, thus reducing overuse of limited available commons; and (1e) greater functionality as measured in, for instance, water quality. Second, we aim to test whether psychological ownership explains the effects of participation on outcomes. We hypothesize that psychological ownership mediates the effect of participation on (2a) acceptance, (2b) preparatory behaviour, (2c) use of infrastructure, (2d) negative behaviour, and (2e) functionality.

Methods and Participants

We carried out a nonrandomized cluster-based controlled trial with pre–post intervention assessment. The study took place in four municipalities of Karnali Province and one municipality of Sudur Paschim Province in Nepal.

Clusters and Participants

Amongst the communities served by the Helvetas integrated water resources management (IWRM) programme, study communities qualified for enrolment if they met the following criteria: a population of less than 5,000 people; primarily served by a gravity-fed piped supply; no pre-existing centralized water treatment works; and located not more than two hours walking distance from one of the laboratories installed for water quality analysis. Drawing on this sample frame of $K = 33$ communities, we purposively assigned 21 communities to the intervention group and 12 matching communities to the control group. Intervention communities were selected based on access and proximity to rural laboratories to which samples could be transferred within two hours of collection, including processing time in the laboratories. Then, control communities were matched according to similarity of locality (e.g. climate, topography, access to roads), while being located far enough in distance from intervention communities to avoid a spillover effect. The oversampling of intervention communities was done for the primary purpose of the study: which was to validate the water safety planning (WSP) framework of the WHO (Rickert et al., 2014). The WSP framework aims at (1) mobilising and training local actors in construction, operation management, and maintenance of drinking water and irrigation schemes; (2) providing adequate sanitation facilities at home and in school; (3) implementing water source conservation and upgrading drinking water schemes; (4) mobilising and training local actors in preparing and using the water use master plan, promoting water integrity/governance, and advocate good practices (see Table S1 for more details).

The survey sample comprised $N = 369$ individuals ($N = 493$ at baseline) in semi-structured computer-assisted personal interviews. The choice of participants in the communities was random,

with 15 households selected from a complete list of residents in the village that benefitted from the same drinking water scheme. Ages of interviewees were 18 or above, and their role in the family was preferably head of the household and responsible for water, sanitation, and hygiene. Individuals and clusters followed the flow diagram in Figure 1.
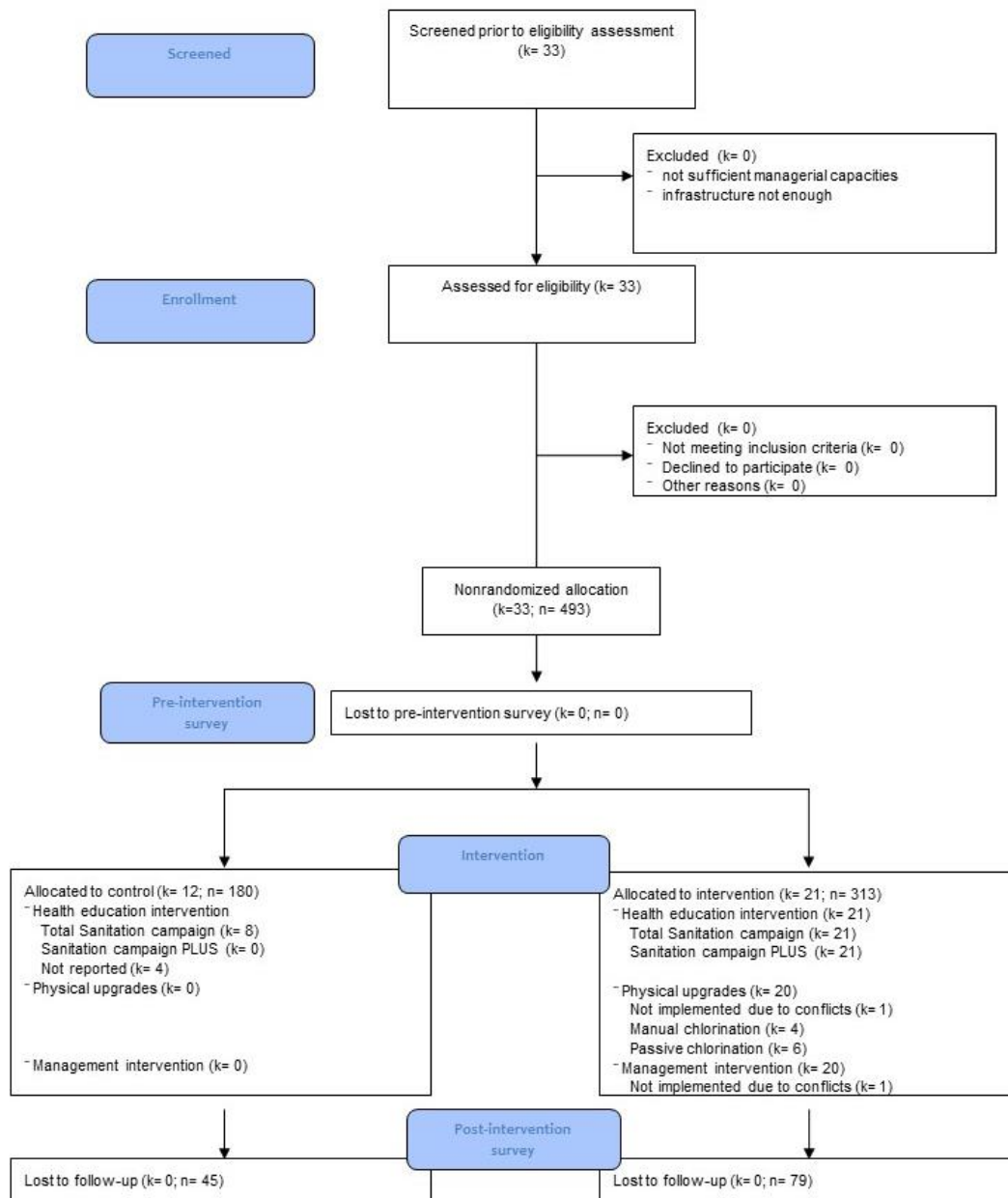
Figure 1. Flow diagram for clusters and participants according to CONSORT (Eldridge et al., 2016)

Independent Variable: Participatory Intervention

The interventions delivered through the IWRM programme of Helvetas can be categorized into three packages: general health and hygiene promotional activities, water supply infrastructure upgrades, and improved managerial practices. We mapped the intervention activities to the corresponding theory-based routes to psychological ownership. We describe this in detail in Table S1 in the supplementary materials.

To foster intimate knowledge, communities took part during the feasibility study and project implementation (e.g. attending meetings, helping in mapping and planning infrastructural upgrades), and communities were also trained in governance and financial management for proper operation to promote transparency and accountability. To foster investment of the self, communities were made responsible for supporting the scheme construction with cash, labour, and arrangement of materials. To foster having control, the water users' committee coordinated with various stakeholders for financial and technical assistance, organized and took part in construction work and ongoing operation and maintenance, and recruited a village maintenance worker who was responsible for the operation and maintenance of the scheme and collection of a water tariff. Communities were trained in participation practices for sustained water supply, sanitation, and hygiene (e.g. how to maintain water distribution channels).

The 21 intervention communities in this study received an intensive version of each package, whereas control communities received no package or only health and hygiene promotion.

Packages two and three of IWRM (Table S1) depend on the water safety planning (WSP) framework that is promoted by the WHO (Rickert et al., 2014). WSPs (Sutherland & Payden, 2017) are a participative tool to support planning, operation, and maintenance of water supply. They are tailored to the specific situation of a given water supply, and they encourage a shift towards more participatory planning of the water supply (Whittington et al., 2007). This is why intensive community participation and training are core features before and throughout the IWRM programme.

Four control communities did not receive the Total Sanitation campaign, a part of the IWRM programme (see Table S1) by Helvetas. One intervention community did not implement infrastructural upgrades because of internal conflicts. All but one of the communities involved reported that manual chlorination was challenging and subsequently dropped this aspect of the intervention.

Outcome Measures

The survey assessed participatory activities and psychological ownership at baseline. At follow up, 16 months later, the survey asked about psychological ownership and safe water outcomes. All items included in the study are listed in Table 1.

Table 1

Items used in survey

Concept	Item	Coding
Scale (Van Dyne & Pierce, 2004), measured at baseline and endline		
Psychological ownership	How much do you agree with the following statement?	
	This is MY water system	0 = agree not at all to 1 = agree very much
	This is our COMMUNITY'S water system.	0 = agree not at all to 1 = agree very much
	My family is one of the owners of the water system	0 = agree not at all to 1 = agree very much
	The water system is owned by all the people who live in this village.	0 = agree not at all to 1 = agree very much
Participatory activities, measured at baseline		
Involvement	Is anyone in this household involved in the water supply system in this community?	0 = No; 1 = Yes (FCH volunteer, VMW, WST, WUSC)
Decision-making	During PLANNING of the water system, did anyone in your family participate in deciding about the level of service to be delivered by the system?	0 = No; 1 = Yes
Influence	Overall, who do you think had the MOST influence over decisions about the water system during planning and construction?	0 = Committee (Donor, NGO, local government, leaders, WUSC); 1 = All users

Water users' committee meetings	How often does WUSC meet with water users to discuss issues about the water system?	0 = Never/Don't know; 1 = as needed; 2 = 1 to 6 meetings a year; 3 = Monthly
Village maintenance worker	Is there a village maintenance worker (VMW) to look after your main drinking water scheme?	0 = No; 1 = Yes
Contribution cash	Did your family contribute cash to the construction of the village's water system?	0 = No; 1 = Yes
Contribution cash (amount)	How much MONEY did your family contribute toward the water system during the construction phase?	0 = 0; 1 = Rs <= 3000; 2 = Rs 3001-5000; 3 = Rs >= 5001
Contribution cash (regularly)	Do the villagers contribute regularly to the water scheme?	0 = No (Not at all, when needed); 1 = Yes (regularly)
Contribution labour	Did your family contribute labour to the construction of the village's water system?	0 = No; 1 = Yes
Contribution materials	Did your family contribute materials to the construction of the village's water system?	0 = No; 1 = Yes

Outcomes, measured at endline

1.Acceptance

Perceived water taste:	How good do you perceive the taste of drinking water from the water system?	0 = not at all good to 1 = very good
Liking treated water	How much do you like or dislike drinking treated water?	-1 = dislike it very much to 1 = like it very much
Satisfaction	How satisfied are you with your main drinking water source?	0 = Dissatisfied; 1 = Satisfied
Safeness	How safe do you think your main drinking water source is for drinking?	-1 = not at all to 1 = very much

2. Preparatory behavior

Caretaking	How much do you feel that you personally need to take care of the water system?	0 = not at all to 1 = very much
Responsibility	How responsible do you feel for the repairing of the water system in case of interruption?	0 = not at all to 1 = very much

3. Health behaviour

Use	Which water source do you use as MAIN drinking water source?	0 = other (Rainwater harvesting, open unprotected source, open protected source, unmanaged piped scheme, river, lake, bottled water); 1 = piped water scheme (Private tap, community tapstand)
Exclusive use	Do you also use other water sources for drinking?	0 = No; 1 = Yes

Treatment	How often did you treat your drinking water in the past 2 weeks?	0 = never to 1 = always
Importance of treatment	How important is it for you to treat your water before drinking	0 = not at all to 1 = very much

4. Negative behaviour

Overuse	How often did you collect more water from the water system than you actually need in the last two weeks?	0 = never to 1 = always
Territoriality	How much does it bother you when other people collect their water from the water system?	0 = not at all to 1 = very much
Source switching	How often did you collect your water from other sources than the water system in the past 2 weeks?	0 = Never; 1 = Rarely; 2 = Half of the times; 3 = Most of the times; 4 = Always

5. Functionality

Self-reported functionality	Is your main drinking water source functioning now?	0 = No (not, not well); 1 = Yes
Availability	Is your main drinking water source available when needed?	0 = No (Never, sometimes); 1 = Yes
Expected functionality	How confident are you that your water system will be functional one year from now?	0 = not at all confident to 1 = very much confident
Interruption:	How many days did the interruption last?	
Confidence in reparation	If main drinking water scheme needed repairs, how confident are you that the problem could be fixed within 1 week?	0 = Not confident (not at all, somewhat confident); 1 = Very confident
Water quality	E.coli count (CFU per 100ml)	0 = 0; 1 = 1-10; 2 = 11-100; 3 = 101-TNTC

Covariate

Socio-economic status	About how much does your household spend PER MONTH on regular expenses (regular expenses = food, transport, clothing, and school fees)?	

Note: CFU = Coliform units; FCH = female community health; TNTC = too numerous to count; VMW = village maintenance worker; WUSC = water users' committee; WSTF = water safety task force. Reliability analysis of the psychological ownership scale was assessed by Cronbach's α at pre-intervention survey = .56 and post-intervention survey = .79.

We translated and backtranslated all items to Nepali and pretested in one community not included in the analyses. Interviewers had five days of training, and data collection was supervised. The interviewers measured psychological ownership for items with unipolar 5-point visual Likert scales, each with five dots of increasing size (Harter et al., 2020). To create composite scores for constructs such as psychological ownership, we summed corresponding items. Finally, we normed all scores to values of 0–1, with higher values indicating a higher score on this construct. For binary items, 1 indicated the presence of an outcome.

Psychological Ownership

We adapted the validated individual psychological ownership scale (van Dyne & Pierce, 2004b) to assess psychological ownership of the water system in the Nepali context (Ambuehl et al., 2021). We used five items with the highest face validity in this cultural context. For the data analysis, we also removed one reverse-coded item from the scale due to low item–total correlations. Internal consistency (Cronbach's alpha) was calculated as ICC with a 95% confidence interval (Bravo & Potvin, 1991) at baseline of 0.46 [0.37 - 0.55], and at endline of 0.76 [0.75 - 0.82]. The removal of further items did not improve reliability. A measure of re-test reliability cannot be calculated from baseline to endline, because psychological ownership is expected to change even in the control group.

Routes to Psychological Ownership

We measured routes to psychological ownership as independent variables and operationalized them with eight measures, targeting the three routes to psychological ownership. For control, we assessed perceived influence in decision-making about upgrading and running water schemes, deciding about planning service delivery, and involvement of the household in planning water supply. For intimate knowledge, we assessed frequency of attendance of water users' committee meetings, and knowing the village maintenance worker. For investment of the self, we assessed personal

contribution of labour, contribution of materials, and contribution of cash during the infrastructural upgrades.

Consequences of Psychological Ownership

We measured the consequences of psychological ownerships as dependent variables and operationalized as the following groups: For acceptance, we measured perceived water taste, liking treated water, satisfaction with the water supply, and perceived safeness. For caretaking, we measured willingness to take care and responsibility for the water supply. For use of infrastructure, we measured use of water supply and exclusive use of water supply as water source. For treatment, we measured the importance of treatment. For negative behaviour, we measured overuse, territoriality, and source switching. For functionality, we measured self-reported functionality, availability of water supply, expected functionality, frequency of interruption, confidence in repairing, and *E.coli* risk.

Microbial Water Quality

Faecal contamination of household stored drinking water samples was assessed using the membrane filtration technique with CompactDry™ Plates (Nissui Pharmaceutical Co., Ltd, Japan) and 24-hours incubation at 37o C. Quality control measures included daily positive and negative lab controls and two duplicate samples processed in each study community. Further details on laboratory procedures are described in Bänziger et al. (2021).

Functionality

Bonsor et al. (2018) distinguish functionality of water schemes from sustainability of infrastructure. Functionality is a snapshot of sustainability. We follow this understanding, and our definition of water supply scheme functionality also includes water quality (Walters & Javernick-Will, 2015). Subsequently, we define a safe water supply system as functional when it produces water flow of a good quality of water at a particular time.

Analyses

The data analysis was carried out in three steps. Firstly, the effect of participation on psychological ownership and safe water outcomes was tested using condition (intervention group = 1 vs. control group = 0) as the independent variable to predict changes in psychological ownership and safe water outcomes. Since we used a nonrandomized design, conducting analysis with change scores is preferable compared to regressed change (Deeks et al., 2003). The modelling approach we used were generalized estimating equations (GEE) that account for the nested structure of the data: individuals nested in water systems (Liang & Zeger, 1986). Secondly, to identify which forms of participation related to psychological ownership, we computed a model with forms of participation as predictors and psychological ownership of the water system as the outcome. For the consequences of psychological ownership, we fitted separate GEEs for continuous outcomes and dichotomous outcomes. As effect size measures for the GEE models, we calculated odds ratios (ORs) with asymptotic Wald 95% confidence intervals (CIs) for dichotomous outcomes. We interpreted them as the percentage increase (values >1) or decrease (values <1) in the outcome for a unit increase in the predictor. These analyses were adjusted for intervention, gender, and socio-economic status (SES).

Thirdly, we estimated the relationship of participatory activities with change in psychological ownership and consequences in mediation models (Figure 2). Mediation analysis can indicate how participation affects change in outcomes because they test the underlying mechanisms by which two variables affect each other (Baron & Kenny, 1986). In line with the assumptions of mediation analysis, we only tested mediation for participatory activities that showed a significant relation to changes in psychological ownership (established in Step 2). For each form of participation and outcome combination, we tested a separate mediation model following procedures proposed by Preacher et al. (2007) and using the PROCESS SPSS macro (Hayes, 2012). Confidence intervals were computed by bootstrapping 1000 resamples to test for positive indirect effects of the interventions on outcomes. Because these models referred to separate hypotheses, no control for the error rate was necessary (Bender & Lange, 2001).
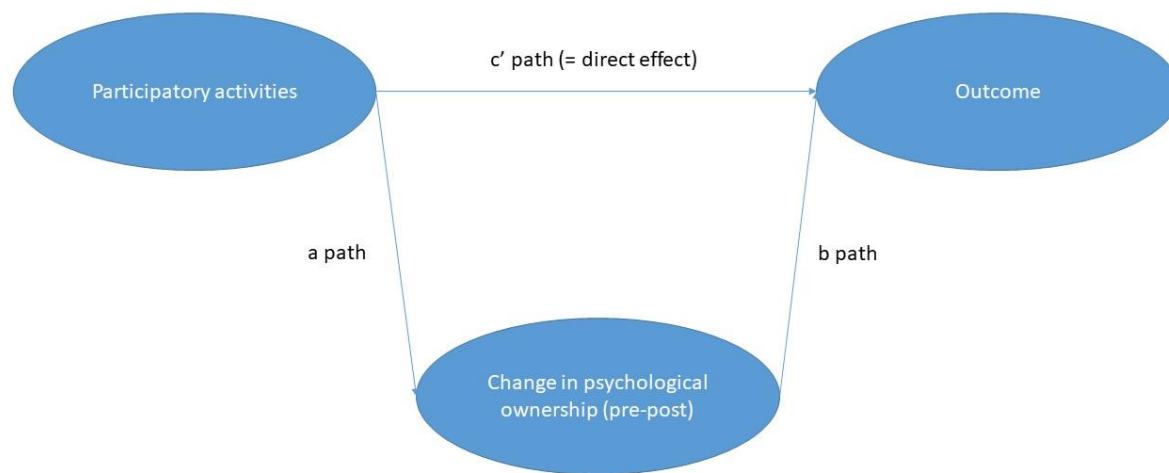
Figure 2. Schematic representation of mediation model

Ethics & Registration

We conducted the research in accordance with the Declaration of Helsinki and obtained ethical approval from the institutional review board of the first author's institution (Eawag Ethics Committee, policy directive 16-09). We obtained written informed consent from each participant prior to data collection. The study received government approval in Nepal as part of the Helvetas IWRM research programme.

Results

See Table 2 for the sample characteristics.

Table 2

Sample characteristics

Characteristics	*n*	*%f*	*M*	*SD*
Age	369		38.11	14.37
Gender				
Female	259	70.2		
Male	110	29.8		
Education level				
College or higher	10	2.71		
no formal schooling (illiterate)	106	28.7		
no formal schooling (literate)	125	33.9		
primary	64	17.3		
secondary	63	17.1		
none	1	0.27		
Ethnicity				
Bramihin Chhetr Thakuri	252	68.3		
Dalit	81	22		
Janajati	34	9.21		
Other	2	0.54		
Occupation in household				
Agriculture (independent)	198	53.7		
Agriculture (employed)	24	6.5		
Agriculture (labourer)	6	1.63		
Agriculture (business)	107	29		
Small business	4	1.08		
Government employed	28	7.59		
Labourer (daily)	2	0.54		
Expenses per month (NPR [a])			10509.65	6463.56
Land owning (Ropanis [b])			6.81	7.75
People living in household			6.35	2.71
Children in household			2.78	1.63
Children going to school			2.4	1.41

Note: N = 369, %f = relative frequency, n = Total Sample size; M = Mean; SD = Standard deviation; [a] Nepali Rupee, 118 NPR = 1 US-$; [b] Ropanis 30 = 1.5 ha

Descriptive statistics of survey items are presented in Table 3. Control and intervention groups differed at baseline only in whether they contributed materials to the water system (treatment group contributed significantly more materials $t(491) = -1.987$, $p = .047$); compare with Table S2 in supplementary materials.

Intervention effect

In the intervention group, individuals were more satisfied with the water system (OR = 1.83; $p = .014$) than the control group, expected functionality was higher (B = .11; $p = .018$), reported overuse less (B = -.11; $p = .006$), and responsibility for the water system greater (B = .07; $p = .033$). Further, people reported greater importance of water treatment (B = .04; $p = .046$) and more frequent treatment of the water after collecting it from the water system (B = .127; $p = .035$). There were no group differences in changes in psychological ownership (B < .01; SE=.03; $p = .468$).

Participatory activities and changes in psychological ownership

Although an overall effect of the intervention was absent on psychological ownership, several individual forms of participation related to changes in psychological ownership: We found greater psychological ownership in individuals who influenced decision-making about the service levels, who reported more frequent meetings with the water users' committee, and who contributed materials or labour. We found lower psychological ownership in individuals who influenced decision-making about the water system and who contributed labour (see Table 3).

Table 3

The relationship between different forms of participation and psychological ownership

	B	SE	p
Intervention	.02	.03	.468
Influence in decision-making	-.05	.02	.005
Decision about planning of service delivery	.07	.02	.002
Involvement of household in planning of water supply	.00	.02	.894
Water users' committee meetings frequency	.08	.03	.007
Village maintenance worker	.04	.03	.282
Contribution: labour	-.09	.04	.021
Contribution: materials	.11	.05	.026
Contribution: cash	.02	.02	.481
Gender	-.01	.02	.645
Socio-economic status	.00	.01	.436

Note: N = 369, 33 schemes, Dependent variable = Difference in psychological ownership, *B* = Parameter Estimates, *SE* = Standard error. All *p* values are two-tailed. Probability distribution: normal, link function: identity.

Psychological ownership and safe water outcomes

Table 4 GEE results indicated that individuals with greater psychological ownership also reported greater acceptance on all measures except satisfaction and greater responsibility for the water system. Further, greater psychological ownership related to increased use of the water system, more frequent water treatment after collection from it, less reported overuse, and greater optimism regarding functionality.

Table 4

Relationship between changes in psychological ownership and safe water outcomes

	B	*SE*	*p*	OR	CI95 LL	CI95 UL
Acceptance						
Perceived water taste	.15	.06	.013			
Liking treated water (Binary)	.75	.10	<.001			
Satisfaction	-.96	1.06	.365	.38	.05	3.05
Safeness	-.71	.24	.004			
Caretaking						
Caretaking	.49	.06	<.001			
Responsibility	.38	.05	<.001			
Use of infrastructure						
(Binary) Use	5.02	2.43	.039	151.81	1.30	17766.91
(Binary) Exclusive Use	.75	1.48	.613	2.11	.12	38.22
Treatment	.44	.14	.001			
Importance of treatment	.29	.05	<.001			
Negative behaviour						
Overuse	-.21	.09	.024			
Territoriality	-.16	.09	.084			
Source switching	-.15	.12	.208			
Functionality						
(Binary) Self-reported functionality	1.35	.99	.176	3.87	.55	27.46
(Binary) Availability	1.26	.87	.148	3.52	.64	19.29
Expected functionality	.39	.08	<.001			
Interruption	.31	10.07	.976			
(Binary) Confidence in repairing	3.46	.68	<.001	31.78	8.40	120.36
E.coli risk	.80	.32	.805			

Note: N = 369, 33 schemes, independent variable = psychological ownership, HH = household, WUSC = water users' committee, B = parameter estimates, SE = standard error, OR = odds ratio, CI95 = confidence interval, LL/ UL = lower/ upper limit of the confidence interval. All *p* values are two-tailed. For continuous items: probability distribution: normal, link function: identity. For binary items: probability distribution: binomial, link function: logit.

Mediation analysis

To test whether the various forms of participation relate to outcomes via changes in psychological ownership, we performed mediation analysis. We found that for five categories of outcomes, psychological ownership mediated some effects of participatory activities on consequences (Table 5). Water users' committee meetings and participation in decision-making were the predominant routes by which psychological ownership partially mediated the link to outcomes. We did not find a mediating effect of psychological ownership on functionality.

Table 5

Mediation models according to schematic representation of mediation in Figure 2

	a path			b path			c' path			indirect effect		
	B	*SE*	*p*	B	SE	p	*B*	*SE*	*p*	*B*	LL	UL
Outcomes X Forms of participation												
Acceptance (confidence in functionality)				0.23	0.05	<0.001						
Influence on decision-making	-0.08	0.04	<0.001				0.00	0.04	0.10	-0.02	-0.05	0.00
Decision about planning of service delivering	0.12	0.05	<0.001				**0.10**	**0.05**	**0.03**	**0.03**	**0.00**	**0.06**
WUSC meetings	0.17	0.05	<0.001				0.02	0.05	0.64	**0.04**	**0.01**	**0.07**
Contribution: labour	-0.07	0.04	<0.001				0.01	0.04	0.79	-0.01	-0.04	0.01
Contribution: materials	0.06	0.04	<0.001				0.01	0.04	0.87	0.01	0.00	0.03
Caretaking				0.33	0.04	<0.001						
Influence on decision-making	-0.08	0.04	<0.001				**-0.06**	**0.04**	**<0.001**	-0.02	-0.06	0.01
Decision about planning of service delivering	0.12	0.05	<0.001				**0.17**	**0.04**	**<0.001**	**0.04**	**0.01**	**0.08**
WUSC meetings	0.17	0.05	<0.001				**0.01**	**0.04**	**<0.001**	**0.05**	**0.02**	**0.10**
Contribution: labour	-0.07	0.04	<0.001				**0.02**	**0.04**	**<0.001**	-0.02	-0.05	0.01
Contribution: materials	0.06	0.04	<0.001				**-0.07**	**0.04**	**<0.001**	0.02	0.00	0.04
Use of infrastructure				0.13	0.05	0.01						
Influence on decision-making	-0.08	0.04	<0.001				0.06	0.05	0.22	-0.01	-0.03	0.00
Decision about planning of service delivering	0.12	0.05	<0.001				-0.08	0.05	0.14	0.02	0.00	0.04
WUSC meetings	0.17	0.05	<0.001				**0.13**	**0.05**	**0.01**	**0.02**	**0.00**	**0.05**
Contribution: labour	-0.07	0.04	<0.001				-0.05	0.05	0.31	-0.01	-0.03	0.00
Contribution: materials	0.06	0.04	<0.001				**-0.10**	**0.04**	**0.03**	0.01	0.00	0.02

	B	SE	p	B	SE	p	B	SE	p	B	LL	UL
Use of infrastructure (treatment of water after collection)				0.31	0.05	<0.001						
Influence on decision-making	-0.08	0.04	<0.001				0.00	0.04	0.99	-0.02	-0.06	0.01
Decision about planning of service delivering	0.12	0.05	<0.001				0.04	0.05	0.37	**0.04**	**0.00**	**0.08**
WUSC meetings	0.17	0.05	<0.001				**-0.10**	**0.05**	**0.05**	**0.05**	**0.01**	**0.09**
Contribution: labour	-0.07	0.04	<0.001				-0.02	0.04	0.73	-0.02	-0.06	0.01
Contribution: materials	0.06	0.04	<0.001				**-0.09**	**0.04**	**0.03**	**0.02**	**0.00**	**0.04**
Negative behaviour: Overuse				-0.14	0.05	0.00						
Influence on decision-making	-0.08	0.04	<0.001				-0.07	0.04	0.11	0.01	0.00	0.03
Decision about planning of service delivering	0.12	0.05	<0.001				-0.08	0.05	0.09	**-0.02**	**-0.04**	**0.00**
WUSC meetings	0.17	0.05	<0.001				-0.05	0.05	0.34	**-0.02**	**-0.06**	**0.00**
Contribution: labour	-0.07	0.04	<0.001				-0.05	0.04	0.28	0.01	0.00	0.03
Contribution: materials	0.06	0.04	<0.001				0.04	0.04	0.38	-0.01	-0.02	0.00
Functionality (self-reported)				0.02	0.05	0.72						
Influence on decision-making	-0.08	0.04	<0.001				**0.10**	**0.05**	**0.03**	0.00	-0.01	0.01
Decision about planning of service delivering	0.12	0.05	<0.001				-0.02	0.05	0.06	0.00	-0.01	0.02
WUSC meetings	0.17	0.05	<0.001				**0.10**	**0.05**	**0.04**	0.00	-0.02	0.03
Contribution: labour	-0.07	0.04	<0.001				-0.02	0.05	0.63	0.00	-0.01	0.01
Contribution: materials	0.06	0.04	<0.001				-0.01	0.04	0.85	0.00	-0.01	0.01

Note: N = 369, 33 schemes, independent variable = psychological ownership, HH = household, WUSC = water users' committee, B = parameter estimates, SE = standard error, OR = odds ratio, CI95 = confidence interval, LL/ UL = lower/ upper limit of the confidence interval. All *p* values are two-tailed. For continuous items: probability distribution: normal, link function: identity. For binary items: probability distribution: binomial, link function: logit

Discussion

The present study is the first to use an intervention study design to investigate whether participation leads to sustainable use and management of a shared resource, in this case community-based safe water infrastructure. We further investigated whether this relationship is mediated by psychological ownership for the shared infrastructure. The participatory intervention positively affected several safe water outcomes compared to the control group, but not psychological ownership. However, several specific participatory activities related to favourable safe water outcomes, and some of these relationships were explained by changes in psychological ownership.

We found greater satisfaction with the water supply, increased expected functionality, greater sense of responsibility, and lower reported overuse in intervention communities than in control ones. In addition, the intervention group reported that households treated drinking water more frequently. However, we did not find an intervention effect for either observed water quality or improved functionality of safe water infrastructure. This may not be surprising, as several other studies also found little evidence for any effectiveness of participatory water safety planning interventions on overall outcomes, especially in rural contexts (e.g., String et al., 2020; van den Broek & Brown, 2015). One set of likely explanations can be found in the nature of participation: communities did not participate enough (Jiménez et al., 2019), or participation was not in the right form (Kayaga, 2013), or did not last long enough (Ferrero et al., 2019). Another explanation could be that structural factors, such as external support programmes (Miller et al., 2019) and design-matched infrastructure (Marks et al., 2018), are necessary to improve water quality and observed functionality of infrastructure.

In line with our assumptions, we found that certain participatory activities related to increased psychological ownership. Involvement in decision-making, attending water users' committee meetings, and contributing materials were each independently associated with greater psychological ownership of the safe water infrastructure. In contrast, influence in decision-making for all users was negatively associated with psychological ownership. An explanation for this could be, that if the influence is distributed too broadly in the public, this can lead to diffusion of responsibility, and thus to lower psychological ownership in the individual (Beyer et al., 2017). Contribution of labour related

143

to decreased psychological ownership too. This confirms findings from cross-sectional studies (e.g., Contzen & Marks, 2018; Marks & Davis, 2012) that not every form of contribution invokes feelings of ownership equally, and these feelings may be very short-lived (Kamleitner & Erki, 2013). Financial contributions, in particular, are seen as less important than intrinsic contributions to determining long-lasting behaviour change (Kaiser et al., 2020; Ryan & Deci, 2000). Therefore, although labour contributions undoubtedly play a practical role in water supply projects by reducing overall project costs and using local materials by delegating construction activities, their role in influencing community ownership feelings remains uncertain. Alternatively, this finding may potentially be attributable to baseline differences in contributing materials. The findings of our mediation analysis speaks against this interpretation, however. We found that only certain ways of fostering psychological ownership work well, and contributing material is not one of them. Therefore, we may argue that the baseline differences in contribution of materials are negligible for the intervention effect.

Psychological ownership was associated with multiple positive safe water outcomes in this study, including increased acceptance and caretaking of safe drinking water infrastructure, increased use of infrastructure, and reduced negative behaviour. This agrees with findings from research on other shared resources. For example, greater psychological ownership was associated with increased satisfaction with community development, higher self-esteem, and increased quality of contributions for virtual communities (Lee & Suh, 2015); increased perceived usefulness and perceived ease of use of a new learning environment (Yim et al., 2019); acceptance of and increased participation in new technology adaptation (Pare et al., 2006); augmented car sharing (Paundra et al., 2017); and increased service use in an access-based service economy (Fritze et al., 2020). Contrary to our hypotheses, psychological ownership did not relate to more distal outcomes such as functionality, and all of the effects found were weak. These findings are in line with earlier studies on shared resources and psychological ownership (Shu & Peck, 2018), and also from organizational research, where for example Van Dyne, & Pierce (2004) found no incremental prediction of psychological ownership on distal outcomes. In our study, an explanation may be that technical expertise and influence over

functionality are often assigned to an exclusive selection of villagers: the water users' committees. Hence, users may not have a significant direct influence on functionality and water quality. This may further explain why the activities of water users' committees are so strongly related to users' psychological ownership. Users who report attending more frequent committee meetings are most likely to be close and follow the news of what happens in the water users' committee and subsequently have more knowledge about and increased influence over the water scheme and thus have a higher psychological ownership of it.

Finally, the effects of some forms of participation on outcomes were mediated by psychological ownership whereas others were not. A potential explanation for this may lie in the fact that some forms of participation were more accepted than others, wherefore the communities engaged in them to differing extents. For example, households could decide whether to contribute materials, money, or labour to infrastructural upgrades. Participation in community meetings and election of water users' committee members were voluntary elements in the intervention. One practical implication of this finding is that interventions do not need to cover all forms of participation to promote psychological ownership. Instead, participatory activities that are guided by institutional frameworks, but are selected by the community itself may be more effective. Selection of participatory interventions could be coupled with assessment of users' needs and preferences for different water service attributes (e.g., choice experiments) and from there, the needs of the community become more clear and thus inform the extent and type of participation. Like this, in-depth activation of participatory forms based on self-realization may prove to be most effective.

Limitations & future directions

The present study provided valuable first insights into the effects and mechanisms of participation on the use and maintenance of a shared resource, here safe water infrastructure. The results hint that psychological ownership can only be triggered by a few in-depth forms of participation. However, psychological ownership is found to relate beneficially to several positive

safe water outcomes and negatively to hindering safe water outcomes. More research is needed to investigate the extent of generalizability to other shared resources. There are also some limitations to be acknowledged.

At baseline, we found that internal consistency of our measurement scale for psychological ownership was very low, compared to the originally validated measurement scale (i.e. Van Dyne, Pierce, 2004). This could be due to the novel context of application. Future research should investigate validity and reliability of the psychological ownership measurement scale towards safe water infrastructure.

We used mediation analysis to show how participatory activities related to safe water outcomes by enhancing psychological ownership. However, psychological ownership did not fully mediate the effect of participation on safe water outcomes, and effect sizes were small. Future research should therefore investigate additional potential mediators. For example, participation may influence various outcomes for safe water supply by promoting people's concern about safe water consumption and consideration of future consequences (Bruderer Enzler et al., 2019; Kaiser et al., 1999).

Although this was the first intervention study of participation on outcomes via psychological ownership, the nonrandomized study design with purposeful assignment of communities to treatment and control group is a limitation; third-variable bias cannot be ruled out. In future research, a randomized controlled design should be used to replicate what we have found.

Another limitation is that we found very high psychological ownership at baseline. This may be explained by the previous activities of Helvetas in these communities. Helvetas works with communities in a very participatory way on an ongoing basis. Therefore, many participatory activities are regularly implemented in the communities, and the mechanism of action presented in this study can only assesses additional effects. Replication is therefore necessary in conditions with low previous participatory activity.

Finally, insufficient detailed descriptions were available to precisely code all intervention content. Therefore, the active ingredients of the intervention remain rather imprecisely defined. Future studies should emphasize the establishment of detailed implementation reports based on systematic description and reporting guidelines for interventions developed in behavioural science (Toomey et al., 2020).

Conclusion

This study used the example of water supply management to provide support for the assumption that participatory approaches can foster psychological ownership to achieve improved safe water supply. This is in line with application recommendations for means of implementation approaches as formulated in SDGs (e.g., SDGs 6b) for guaranteeing sustainable behaviour change and development. Even though we established psychological ownership as a mediating factor, we find that forms of participation differ in the extent to which they strengthen feelings of ownership and achieve safe water outcomes. This suggests that different forms of community participation might be important for different target resources. We recommend critical advance assessment of forms of participation and in-depth activation techniques to identify those relevant to effective community engagement.

Our findings extend previous findings, for example that psychological ownership enhances stewardship of public goods (Peck et al., 2021), and they can also be generalized to other community-managed systems and environments. We have identified psychological ownership as an additional factor in environmental psychology (Russell & Fielding, 2010) that can contribute to behaviour change for successful protection and sustainable management of shared resources and thus, to a beneficial environment for the individual and the community.

References

Abbott, J. (1995). Community participation and its relationship to community development. *Community Development Journal, 30*(2), 158-168.

Agrawal, A., & Gupta, K. (2005). Decentralization and participation: the governance of common pool resources in Nepal's Terai. *World development, 33*(7), 1101-1114.

Adhikari, S., Kingi, T., & Ganesh, S. (2014). Incentives for community participation in the governance and management of common property resources: the case of community forest management in Nepal. *Forest Policy and Economics, 44*, 1-9.

Aga, D. A., Noorderhaven, N., & Vallejo, B. (2018). Project beneficiary participation and behavioural intentions promoting project sustainability: The mediating role of psychological ownership. *Development Policy Review, 36*(5), 527–546. https://doi.org/10.1111/dpr.12241

Ambuehl, B., Tomberge, V. M. J., Kunwar, B. M., Schertenleib, A., Marks, S. J., & Inauen, J. (2021). The role of psychological ownership in safe water management: A mixed-methods study in Nepal. *Water, 13*(5). https://doi.org/10.3390/w13050589

Bänziger C., Schertenleib, A., Kunwar, B. M., Bhatta, M., Marks, S. J. 2021. Assessing microbial water quality, users' perceptions and system functionality following a combined water safety intervention in rural Nepal. *Frontiers in Water, 3*:750802. doi: 10.3389/frwa.2021.750802

Bain, R., Johnston, R., Mitis, F., Chatterley, C., & Slaymaker, T. (2018). Establishing sustainable development goal baselines for household drinking water, sanitation and hygiene services. *Water, 10*(12). https://doi.org/10.3390/w10121711

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173

Bender, R., & Lange, S. (2001). Adjusting for multiple testing—when and how? Journal of Clinical *Epidemiology, 54*(4), 343–349. https://doi.org/10.1016/S0895-4356(00)00314-0

Beyer, F., Sidarus, N., Bonicalzi, S., & Haggard, P. (2017). Beyond self-serving bias: diffusion of responsibility reduces sense of agency and outcome monitoring. *Social cognitive and affective neuroscience, 12*(1), 138-145.

Bisung, E., Elliott, S. J., Schuster-Wallace, C. J., Karanja, D. M., & Bernard, A. (2014). Social capital, collective action and access to water in rural Kenya. *Social Science and Medicine, 119*, 147–154. https://doi.org/10.1016/j.socscimed.2014.07.060

Bonsor, H., MacDonald, A., Casey, V., Carter, R., & Wilson, P. (2018). The need for a standard approach to assessing the functionality of rural community water supplies. *Hydrogeology Journal, 26*(2). https://doi.org/10.1007/s10040-017-1711-0

Bravo, G., & Potvin, L. (1991). Estimating the reliability of continuous measures with cronbach's alpha or the intraclass correlation coefficient: Toward the integration of two traditions. *Journal of Clinical Epidemiology, 44*(4–5), 381–390. https://doi.org/10.1016/0895-4356(91)90076-L

Brown, G., & Zhu, H. (2016). 'My workspace, not yours': The impact of psychological ownership and territoriality in organizations. *Journal of Environmental Psychology, 48*, 54–64. https://doi.org/10.1016/j.jenvp.2016.08.001

Bruderer Enzler, H., Diekmann, A., & Liebe, U. (2019). Do environmental concern and future orientation predict metered household electricity use? *Journal of Environmental Psychology, 62*, 22–29. https://doi.org/10.1016/j.jenvp.2019.02.004

Contzen, N., & Marks, S. J. (2018). Increasing the regular use of safe water kiosk through collective psychological ownership: A mediation analysis. *Journal of Environmental Psychology, 57*, 45–52. https://doi.org/10.1016/j.jenvp.2018.06.008

Deeks, J. J., Dinnes, J., & D'amico, R. (2003*). Evaluating non-randomised intervention studies HTA Health Technology Assessment NHS R&D HTA Programme.* In Health Technology Assessment (Vol. 7, Issue 27). www.hta.ac.uk/htacd.htm

Eldridge, S. M., Chan, C. L., Campbell, M. J., Bond, C. M., Hopewell, S., Thabane, L., & Lancaster, G. A. (2016). CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ*, i5239. https://doi.org/10.1136/bmj.i5239

Ferrero, G., Setty, K., Rickert, B., George, S., Rinehold, A., DeFrance, J., & Bartram, J. (2019). Capacity building and training approaches for water safety plans: A comprehensive literature review. *International Journal of Hygiene and Environmental Health, 222*(4), 615–627. https://doi.org/10.1016/j.ijheh.2019.01.011

Fischer, A., Hope, R., Manandhar, A., Hoque, S., Foster, T., Hakim, A., Islam, M. S., & Bradley, D. (2020). Risky responsibilities for rural drinking water institutions: The case of unregulated self-supply in Bangladesh. *Global Environmental Change, 65*. https://doi.org/10.1016/j.gloenvcha.2020.102152

Fritze, M. P., Marchand, A., Eisingerich, A. B., & Benkenstein, M. (2020). Access-Based Services as Substitutes for Material Possessions: The Role of Psychological Ownership. *Journal of Service Research, 23*(3), 368–385. https://doi.org/10.1177/1094670520907691

George, A. S., Mehra, V., Scott, K., & Sriram, V. (2015). Community Participation in Health Systems Research: A Systematic Review Assessing the State of Research, the Nature of Interventions Involved and the Features of Engagement with Communities. *PLOS ONE, 10*(10), e0141091. https://doi.org/10.1371/journal.pone.0141091

Han, T. S., Chiang, H. H., & Chang, A. (2010). Employee participation in decision making, psychological ownership and knowledge sharing: Mediating role of organizational

commitment in Taiwanese high-tech organizations. *International Journal of Human Resource Management, 21*(12), 2218–2233. https://doi.org/10.1080/09585192.2010.509625

Harter, M., Inauen, J., & Mosler, H.-J. (2020). How does Community-Led Total Sanitation (CLTS) promote latrine construction, and can it be improved? A cluster-randomized controlled trial in Ghana. *Social Science & Medicine, 245*, 112705. https://doi.org/10.1016/j.socscimed.2019.112705

Harvey, P. A., & Reed, R. A. (2007). Community-managed water supplies in Africa: sustainable or dispensable? *Community Development Journal, 42*(3), 365–378. https://doi.org/10.1093/cdj/bsl001

Hayes, A. F. (2012*). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modelling* [White paper]. Retrieved from www.afhayes.com/public/

process2012.pdfInauen, J., Contzen, N., Frick, V., Kadel, P., Keller, J., Kollmann, J., Mata, J., & van Valkengoed, A. M. (2021). Environmental Issues Are Health Issues. *European Psychologist, 26*(3), 219–229. https://doi.org/10.1027/1016-9040/a000438

Inauen, J., Lilje, J., & Mosler, H. J. (2020). Refining hand washing interventions by identifying active ingredients: A cluster-randomized controlled trial in rural Zimbabwe. *Social Science and Medicine, 245*. https://doi.org/10.1016/j.socscimed.2019.112712

Jenny, A., Fuentes, F. H., & Mosler, H. J. (2007). Psychological factors determining individual compliance with rules for common pool resource management: the case of a Cuban community sharing a solar energy system. *Human Ecology, 35*(2), 239-250.

Jo, H., Aryee, S., Hsiung, H. H., & Guest, D. (2021). Service-oriented high-performance work systems and service role performance: Applying an integrated extended self and psychological ownership framework. *Human Relations,* 00187267211035656.

Jiang, M., Wang, H., & Li, M. (2019). Linking Empowering Leadership and Organizational Citizenship Behavior Toward Environment: The Role of Psychological Ownership and Future Time Perspective. *Frontiers in Psychology, 10*. https://doi.org/10.3389/fpsyg.2019.02612

Jiménez, A., LeDeunff, H., Giné, R., Sjödin, J., Cronk, R., Murad, S., Takane, M., & Bartram, J. (2019). The enabling environment for participation in water and sanitation: A conceptual framework. *Water, 11*(2). https://doi.org/10.3390/w11020308

Kabir, A., & Howard, G. (2007). Sustainability of arsenic mitigation in Bangladesh: results of a functionality survey. *International Journal of Environmental Health Research, 17*(3), 207-218.

Kaiser, F. G., Henn, L., & Marschke, B. (2020). Financial rewards for long-term environmental protection. *Journal of Environmental Psychology, 68*, 101411. https://doi.org/10.1016/j.jenvp.2020.101411

Kaiser, F. G., Wölfing, S., & Fuhrer, U. (1999). Environmental Attitude and Ecological Behaviour. *Journal of Environmental Psychology, 19*(1), 1–19. https://doi.org/10.1006/jevp.1998.0107

Kamleitner, B., & Erki, B. (2013). Payment method and perceptions of ownership. *Marketing Letters, 24*(1), 57–69. https://doi.org/10.1007/s11002-012-9203-4

Kayaga, S. (2013). Effective water safety management of piped water networks in low-income urban settlements. *Journal of Water, Sanitation and Hygiene for Development, 3*(3), 402–410. https://doi.org/10.2166/washdev.2013.105

Kelly, E., Lee, K., Shields, K. F., Cronk, R., Behnke, N., Klug, T., & Bartram, J. (2017). The role of social capital and sense of ownership in rural community-managed water systems: Qualitative evidence from Ghana, Kenya, and Zambia. *Journal of Rural Studies, 56*, 156–166. https://doi.org/10.1016/j.jrurstud.2017.08.021

Khwaja, A. I. (2009). Can good projects succeed in bad communities? *Journal of Public Economics, 93*(7–8), 899–916. https://doi.org/10.1016/j.jpubeco.2009.02.010

Kleemeier, E. (2000). The Impact of Participation on Sustainability: An Analysis of the Malawi Rural Piped Scheme Program. *World Development, 28*(5), 929–944. https://doi.org/10.1016/S0305-750X(99)00155-2

Klug, T., Shields, K. F., Cronk, R., Kelly, E., Behnke, N., Lee, K., & Bartram, J. (2017). Water system hardware and management rehabilitation: Qualitative evidence from Ghana, Kenya, and Zambia. *International Journal of Hygiene and Environmental Health, 220*(3), 531–538. https://doi.org/10.1016/j.ijheh.2017.02.009

Kwon, S. (2020). Understanding user participation from the perspective of psychological ownership: The moderating role of social distance. *Computers in Human Behavior, 105*, 106207.

Lee, J., & Suh, A. (2015). How do virtual community members develop psychological ownership and what are the effects of psychological ownership in virtual communities? *Computers in Human Behavior, 45*, 382–391. https://doi.org/10.1016/j.chb.2014.12.002

Liang, K.-Y., & Zeger, S. L. (1986). Longitudinal data analysis using generalized linear models. *Biometrika, 73*(1), 13–22. https://doi.org/10.1093/biomet/73.1.13

Liu, J., Wang, H., Hui, C., & Lee, C. (2012). Psychological Ownership: How Having Control Matters. *Journal of Management Studies, 49*(5), 869–895. https://doi.org/10.1111/j.1467-6486.2011.01028.x

Madajewicz, M., Tompsett, A., & Habib, Md. A. (2021). How does delegating decisions to communities affect the provision and use of a public service? Evidence from a field experiment in Bangladesh. *Journal of Development Economics, 150*, 102609. https://doi.org/10.1016/j.jdeveco.2020.102609

Marks, S. J., & Davis, J. (2012). Does User Participation Lead to Sense of Ownership for Rural Water Systems? Evidence from Kenya. *World Development, 40*(8), 1569–1576. https://doi.org/10.1016/j.worlddev.2012.03.011

Marks, S. J., Komives, K., & Davis, J. (2014). Community Participation and Water Supply Sustainability: Evidence from Handpump Projects in Rural Ghana. *Journal of Planning Education and Research, 34*(3), 276–286. https://doi.org/10.1177/0739456X14527620

Marks, S. J., Kumpel, E., Guo, J., Bartram, J., & Davis, J. (2018). Pathways to sustainability: A fuzzy-set qualitative comparative analysis of rural water supply programs. *Journal of Cleaner Production, 205*, 789–798. https://doi.org/10.1016/j.jclepro.2018.09.029

Marks, S. J., Onda, K., & Davis, J. (2013). Does sense of ownership matter for rural water system sustainability? Evidence from Kenya. *Journal of Water, Sanitation and Hygiene for Development, 3*(2), 122–133. https://doi.org/10.2166/washdev.2013.098

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J., & Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine, 46*(1), 81–95. https://doi.org/10.1007/s12160-013-9486-6

Miller, M., Cronk, R., Klug, T., Kelly, E. R., Behnke, N., & Bartram, J. (2019). External support programs to improve rural drinking water service sustainability: A systematic review. *Science of The Total Environment, 670*, 717–731. https://doi.org/10.1016/j.scitotenv.2019.03.069

Murty, M. N. (1994). Management of common property resources: Limits to voluntary collective action. *Environmental and Resource Economics, 4*(6), 581-594.

Naiga, R., Penker, M., & Hogl, K. (2015). Challenging pathways to safe water access in rural Uganda: From supply to demand-driven water governance. *International Journal of the Commons, 9*, 237–260.

Palmer, R. N., Cardwell, H. E., Lorie, M. A., & Werick, W. (2013). Disciplined planning, structured participation, and collaborative modeling—Applying shared vision planning to water resources. *JAWRA Journal of the American Water Resources Association, 49*(3), 614-628.

Pare, G., Sicotte, C., & Jacques, H. (2006). The Effects of Creating Psychological Ownership on Physicians' Acceptance of Clinical Information Systems. *Journal of the American Medical Informatics Association, 13*(2), 197–205. https://doi.org/10.1197/jamia.M1930

Paundra, J., Rook, L., van Dalen, J., & Ketter, W. (2017). Preferences for car sharing services: Effects of instrumental attributes and psychological ownership. *Journal of Environmental Psychology, 53*, 121–130. https://doi.org/10.1016/j.jenvp.2017.07.003

Peck, J., Kirk, C. P., Luangrath, A. W., & Shu, S. B. (2021). Caring for the Commons: Using Psychological Ownership to Enhance Stewardship Behavior for Public Goods. *Journal of Marketing, 85*(2), 33–49. https://doi.org/10.1177/0022242920952084

Pierce, J. L., & Jussila, I. (2010). Collective psychological ownership within the work and organizational context: Construct introduction and elaboration. *Journal of Organizational Behavior, 31*(6), 810–834. https://doi.org/10.1002/job.628

Pierce, J. L., Kostova, T., & Dirks, K. T. (2003). The State of Psychological Ownership: Integrating and Extending a Century of Research. *Review of General Psychology, 7*(1), 84–107. https://doi.org/10.1037/1089-2680.7.1.84

Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing Moderated Mediation Hypotheses: Theory, Methods, and Prescriptions. *Multivariate Behavioral Research, 42*(1), 185–227. https://doi.org/10.1080/00273170701341316

Preston, S. D., & Gelman, S. A. (2020). This land is my land: Psychological ownership increases willingness to protect the natural world more than legal ownership. *Journal of Environmental Psychology, 70*, 101443. https://doi.org/10.1016/j.jenvp.2020.101443

Prokopy, L. S. (2005). The relationship between participation and project outcomes: Evidence from rural water supply projects in India. *World development, 33*(11), 1801-1819.

Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., Cumming, O., Freeman, M. C., Gordon, B., Hunter, P. R., Medlicott, K., & Johnston, R. (2019). Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low- and middle-income countries. *International Journal of Hygiene and Environmental Health, 222*(5), 765–777. https://doi.org/10.1016/j.ijheh.2019.05.004

Rickert, B., Schmoll, O., Rinehold, A. and Barrenberg, E., 2014. *Water safety plan: a field guide to improving drinking-water safety in small communities.* WHO Press, Geneva, Switzerland.

Rudmin, F. W., & Berry, J. W. (1987). Semantics of Ownership: A Free-Recall Study of Property. *The Psychological Record, 37*(2), 257–268. https://doi.org/10.1007/BF03394988

Russell, S., & Fielding, K. (2010). Water demand management research: A psychological perspective. *Water Resources Research, 46*(5). https://doi.org/10.1029/2009WR008408

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Sahoo, R., & Swain, M. (2013). Contribution of common property resources for sustainable rural livelihoods in Odisha: Prospects and constraints. *Journal of Rural Development, 32*(3), 245-261.

Shrestha, A., Sharma, S., Gerold, J., Erismann, S., Sagar, S., Koju, R., Schindler, C., Odermatt, P., Utzinger, J., & Cissé, G. (2017). Water Quality, Sanitation, and Hygiene Conditions in Schools and Households in Dolakha and Ramechhap Districts, Nepal: Results from A Cross-Sectional Survey. *International Journal of Environmental Research and Public Health, 14*(1), 89. https://doi.org/10.3390/ijerph14010089

Shu, S. B., & Peck, J. (2018). *Solving Stewardship Problems with Increased Psychological Ownership.* In Psychological Ownership and Consumer Behavior (pp. 227–237). Springer International Publishing. https://doi.org/10.1007/978-3-319-77158-8_14

Sloot, D., Jans, L., & Steg, L. (2018). Can community energy initiatives motivate sustainable energy behaviours? The role of initiative involvement and personal pro-environmental motivation. *Journal of Environmental Psychology, 57*, 99–106. https://doi.org/10.1016/j.jenvp.2018.06.007

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology, 29*(3), 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

String, G. M., Singleton, R. I., Mirindi, P. N., & Lantagne, D. S. (2020). Operational research on rural, community-managed Water Safety Plans: Case study results from implementations in India, DRC, Fiji, and Vanuatu. *Water Research, 170*, 115288. https://doi.org/10.1016/j.watres.2019.115288

Suessenbach, S., & Kamleitner, B. (2018). *Psychological Ownership as a Facilitator of Sustainable Behaviors.* In J. Peck & S. B. Shu (Eds.), Psychological Ownership and Consumer Behavior (pp. 211–225). Springer International Publishing. https://doi.org/10.1007/978-3-319-77158-8_13Sutherland, D., & Payden. (2017). Observations and lessons learnt from more than a decade of water safety planning in South-East Asia. *WHO South-East Asia Journal of Public Health, 6*(2), 27. https://doi.org/10.4103/2224-3151.213788

Tomberge, V. M. J., Harter, M., & Inauen, J. (2021). The importance of collective and individual psychological ownership for safe sanitation: A multilevel analysis in rural Ghana. *Global Public Health*. https://doi.org/10.1080/17441692.2021.1928260

Toomey, E., Hardeman, W., Hankonen, N., Byrne, M., McSharry, J., Matvienko-Sikar, K., & Lorencatto, F. (2020). Focusing on fidelity: narrative review and recommendations for improving intervention fidelity within trials of health behaviour change interventions. *Health Psychology and Behavioral Medicine, 8*(1), 132–151. https://doi.org/10.1080/21642850.2020.1738935

van den Broek, M., & Brown, J. (2015). Blueprint for breakdown? Community Based Management of rural groundwater in Uganda. *Geoforum, 67*, 51–63. https://doi.org/10.1016/j.geoforum.2015.10.009

van Dyne, L., & Pierce, J. L. (2004). Psychological ownership and feelings of possession: Three field studies predicting employee attitudes and organizational citizenship behavior. *Journal of Organizational Behavior, 25*(4), 439–459. https://doi.org/10.1002/job.249

Vlek, C., & Steg, L. (2007). Human Behavior and Environmental Sustainability: Problems, Driving Forces, and Research Topics. *Journal of Social Issues, 63*(1), 1–19. https://doi.org/10.1111/j.1540-4560.2007.00493.x

Walters, J. P., & Javernick-Will, A. N. (2015). Long-Term Functionality of Rural Water Services in Developing Countries: A System Dynamics Approach to Understanding the Dynamic

Interaction of Factors. *Environmental Science & Technology, 49*(8), 5035–5043. https://doi.org/10.1021/es505975h

Whittington, D., Hanemann, W. M., Sadoff, C., & Jeuland, M. (2007). The Challenge of Improving Water and Sanitation Services in Less Developed Countries. *Foundations and Trends in Microeconomics, 4*(6—7), 469–609. https://doi.org/10.1561/0700000030

WHO/UNICEF. (2021). *Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs..* In Joint Water Supply, & Sanitation Monitoring Programme.

Woolcock, M., & Narayan, D. (2000). Social Capital: Implications for Development Theory, Research, and Policy. *The World Bank Research Observer, 15*(2), 225–249. https://doi.org/10.1093/wbro/15.2.225

Yacoob, M. (1990). Community self-financing of water supply and sanitation: what are the promises and pitfalls? *Health Policy and Planning, 5*(4), 358–366. https://doi.org/10.1093/heapol/5.4.358

Yim, J. S.-C., Moses, P., & Azalea, A. (2019). Predicting teachers' continuance in a virtual learning environment with psychological ownership and the TAM: a perspective from Malaysia. *Educational Technology Research and Development, 67*(3), 691–709. https://doi.org/10.1007/s11423-019-09661-8

Article 4: Individual Behaviour and Communal Effort Combined Provide Best Chances for Sustainability of Shared Resources: A Cluster-randomized Controlled Trial from Bihar, India

This article is a preprint. The article is going to be submitted for publication at Nature Water.

Individual Behaviour and Communal Effort Combined Provide Best Chances for Sustainability of Shared Resources: A Cluster-randomized Controlled Trial from Bihar, India

Benjamin Ambuehl 1,2 *, Ashok Ghosh 3,4 Bharat Kumar Singh 5, Manoj Kumar 5, Selina Steiner 2, Sara J. Marks 1, Jennifer Inauen 2

1 Eawag, - Swiss Federal Institute of Aquatic Science and Technology, Duebendorf, Switzerland

2 Institute of Psychology, Department of Health Psychology& Behavioural Medicine, University of Bern, Bern, Switzerland

3 BSPCB – Bihar State Pollution Control Board, Patna, India

4) MCSRC – Mahavir Cancer Sansthan Institute & Research Centre, Patna, India

5) Paridhi, Bhagalpur, India

*Corresponding author

E-mail: benjamin.ambuehl@eawag.ch

Abstract

Background: Our interactions with natural habitats or human-made environments demand for an alignment of community and individual if sustainability is to be maximized. For example, sustainable water management depends on availability of water of good quality (nature, common-pool resource), functional community-based water supply (infrastructure), shared management and individual use (behaviour) in the long term. In previous research, psychological ownership for shared infrastructure was found to be associated with several beneficial outcomes and habit was found to be an effective target for behaviour change of the individual.

Methods: We conducted a cluster-randomized controlled trial (N = 1242) in 59 villages in rural Bihar, India, where community-based piped water supply schemes are installed under the Jal Jeevan programme, researching the impact of community (psychological ownership) and individual (habit) interventions on attitudes, commitment, use and functionality.

Findings: Theory-based interventions successfully fostered psychological ownership and habits if delivered together. They caused beneficial outcomes: use of safe water source, behavioural determinants for safe water consumption behaviour and caretaking behaviour, more optimism towards future functionality of the infrastructure. Combined interventions pointed towards other desired effects: improved infrastructure condition and greater share of safe water collected. However, it was shown that single delivery of interventions hampered outcomes if applied solely (i.e. use of unsafe water source). However, none of the interventions could improve drinking water quality.

Interpretation: This study provides robust empirical evidence that social and individual interventions must come together, to achieve successful installation, operation and management of shared resources.

1. Introduction

An overarching and pressing issue of our society is planetary health and sustainability of civilisation to ensure health and wellbeing for all (Horton & Lo, 2015). Sustainability of civilisation is a product of the interaction between human behaviour and different habitats, which has become more complex (Schill et al., 2019). Even though altruism and capacity for collective action were important in less complex human societies, our interactions with natural habitats, such as common-pool resources (e.g. water; Schwarzenbach et al., 2010), or human-made environments (e.g. infrastructure; Thacker et al., 2019) still demand for an alignment of community and individual, if sustainability is to be maximised (Brozyna et al., 2018; Ostrom, 2002; Whitmee et al., 2015). For example, sustainable water management depends on availability of water of good quality (nature, common-pool resource), functional community-based water supply (infrastructure), shared management and individual use (behaviour) in the long term. Still, most of the research so far has focused on individual behaviour only (e.g. Verplanken, 2018). We use water as an example of a common-pool resource in this study to research the interaction of collective and individual behaviour change interventions to achieve sustainability.

Safe drinking and cooking water is a basic need in life and a human right (Gleick, 1998). However, despite rapid progress made in extending access to safe and adequate water supplies in recent years, for at least two billions of people worldwide water supply is still non-existent, scarce (Bain et al., 2020) or of poor quality, causing severe risks to health (Bartram et al., 2005; Nowicki et al., 2020; Onda et al., 2012). Several obstacles impede universal access to safe and adequate water supplies – whether at community or individual level.

On the individual level, irregular use and switching to unsafe sources may occur. This is due to the fact that even if when water systems are well-matched to communities' needs, system-level monitoring and treatment practices are scarce or non-existent in many settings (Bain et al, 2014). This is especially the case in rural areas of low-income countries, where the necessary supply chains and technical capacity remain limited (Diener et al., 2017), negatively influencing water quality and putting people at risk.

On community level, project teams may fail to invest sufficiently in ground-level assessments, leading to the use of technologies which are poorly aligned with communities' needs and preferences (Whittington et al., 1998). To tackle water quality issues, various water point mitigation options were installed top-down and technology-driven over the years, for example handpumps. Recent approaches, in turn, target system level mitigation options, for example community-based filtration units with piped water supply, applying participatory approaches (Cronin et al., 2016). In the behaviour change technique (BCT) catalogue (Michie et al., 2015), interventions on the community level, e.g. restructuring social and physical environment, are listed and linked mechanism of actions, e.g. social norms (Carey et al., 2019; Cislaghi & Heise, 2019). Nevertheless, to the best of the authors knowledge, interventions testing these BCT's are lacking.

One of the only examples of evidence shows the positive influence of restructuring the physical environment on varied outcomes, many of which were drivers and domains of behaviour (Wilkie et al., 2018). But often, social factors (e.g. identification with community or social norms, (Ostrom, 2000) are not sufficiently integrated into institutional approaches to community-based management (Castilla-Rho et al., 2017; Kumar & Kant, 2006)). This results in poor performance, high infrastructure failure rates as well as low levels of service (Moriarty et al., 2013; Jiménez & Pérez-Foguet, 2010).

A psychological theory that has shown promise when it comes to social dynamics is psychological ownership theory (Pierce & Jussila, 2011). Psychological ownership is defined as "the state in which individuals feel as though [a] target of ownership (…) is theirs" (Pierce et al., 2001, p. 299) and was found to influence positively the behavioural intentions of project beneficiaries toward project sustainability (Aga et al., 2018). Building on a dynamic model of identity and the self (Hillenbrand & Money, 2015), psychological ownership was also found to be a promising factor for the sustainable management of shared and natural resources (e.g. Matilainen et al., 2017; Matilainen & Laehdesmaeki, 2021; Peck et al., 2021; Preston & Gelman, 2020; Suessenbach & Kamleitner, 2018). First applications in the context of community-based water supply confirmed cross-sectional associations amongst psychological ownership for successful management, increased acceptance and

use of this infrastructure (Ambuehl et al., 2021; Contzen & Marks, 2018; Marks et al., 2013). However, empirical evidence for the causal role of psychological ownership for sustainability is largely lacking.

And even when water systems are well-matched to communities' needs, system-level monitoring and treatment practices are scarce or non-existent in many settings (Bain et al, 2014). This is especially the case in rural areas of low-income countries, where the necessary supply chains and technical capacity remain limited (Diener et al., 2017), negatively influencing water quality and putting people at risk. Thus, on the individual level, irregular use and switching to unsafe sources may occur as a result (Contzen & Marks, 2018).

Additionally, individuals often do not use and repair community-based infrastructure in the long term because acceptance and positive attitudes may change behaviour instantly but are not sufficient to maintain behaviour change (Kwasnicka et al., 2016). Briscoe and Aboud (2012, p. 590) noted "behaviours may be difficult to change because they are habitual, normative and preventive. Habitual behaviours are difficult to change because they are performed automatically without much thought; normative behaviours bear the weight of tradition and approval; and preventive behaviours often lack a salient immediate outcome". In turn, this resistance to changing habitual behaviours can be used to promote behaviour change in the long term (e.g. Linder et al., 2022; Verplanken & Roy, 2016). Inauen et al. (2014) identified that commitment strength and behavioural intention are underlying psychosocial determinants which predict water collecting habits. We are aware that habit is a complex and hot topic in behaviour change intervention research (Gardner et al., 2021), but for simplicity we label our intervention as habit-intervention. Inauen and Mosler (2016) used BCTs such as public-commitment (BCT 1.9 Commitment Prompts/cues), action plans (BCT 1.4 Action planning) and reminders (BCT 7.1 Prompts/cues) to foster perceived behavioural control, intentions, commitment strength and coping planning. They found these mechanisms to be key to behavioural maintenance in safe water consumption, aligning it with theories of habit formation (Carden & Wood, 2018; Lally & Gardner, 2013). Mosler et al. (2013) found these to be successful interventions to maintain the level of use once it is established.

Therefore, combining BCTs on the individual level and community level to multi-level interventions with their respective outcomes is a necessity to achieve sustainability and sustainable management of shared resources (Dobson et al., 2019). In this study, for the first time, we used a 2x2 factorial study design in a cluster-randomized controlled trial and tested interventions at community (psychological ownership) and individual (habit) levels to research the acceptance, use and functionality of a community-based safe water infrastructure in the long term. We answer the following research questions, preregistered at open science framework (https://osf.io/8zukt):

1)   Can a psychological ownership intervention promote acceptance (i.e. positive attitudes and stronger commitment), use and functionality of safe water infrastructure in the long term?

• In the long term, participants in the psychological ownership intervention arms will show more positive attitudes (H1a), stronger commitment (H1b), greater use (H1c) and greater number of functional safe water taps (H1d) than participants in control arms.

2)   Can a habit intervention promote the use of safe water infrastructure in the long term?

• In the long term, participants in the habit intervention arms will use safe water infrastructure more often (H2a) than participants in the control arms.

3)   Is a combined intervention of psychological ownership and habit more effective than the psychological ownership or habit intervention alone in promoting the acceptance, use, and functionality of safe water infrastructure?

• In the long term, participants in the combined intervention arm will exhibit more positive attitudes (H3a), stronger commitment (H3b), greater use (H3c) and a greater number of functional safe water taps (H3d) than participants in the arms of psychological ownership or habit intervention alone.

Descriptive statistics

Descriptive statistics of all items are displayed in Table 1.1, 1.2, 1.3., and 1.4.

Table 1.1

Descriptive statistic of demographics

	control		po		habit		po + habit	
	f	*f%*	*f*	*f%*	*f*	*f%*	*f*	*f%*
caste								
General Caste	39	9,725686	44	8,817635	92	19,28721	109	19,05594
BC	161	40,14963	214	42,88577	178	37,31656	188	32,86713
EBC / MBC	156	38,90274	214	42,88577	179	37,52621	229	40,03497
SC	37	9,226933	17	3,406814	22	4,612159	38	6,643357
ST	8	1,995012	10	2,004008	6	1,257862	8	1,398601
religion								
hindu	344	85,14851	453	90,41916	447	93,51464	539	94,23077
buddhist	2	0,49505	0	0	0	0	1	0,174825
islam	58	14,35644	48	9,580838	31	6,485356	32	5,594406
sex								
female	72	18,04511	90	18,14516	90	19,0678	98	17,16287
male	327	81,95489	406	81,85484	382	80,9322	473	82,83713

Note. Frequencies are displayed split by intervention arm. Abbreviations: po = psychological ownership, *f* = absolute frequencies, *f%* = relative frequencies, BC = Backward Caste, EBC / MBC = Economically backward caste / most backward caste, SC = Scheduled caste, ST = Scheduled tribe

Table 1.2

Descriptive statistics at baseline

	Source or example item	interventionarm	N	M(SD)	alpha[LL;UL]
Socio-economic status	Saleem and Jan (2019)	control	402	18,52(7,45)	
		po	502	17,29(7,12)	
		habit	478	18,3(6,63)	
		po+habit	572	18,05(7,23)	
Trust	Costa and Anderson (2010)	control	382	2,5(0,54)	0,93[0,92;0,93]
		po	485	2,48(0,57)	
		habit	462	2,54(0,55)	
		po+habit	546	2,47(0,54)	
Social identity	Cameron (2004)	control	379	2,95(0,32)	0,92[0,91;0,92]
		po	483	2,93(0,29)	
		habit	462	2,93(0,29)	
		po+habit	545	2,91(0,3)	
Individual psychological ownership for handpump	Van Dyne and Pierce (2004)	control	400	4,66(0,6)	0,83[0,82;0,84]
		po	501	4,58(0,71)	
		habit	476	4,65(0,61)	
		po+habit	569	4,63(0,68)	
Collective psychological ownership for handpump	Pierce and Jussila (2010)	control	402	4,2(1,08)	0,81[0,8;0,82]
		po	499	4,19(1,05)	
		habit	477	4,26(1,01)	
		po+habit	565	4,28(1,01)	

Habit for water collection at handpump	Verplanken and Orbell (2003)	control	383	4,39(0,65)	0,89[0,88;0,89]					
		po	491	4,33(0,68)						
		habit	466	4,39(0,7)						
		po+habit	552	4,4(0,62)						
Water use (share of safe water in %)	Inauen et al. (2013)	control	326	0,55(4,46)						
		po	402	1,14(8,44)						
		habit	379	1,33(7,47)						
		po+habit	461	1,26(7,07)						

		control		po		habit		po + habit	
		f	*f%*	*f*	*f%*	*f*	*f%*	*f*	*f%*
Water quality	Das et al. (2014)								
arsenic <=,01		202	50,24876	273	54,6	234	48,95397	318	55,59441
arsenic >,01		200	49,75124	227	45,4	244	51,04603	254	44,40559

Note. Frequencies are displayed split by intervention arm. Abbreviations: po = psychological ownership, *f* = absolute frequencies, *f%* = relative frequencies, *N* = number of participants in analysis, *M* = Mean, *SD* = Standard deviation, alpha = Cronbach's alpha, LL / UL= lower / upper limit of the confidence interval.

Table 1.3

Descriptive statistics at follow up

		interventionarm	*N*	*M*(*SD*)	alpha[LL;UL]
Individual psychological ownership for handpump	Van Dyne and Pierce (2004)	control	276	4,58(0,62)	0,8[0,78;0,81]
		po	281	4,62(0,55)	
		habit	310	4,61(0,67)	
		po+habit	335	4,62(0,58)	
Collective psychological ownership for handpump	Pierce and Jussila (2010)	control	277	4,02(1,61)	0,85[0,84;0,86]
		po	280	4,23(1,02)	
		habit	308	4,06(1,17)	
		po+habit	336	3,93(1,2)	
Habit for water collection at handpump	Verplanken and Orbell (2003)	control	276	4,2(0,89)	0,89[0,88;0,89]
		po	279	4,3(0,8)	
		habit	310	4,29(0,77)	
		po+habit	336	4,21(0,74)	
Individual psychological ownership for water scheme	Van Dyne and Pierce (2004)	control	277	4,16(0,93)	0,85[0,84;0,86]
		po	278	4,17(0,9)	
		habit	310	4,32(0,84)	
		po+habit	334	4,34(0,78)	
Collective psychological ownership for water scheme	Pierce and Jussila (2010)	control	275	4,04(1,02)	0,82[0,8;0,83]
		po	279	4,02(1,07)	

		interventionarm	N	M(SD)	alpha[LL;UL]
		habit	308	4,14(1,02)	
		po+habit	337	4,22(0,98)	
Habit for water collection at water scheme	Verplanken and Orbell (2003)	control	274	4,18(0,86)	0,9[0,89;0,91]
		po	280	4,27(0,79)	
		habit	309	4,33(0,76)	
		po+habit	337	4,27(0,79)	
Water use (share of safe water in %)	Inauen et al. (2013)	control	267	26,34(35,77)	
		po	274	21,5(32,56)	
		habit	291	23,81(33,38)	
		po+habit	335	38,38(28,46)	
Routes to psychological ownership					
Investing the self	I invested money or donated land for the construction of the water system.	control	269	2,81(1,08)	
	I invested labour in the construction of the water system.	po	261	2,98(1,06)	
	Without my contribution, the water system would not exist.	habit	300	2,86(1,09)	
	I contributed my ideas to the water system.	po+habit	318	3,1(0,99)	
Intimately knowing	I know best when something has to be decided over the water system.	control	276	3,06(1,18)	
	I know how this water system is organized.	po	278	3,24(1,19)	
	I know how this water system works.	habit	309	3,26(1,23)	
	I know who is responsible for the water system if there are any troubles.	po+habit	336	3,48(1,12)	
Having control	I feel like it is in my hand who can use the water system and who cannot.	control	273	2,88(0,97)	
	I feel like it is in my hand how often I may use the water system.	po	279	2,95(1)	
	I am the head of the water system.	habit	309	2,99(1)	

		interventionarm	N	M(SD)	alpha[LL;UL]
	I am one of the leaders over the water system.	po+habit	335	3,11(0,96)	
Consequences of psychological ownership					
Behavioural intention	Inauen et al. (2014)	control	277	3,01(0,97)	0,87[0,85;0,88]
		po	281	2,88(0,98)	
		habit	310	2,94(1,06)	
		po+habit	336	3,13(0,98)	
Risk exposure	How many people of your household do you know that suffer from effects of arsenic exposure?	control	276	1,49(0,78)	0,89[0,88;0,9]
		po	281	1,46(0,76)	
		habit	304	1,36(0,72)	
		po+habit	336	1,4(0,76)	
Others approval	Inauen et al. (2014)	control	277	1,78(0,78)	0,84[0,83;0,85]
		po	281	1,74(0,77)	
		habit	309	1,83(0,86)	
		po+habit	336	1,9(0,82)	
Behavioural obligation/commitment	Inauen et al. (2014)	control	277	2,35(1,09)	
		po	280	2,23(1,07)	
		habit	310	2,32(1,11)	
		po+habit	336	2,51(1,09)	
Overcoming hindrance	Harter et al. (2020)	control	277	2,42(0,91)	0,88[0,87;0,89]
		po	280	2,36(0,88)	
		habit	309	2,46(0,94)	
		po+habit	335	2,55(0,94)	
Respect	Do you think you are more or less respected by your community because you collect drinking and cooking water of the community water scheme?	control	275	2,19(0,94)	
		po	281	2,21(0,97)	
		habit	309	2,4(1,02)	

		interventionarm	N	M(SD)	alpha[LL;UL]
		po+habit	333	2,32(0,96)	
Others disapproval	If you collect drinking and cooking water at the community water scheme, to what extent do you think people will envy you?	control	276	1,96(0,98)	
		po	281	1,91(0,96)	
		habit	310	1,89(0,99)	
		po+habit	336	1,81(0,91)	
Confidence in performance	Mosler (2012)	control	276	2,94(0,46)	0,71[0,69;0,74]
		po	280	2,98(0,39)	
		habit	309	2,94(0,4)	
		po+habit	336	2,87(0,46)	
Perceived behavioural control	Inauen et al. (2014)	control	277	2,61(0,67)	0,87[0,85;0,88]
		po	279	2,79(0,73)	
		habit	308	2,8(0,66)	
		po+habit	336	2,57(0,73)	
Action control	Mosler (2012)	control	277	3,44(1,03)	
		po	280	3,48(1,03)	
		habit	308	3,64(0,88)	
		po+habit	336	3,33(1,01)	
Leader's approval	Mosler (2012)	control	275	1,69(0,87)	0,85[0,84;0,87]
		po	280	1,61(0,78)	
		habit	306	1,75(0,91)	
		po+habit	335	1,81(0,9)	
Having unique rights	I have rights on the water system that no one else has.	control	277	2,95(1,78)	
		po	279	3,3(1,72)	
		habit	310	2,86(1,74)	
		po+habit	337	3(1,79)	
Responsibility	If something happens to this water system, others think that I am responsible for the water system.	control	276	3,44(1,21)	

		interventionarm	N	M(SD)	alpha[LL;UL]
		po	280	3,55(1,09)	
		habit	309	3,49(1,2)	
		po+habit	334	3,75(1,04)	
Acceptance	I accept the water system as my water system.	control	277	3,65(1,58)	
		po	280	3,86(1,48)	
		habit	310	3,73(1,58)	
		po+habit	337	3,89(1,44)	
Preference	Every other water source is second to the water system.	control	276	3,75(1,47)	
		po	280	3,83(1,49)	
		habit	310	3,87(1,51)	
		po+habit	336	4,09(1,38)	
Territoriality	Brown & Zhu (2016)	control	277	3,17(1,24)	
		po	279	3,23(1,19)	
		habit	309	3,4(1,22)	
		po+habit	336	3,3(1,19)	
Benefit	I benefit from the water system financially.	control	277	2,8(1,71)	
		po	280	3,04(1,65)	
		habit	310	2,93(1,75)	
		po+habit	336	3,16(1,68)	
Self-efficacy	Bandura (2006)	control	277	3,52(1,63)	
		po	280	3,7(1,56)	
		habit	310	3,77(1,59)	
		po+habit	336	3,88(1,47)	
Self-efficacy (inverse)	I can do whatever I want for the water system, I will not achieve anything.	control	277	2,62(1,65)	
		po	280	2,53(1,65)	
		habit	310	2,6(1,74)	
		po+habit	336	2,53(1,69)	

		interventionarm	N	M(SD)	alpha[LL;UL]
Use anytime	When I want to collect water at the water system, I use it anytime at my convenience.	control	276	3,49(1,66)	
		po	280	3,51(1,71)	
		habit	308	3,68(1,62)	
		po+habit	336	3,85(1,56)	
Repair	When the water system is damaged, I try my best to have it repaired.	control	277	3,74(1,17)	
		po	279	3,7(1,25)	
		habit	309	3,71(1,24)	
		po+habit	336	3,9(1,1)	
Importance	The community water scheme is very important to me.	control	277	3,92(1,34)	
		po	280	3,88(1,39)	
		habit	309	4,11(1,25)	
		po+habit	336	4,18(1,24)	
Engage	I often motivate other people to take care of the water system.	control	277	3,79(1,4)	
		po	280	3,65(1,47)	
		habit	309	3,96(1,44)	
		po+habit	336	4,11(1,24)	
Optimism	I am sure, the water system will be broken in the future.	control	277	2,81(1,55)	
		po	280	2,83(1,56)	
		habit	309	2,75(1,57)	
		po+habit	336	2,79(1,61)	
Confidence in functionality	Marks & Davis (2012)	control	277	3,36(1,68)	
		po	280	3,25(1,62)	
		habit	309	3,2(1,75)	
		po+habit	336	3,76(1,5)	

		interventionarm	N	M(SD)	alpha[LL;UL]
Caretaking as duty	How much do you feel the duty that you personally need to take care of the water system?	control	277	3,82(1,35)	
		po	280	3,85(1,38)	
		habit	309	3,89(1,44)	
		po+habit	336	4,15(1,15)	
Caretaking indifferent	I feel the same, it doesn't matter if I do maintain the water system or not.	control	277	3(1,7)	
		po	280	3,22(1,66)	
		habit	309	3,12(1,69)	
		po+habit	336	2,83(1,71)	
Having general rights	I am having rights on the water system.	control	277	3,53(1,49)	
		po	280	3,42(1,55)	
		habit	309	3,83(1,48)	
		po+habit	336	3,87(1,4)	

Note. Abbreviations: po = psychological ownership, *N* = number of participants in analysis, *M* = Mean, *SD* = Standard deviation, alpha = Cronbach's alpha, LL / UL= lower / upper limit of the confidence interval.

Table 1.4

Frequencies at follow up

		control		po		habit		po + habit	
		f	*f%*	*f*	*f%*	*f*	*f%*	*f*	*f%*
Water use (observed)									
water scheme		65	20,56962	80	22,16066	65	18,15642	117	31,88011
other source		251	79,43038	281	77,83934	293	81,84358	250	68,11989
Water quality									
arsenic <=,01	Das et al. (2014)	169	53,48101	184	50,82873	199	55,58659	201	55,06849
arsenic >,01		147	46,51899	178	49,17127	159	44,41341	164	44,93151
ecoli Absence	Tambi et al. (2016)	109	33,95639	158	42,02128	129	36,13445	139	35,82474
ecoli Presence		212	66,04361	218	57,97872	228	63,86555	249	64,17526

Note. Frequencies are displayed split by intervention arm. Abbreviations: po = psychological ownership, *f* = absolute frequencies, *f%* = relative frequencies.

Preliminary analysis

Preliminary analysis consisted of the assessment of intervention fidelity and several checks to inform the choice of analysis method.

Intervention fidelity

Detailed overview over intervention fidelity per cluster is provided in supplementary materials. Adherence to protocol was assessed to be $M(SD)$=0.54(0.11) for control arm; $M(SD)$=0.56(0.19) for ownership intervention arm; $M(SD)$=0.6(0.14) for habit intervention arm; $M(SD)$=0.63(0.22) for ownership+habit intervention arm. Group comparison gave no indications for differences in adherence level for the different groups (F=2.56, p=.12).

Table 2

Interrater reliability of intervention fidelity rating

	ICC	p
control	.95	<0.01
po	.97	<0.01
habit	1	<0.01
po + habit	.99	<0.01

Note. Abbreviations: ICC = Intraclass correlation coefficient, < .5 (poor), ICC = .75 (average), ICC = .9 (good), ICC > .9 (very good) (Koo & Li, 2016). All p-values are two-tailed.

Randomization check

To ensure random allocation of clusters to control and intervention arms, we calculated differences between conditions at baseline. The results showed no significant differences but one: the combined intervention arm had significantly lower social identity compared to the control arm (Table 3).

Table 3

Fixed and random effects of multi-level models for randomization check

	Fixed effects	B[LL;UL](*SE*)	*p*
Individual psychological ownership for handpump			
N=1946, *K*=61	intercept	4,66[4,58;4,73](0,04)	<0,01
	po	-0,08[-0,19;0,02](0,05)	0,13
	habit	-0,01[-0,11;0,1](0,05)	0,89
	po +habit	-0,03[-0,12;0,07](0,05)	0,6
	Random effects	Variance(*SD*)	
	Random intercept	0,006(0,08)	
	Residual	0,42(0,65)	
	ICC	0,016()	
Collective psychological ownership for handpump			
N=1943, *K*=61	intercept	4,19[4,08;4,32](0,06)	<0,01
	po	-0,02[-0,18;0,15](0,09)	0,85
	habit	0,06[-0,11;0,23](0,09)	0,48
	po +habit	0,08[-0,09;0,24](0,08)	0,35
	Random effects	Variance(*SD*)	
	Random intercept	0,019(0,14)	
	Residual	1,05(1,02)	
	ICC	0,018()	
Habit for water collection at handpump			
N=1892, *K*=61	intercept	4,39[4,32;4,46](0,03)	<0,01
	po	-0,06[-0,15;0,03](0,05)	0,19
	habit	0,01[-0,08;0,1](0,05)	0,88
	po +habit	0,02[-0,08;0,1](0,04)	0,81
	Random effects	Variance(*SD*)	
	Random intercept	0(0)	
	Residual	0,44(0,66)	
	ICC	0()	
Water quality (arsenic)			
N=1952, *K*=61	intercept	1,01[-0,621;0,638]	0,98
This is a dummy-doded item with			
0 = safe water			
1 = arsenic contaminated water			
B is OR (Odds Ratio) in this case	po	1,17[-0,7;1,036]	0,71
	habit	0,93[-0,947;0,816]	0,88
	po +habit	1,62[-0,535;1,139]	0,48
	Random effects	Variance(*SD*)	

	Random intercept	1,239(1,113)	
	Residual	()	
	ICC	0,274()	
Trust			
N=1875, K=61	intercept	2,51[2,44;2,58](0,04)	<0,01
	po	-0,02[-0,12;0,07](0,05)	0,66
	habit	0,03[-0,07;0,13](0,05)	0,54
	po +habit	-0,03[-0,13;0,06](0,05)	0,51
	Random effects	Variance(*SD*)	
	Random intercept	0,01(0,08)	
	Residual	0,3(0,55)	
	ICC	0,024()	
Social identity			
N=1869, K=61	intercept	2,95[2,92;2,98](0,02)	<0,01
	po	-0,02[-0,06;0,02](0,02)	0,27
	habit	-0,01[-0,06;0,02](0,02)	0,38
	po +habit	-0,04[-0,08;-0,01](0,02)	0,04
	Random effects	Variance(*SD*)	
	Random intercept	0(0)	
	Residual	0,09(0)	
	ICC	0()	
Socio-economic status			
N=1954, K=61	intercept	18,64[17,41;19,88](0,64)	<0,01
	po	-1,39[-3,1;0,31](0,88)	0,12
	habit	-0,49[-2,22;1,23](0,9)	0,58
	po +habit	-1,56[-2,19;1,1](0,85)	0,52
	Random effects	Variance(*SD*)	
	Random intercept	4,08(2,02)	
	Residual	46,83(6,84)	
	ICC	0,08()	

Note. Abbreviations: po = psychological ownership, ICC = Intraclass correlation coefficient, *N* = number of participants in analysis, *K* = number of clusters in analysis, *B* = Parameter estimates, *SE* = Standard error, alpha = Cronbach's alpha, LL / UL= lower / upper limit of the confidence interval. All *p*-values are two-tailed.

Dropout analysis

We find a dropout rate from baseline to endline of 28,4% of participants and 11% of clusters (Figure 1). To ensure dropouts over time were not systematic or due to the allocation of clusters to control and intervention arms, we calculated differences between dropouts and remaining participants at baseline, following Bell et al. (2014). The results showed no significant differences but one: Dropouts had a significantly increased odds ratio for arsenic contaminated water (Table 4). To ensure validity of multi-level models based on complete case analysis (Armijo-Olivo et al., 2009; Fielding et al., 2012). Multiple imputation approaches are not advisable, due to high dropout rates (Jakobsen et al., 2017).

Table 4

Fixed and random effects of multi-level models for dropouts

	Fixed effects	B[LL;UL](SE)	p
Individual psychological ownership for handpump			
N=1946, K=61	intercept	4,66[4,6;4,68](0,04)	<0,01
	missings	-0,04[-0,11;0,018](0,03)	0,17
	Random effects	Variance(SD)	
	Random intercept	0,006(0,08)	
	Residual	0,42(0,65)	
	ICC	0,015()	
Habit for water collection at handpump			
N=1892, K=61	intercept	4,39[4,35;4,42](0,02)	<0,01

	missings	-0,01[-0,08;0,04](0,03)	0,574
	Random effects	Variance(*SD*)	
	Random intercept	0(0,02)	
	Residual	0,44(0,66)	
	ICC	0,001()	

Trust

N=1875, K=61

	intercept	2,51[2,48;2,55](0,02)	<0,01
	missings	-0,04[-0,09;0,01](0,03)	0,129
	Random effects	Variance(*SD*)	
	Random intercept	0,007(0,09)	
	Residual	0,3(0,55)	
	ICC	0,024()	

Socio-economic status

N=1954, K=61

	intercept	18,05[17,4;18,7](0,33)	<0,01
	missings	-0,09[-0,78;0,589](0,35)	0,789
	Random effects	Variance(*SD*)	
	Random intercept	3,99(1,99)	
	Residual	46,87(6,85)	
	ICC	0,078()	

Collective psychological ownership for handpump

N=1943, K=61

	intercept	4,25[4,18;4,32](0,03)	<0,01
	missings	-0,04[-0,14;0,05](0,05)	0,39
	Random effects	Variance(*SD*)	
	Random intercept	0,018(0,03)	

	Residual	-0,04(0,05)	
	ICC	0,017()	
Social identity			
N=1869, *K*=61	intercept	2,93[2,92;2,95](0,009)	<0,01
	missings	-0,01[-0,04;0,02](0,014)	0,445
	Random effects	Variance(*SD*)	
	Random intercept	0(0,009)	
	Residual	0,09(0)	
	ICC	0,001()	
Water quality (arsenic)			
N=1952, *K*=61	intercept	1,02[0,75;1,39]	0,89
This is a dummy-doded item with			
0 = safe water			
1 = arsenic contaminated water			
B is OR (Odds Ratio) in this case	missings	1,31[1,04;1,63]	0,02
	Random effects	Variance(*SD*)	
	Random intercept	1,249(1,118)	
	Residual	()	
	ICC	0,275()	

Note. Abbreviations: po = psychological ownership, ICC = Intraclass correlation coefficient, *N* = number of participants in analysis, *K* = number of clusters in analysis, *B* = Parameter estimates, *SE* = Standard error, alpha = Cronbach's alpha, LL / UL= lower / upper limit of the confidence interval, missings = dropouts at follow-up. All *p*-values are two-tailed.

Manipulation check

We calculated a manipulation check to see whether our interventions were successfully targeting the routes to psychological ownership. Only in the combined intervention arm routes were significantly increased compared to the control arm (Table 5).

Table 5

Fixed and random effects of multi-level models for manipulation check

	Fixed effects	B[LL;UL](*SE*)	*p*
Having control			
N=1196, *K*=56	control	2,88[2,77;3](0,03)	<0,01
	po	0,05[-0,17;0,28](0,05)	0,64
	habit	0,11[-0,05;0,27](0,05)	0,17
	po +habit	0,24[0,07;0,42](0,04)	0,01
	Random effects	Variance(*SD*)	
	control	0(0)	
	po	0,08(288,1)	
	habit	0(0,05302)	
	po +habit	0,02(155,2)	
	Residual	0,95(972,2)	
	ICC	0,027()	
Investing the self			
N=1148, *K*=55	control	2,83[2,67;3](0,08)	<0,01
	po	0,14[-0,15;0,41](0,14)	0,347
	habit	0,04[-0,16;0,23](0,09)	0,707
	po +habit	0,29[0,09;0,49](0,1)	0,01
	Random effects	Variance(*SD*)	
	control	0,03(0,16)	
	po	0,1(0,32)	
	habit	0,03(0,16)	
	po +habit	0,08(0,28)	
	Residual	1,1(1,03)	
	ICC	0,041()	
Intimately knowing			
N=1199, *K*=56	control	3,06[3;3,23](0,09)	<0,01
	po	0,16[-0,12;0,43](0,15)	0,28
	habit	0,2[-0,01;0,41](0,11)	0,09
	po +habit	0,42[0,22;0,63](0,11)	<0,01
	Random effects	Variance(*SD*)	

control	0,03(0,18)	
po	0,21(0,46)	
habit	0,06(0,23)	
po +habit	0,03(0,18)	
Residual	1,36(1,17)	
ICC		0,035

Note. Abbreviations: po = psychological ownership, ICC = Intraclass correlation coefficient, *N* = number of participants in analysis, *K* = number of clusters in analysis, *B* = Parameter estimates, *SE* = Standard error, alpha = Cronbach's alpha, LL / UL= lower / upper limit of the confidence interval. All *p*-values are two-tailed.

We continued the manipulation check to see whether our interventions were successfully targeting only individual psychological ownership and habit for the water scheme (Table 6).

Table 6

Fixed and random effects of multi-level models for manipulation check

	Fixed effects	*B*[LL;UL](*SE*)	*p*
Individual psychological ownership for water scheme			
N=1199, *K*=56	intercept	4,15[4;4,3](0,08)	<0,01
	po	0,01[-0,18;0,2](0,1)	0,9
	habit	0,17[-0,02;0,35](0,09)	0,09
	po +habit	0,19[0,01;0,36](0,09)	0,04
	Random effects	Variance(*SD*)	
	intercept	0,04(0,19)	
	po	0,1(0,31)	
	habit	0,07(0,25)	
	po +habit	0,04(0,19)	
	Residual	0,73(0,85)	
	ICC		0,023
Individual psychological ownership for handpump			
N=1202, *K*=57	intercept	4,58[4,5;4,66](0,04)	<0,01
	po	0,04[-0,09;0,16](0,06)	0,55
	habit	0,03[-0,09;0,14](0,06)	0,64
	po +habit	0,04[-0,06;0,14](0,05)	0,42
	Random effects	Variance(*SD*)	
	intercept	0(0,05)	
	po	0,02(0,12)	
	habit	0(0,05)	
	po +habit	0(0,06)	
	Residual	0,36(0,6)	
	ICC		0,01
Collective psychological ownership for water scheme			
N=1199, *K*=56	intercept	4,04[3,84;4,24](0,1)	<0,01
	po	-0,03[-0,29;0,23](0,13)	0,84
	habit	0,1[-0,16;0,35](0,13)	0,46
	po +habit	0,18[-0,07;0,43](0,13)	0,17
	Random effects	Variance(*SD*)	
	intercept	0,09(0,29)	
	po	0,03(0,17)	
	habit	0,09(0,31)	

	po +habit	0,04(0,19)	
	Residual	0,99(0,99)	
	ICC		0,049

Habit for water collection at water scheme

N=1200, K=56	intercept	4,18[4,06;4,31](0,06)	<0,01
	po	0,08[-0,07;0,24](0,08)	0,31
	habit	0,15[0,01;0,31](0,08)	0,05
	po +habit	0,09[-0,06;0,24](0,08)	0,24
	Random effects	Variance(*SD*)	
	intercept	0,02(0,14)	
	po	0,02(0,14)	
	habit	0,02(0,14)	
	po +habit	0,02(0,15)	
	Residual	0,63(0,79)	
	ICC		0,007

Habit for water collection at handpump

N=1201, K=56	intercept	4,21[4,06;4,36](0,07)	<0,01
	po	0,09[-0,09;0,29](0,09)	0,345
	habit	0,09[-0,09;0,26](0,09)	0,332
	po +habit	-0,001[-0,17;0,17](0,09)	0,982
	Random effects	Variance(*SD*)	
	intercept	0,04(0,2)	
	po	0,05(0,23)	
	habit	0,04(0,2)	
	po +habit	0,05(0,22)	
	Residual	0,62(0,78)	
	ICC		0,02

Note. Abbreviations: po = psychological ownership, ICC = Intraclass correlation coefficient, N = number of participants in analysis, K = number of clusters in analysis, B = Parameter estimates, SE = Standard error, alpha = Cronbach's alpha, LL / UL= lower / upper limit of the confidence interval. All *p*-values are two-tailed.

Multilevel models

The results of the intervention arms on several outcomes are displayed in table 7.

Table 7

Fixed and random effects of multi-level models for pre-registered outcomes

	Fixed effects	B[LL;UL](*SE*)	*p*
Attitudes			
Acceptance			
N=1203, *K*=56	intercept	3,63[3,36;3,91](0,14)	<0,01
	po	0,21[-0,2;0,6](0,2)	0,32
	habit	0,09[-0,23;0,41](0,16)	0,58
	po +habit	0,26[-0,06;0,57](0,16)	0,13
	Random effects	Variance(*SD*)	
	intercept	0,14(0,37)	
	po	0,5(0,71)	
	habit	0,14(0,37)	
	po +habit	0,13(0,36)	
	Residual	2,24(1,5)	
	ICC	0,028	
Preference			
N=1202, *K*=56	intercept	3,72[3,47;3,97](0,13)	<0,01
	po	0,08[-0,29;0,44](0,18)	0,66
	habit	0,13[-0,2;0,46](0,17)	0,44
	po +habit	0,34[-0,01;0,7](0,18)	0,07
	Random effects	Variance(*SD*)	
	intercept	0,11(0,34)	
	po	0,03(0,16)	
	habit	0,28(0,52)	
	po +habit	0,41(0,64)	
	Residual	2,02(1,42)	
	ICC	0,057	
Benefit			
N=1203, *K*=56	intercept	2,77[2,42;3,11](0,18)	<0,01
	po	0,26[-0,2;0,69](0,23)	0,26
	habit	0,16[-0,26;0,58](0,21)	0,46
	po +habit	0,43[-0,07;0,91](0,25)	0,1
	Random effects	Variance(*SD*)	
	intercept	0,27(0,52)	
	po	0,74(0,86)	
	habit	0,48(0,69)	
	po +habit	1,19(1,1)	
	Residual	2,69(1,64)	
	ICC	0,073	
Importance (inverse)			
N=1200, *K*=54	intercept	3,04[2,75;3,34](0,15)	<0,01
	po	0,16[-0,26;0,58](0,21)	0,46
	habit	0,07[-0,3;0,45](0,19)	0,7

	po +habit	-0,18[-0,57;0,2](0,2)	0,36
	Random effects	Variance(*SD*)	
	intercept	0,16(0,39)	
	po	0,62(0,78)	
	habit	0,33(0,58)	
	po +habit	0,4(0,64)	
	Residual	2,74(1,66)	
	ICC		0,048
Importance			
N=1204, *K*=56	intercept	2,86[2,68;3,03](0,09)	<0,01
	po	0,07[-0,19;0,33](0,13)	0,59
	habit	0,08[-0,12;0,29](0,1)	0,44
	po +habit	0,15[-0,1;0,4](0,13)	0,26
	Random effects	Variance(*SD*)	
	intercept	0,05(0,23)	
	po	0,25(0,5)	
	habit	0,06(0,23)	
	po +habit	0,2(0,45)	
	Residual	0,95(0,97)	
	ICC		0,05
Social standing			
N=1198, *K*=56	intercept	2,19[2,04;2,33](0,07)	<0,01
	po	0,03[-0,22;0,27](0,13)	0,78
	habit	0,22[0,04;0,41](0,09)	0,03
	po +habit	0,14[-0,06;0,33](0,1)	0,18
	Random effects	Variance(*SD*)	
	intercept	0,03(0,16)	
	po	0,18(0,43)	
	habit	0,06(0,24)	
	po +habit	0,07(0,26)	
	Residual	0,92(0,96)	
	ICC		0,039
Perceived behavioural control			
N=1198, *K*=54	intercept	2,63[2,48;2,78](0,08)	<0,01
	po	0,18[-0,02;0,38](0,1)	0,08
	habit	0,17[-0,03;0,37](0,1)	0,1
	po +habit	-0,04[-0,23;0,16](0,1)	0,71
	Random effects	Variance(*SD*)	
	intercept	0,05(0,23)	
	po	0,01(0,05)	
	habit	0,05(0,22)	
	po +habit	0,02(0,14)	
	Residual	0,45(0,67)	
	ICC		0,042

Convenience to use

N=1201, K=56

	intercept	3,47[3,21;3,73](0,13)	<0,01
	po	0[-0,3;0,32](0,16)	0,993
	habit	0,16[-0,13;0,46](0,15)	0,29
	po +habit	-0,11[-0,44;0,2](0,16)	0,5
	Random effects	Variance(*SD*)	
	intercept	0,18(0,43)	
	po	0,18(0,42)	
	habit	0,22(0,47)	
	po +habit	0,08(0,28)	
	Residual	0,89(0,94)	
	ICC		0,095

Organizational Citizenship Behaviour

Having general rights

N=1203, K=56

	intercept	3,52[3,35;3,71](0,09)	<0,01
	po	-0,13[-0,45;0,17](0,16)	0,43
	habit	0,3[0,05;0,55](0,13)	0,03
	po +habit	0,34[0,1;0,58](0,12)	0,01
	Random effects	Variance(*SD*)	
	intercept	0(0,09)	
	po	0,09(0,31)	
	habit	0,01(0,09)	
	po +habit	0,01(0,09)	
	Residual	2,15(1,47)	
	ICC		0,024

Engage others

N=1202, K=56

	intercept	3,78[3,59;4](0,1)	<0,01
	po	-0,13[-0,48;0,2](0,17)	0,47
	habit	0,17[-0,08;0,43](0,13)	0,19
	po +habit	0,32[0,08;0,57](0,12)	0,01
	Random effects	Variance(*SD*)	
	intercept	0,04(0,2)	
	po	0,18(0,42)	
	habit	0,07(0,27)	
	po +habit	0,04(0,2)	
	Residual	1,87(1,37)	
	ICC		0,035

Responsibility

N=1199, K=56

	intercept	3,44[3,29;3,6](0,08)	<0,01
	po	0,08[-0,2;0,35](0,14)	0,55
	habit	0,04[-0,19;0,27](0,12)	0,72
	po +habit	0,31[0,11;0,5](0,1)	<0,01

	Random effects	Variance(*SD*)	
	intercept	0,02(0,14)	
	po	0,22(0,47)	
	habit	0,07(0,26)	
	po +habit	0,02(0,14)	
	Residual	1,26(0,12)	
	ICC		0,034

Protection
N=1202, K=56

intercept	3,96[3,73;4,2](0,12)	<0,01
po	0,06[-0,3;0,4](0,18)	0,72
habit	0,23[-0,06;0,51](0,15)	0,13
po +habit	0,31[0,03;0,59](0,14)	0,04

Random effects	Variance(*SD*)	
intercept	0,1(0,32)	
po	0,47(0,69)	
habit	0,09(0,3)	
po +habit	0,2(0,45)	
Residual	1,66(1,3)	
ICC		0,042

Caretaking
N=1202, K=56

intercept	3,82[3,67;3,97](0,08)	<0,01
po	0,02[-0,27;0,28](0,14)	0,92
habit	0,07[-0,18;0,31](0,12)	0,6
po +habit	0,33[0,09;0,56](0,12)	<0,01

Random effects	Variance(*SD*)	
intercept	0(0)	
po	0,1(0,31)	
habit	0,04(0,2)	
po +habit	0,04(0,2)	
Residual	1,72(1,31)	
ICC		0,03

Commitment

Commitment to use
N=1203, K=56

intercept	2,31[2,07;2,54](0,12)	<0,01
po	-0,07[-0,33;0,19](0,13)	0,627
habit	0,01[-0,24;0,27](0,13)	0,916
po +habit	0,18[-0,11;0,48](0,15)	0,236

Random effects	Variance(*SD*)	
intercept	0(0)	
po	0,12(0,35)	
habit	0,12(0,35)	
po +habit	0,26(0,52)	
Residual	1,14(1,06)	
ICC		1,14

Self-efficacy

N=1203, K=56

	intercept	3,52[3,27;3,76](0,12)	<0,01
	po	0,16[-0,19;0,5](0,17)	0,37
	habit	0,25[-0,04;0,55](0,15)	0,11
	po +habit	0,36[0,06;0,65](0,15)	0,03
	Random effects	Variance(*SD*)	
	intercept	0,08(0,29)	
	po	0,23(0,48)	
	habit	0,08(0,29)	
	po +habit	0,08(0,29)	
	Residual	2,39(1,55)	
	ICC		0,011

Functionality

Water quality (e.coli)

N=1440, K=54
This is a dummy-doded item with
0 = safe water
1 = e.coli contaminated water
B is OR (Odds Ratio) in this case

	intercept	1,94[1,54;2,46]	<0,01
	po	0,72[0,5;1,03]	0,07
	habit	0,97[0,58;1,6]	0,88
	po +habit	0,92[0,67;1,27]	0,62
	Random effects	Variance(*SD*)	
	intercept	0,000006018(0,07758)	
	po	109,8(331,4)	
	habit	519(720,4)	
	po +habit	12,22(110,6)	
	Residual	()	
	ICC		0

Water quality (arsenic)

N=1400, K=54
This is a dummy-doded item with
0 = safe water
1 = arsenic contaminated water
B is OR (Odds Ratio) in this case

	intercept	0,9[0,42;1,99]	0,8
	po	1,14[0,42;3,1]	0,79
	habit	0,73[0,23;2,36]	0,61
	po +habit	0,82[0,27;2,54]	0,73
	Random effects	Variance(*SD*)	
	intercept	1,83(1,35)	
	po	0,57(0,76)	
	habit	0,77(0,88)	
	po +habit	0,73(0,85)	
	Residual		
	ICC		0

189

Functionality (WHO)

N=1040, K=55

	intercept	6,97[6,32;7,63](0,33)	<0,01
	po	-0,32[-1,29;0,74](0,51)	0,54
	habit	-0,03[-1,12;1,04](0,55)	0,94
	po +habit	-0,81[-1,66;0,03](0,43)	0,07
	Random effects	Variance(*SD*)	
	intercept	0,9(0,95)	
	po	2,43(1,56)	
	habit	1,35(1,16)	
	po +habit	0,07(0,27)	
	Residual	7,77(2,79)	
	ICC	0,138	

Confidence in functionality

N=1440, K=54

	intercept	3,33[3,04;3,62](0,15)	<0,01
	po	-0,1[-0,55;0,33](0,22)	0,67
	habit	-0,11[-0,55;0,32](0,22)	0,61
	po +habit	0,43[0,074;0,8](0,19)	0,03
	Random effects	Variance(*SD*)	
	intercept	0,16(0,4)	
	po	0,04(0,21)	
	habit	0,14(0,38)	
	po +habit	0,33(0,57)	
	Residual	2,5(1,58)	
	ICC	0,08	

Use

Amount of safe water

N=1167, K=56

	intercept	24,67[13,88;35,47](5,5)	<0,01
	po	-3,43[-19,73;11,9](7,97)	0,67
	habit	-0,79[-14,94;13,37](7,22)	0,91
	po +habit	13,97[-0,55;28,08](7,24)	0,06
	Random effects	Variance(*SD*)	
	intercept	344,7(18,57)	
	po	326,1(18,06)	
	habit	634,3(25,19)	
	po +habit	1073,6(32,77)	
	Residual	928,3(30,47)	
	ICC	0,273	

Use (observed)			
N=1401, K=54	intercept	7,39[7,39;7,39]	<0,01
This is a dummy-doded item with			
0 = water scheme			
1 = all other sources			
B is OR (Odds Ratio) in this			
case	po	1,95[1,95;1,95]	<0,01
	habit	1,28[1,28;1,28]	<0,01
	po +habit	0,41[0,41;0,41]	<0,01
	Random effects	Variance(SD)	
	intercept	2,15(1,46)	
	po	2,49(1,57)	
	habit	0,93(0,96)	
	po +habit	0,66(0,81)	
	Residual	()	
	ICC		0
Use (self-report)			
N=1200, K=56	intercept	3,49[3,3;3,68](0,01)	<0,01
	po	-0,001[-0,37;0,34](0,18)	0,98
	habit	0,18[-0,1;0,45](0,14)	0,21
	po +habit	0,36[0,1;0,62](0,13)	<0,01
	Random effects	Variance(SD)	
	intercept	0(0)	
	po	0,18(0,42)	
	habit	0,02(0,15)	
	po +habit	0(0,05)	
	Residual	2,62(1,61)	
	ICC		0,018

Note. Abbreviations: po = psychological ownership, ICC = Intraclass correlation coefficient, N = number of participants in analysis, K = number of clusters in analysis, B = Parameter estimates, SE = Standard error, alpha = Cronbach's alpha, LL / UL= lower / upper limit of the confidence interval. All *p*-values are two-tailed.

3. Discussion

In the following, we discuss the main effects found in this cluster randomized controlled trial and extend the discussion to the strengths and limitations, openings for further research and implications for practice.

Testing in a 2x2 factorial cluster-randomized controlled trial community (psychological ownership) and individual (habit) behaviour change interventions, we found that psychological ownership intervention and habit intervention do not engage acceptance (i.e. positive attitudes and stronger commitment), self-reported and calculated use, nor observed functionality of safe water infrastructure in the long term when applied separately. Single intervention arms even show to have aversive effects: significantly decreased odds for using the safe water source. However, combining multi-level interventions by using social and individual approaches, significantly improved organizational citizenship behaviour, self-efficacy, observed use and self-reported functionality of the shared resource. Therefore, hypotheses H1a, b, c and d as well as hypothesis H2a can be rejected. Hypotheses H3a, b, c and d can be partially confirmed.

Psychological ownership interventions solely showed mixed effects, compared to the control group: none of the hypothesized outcomes was fostered and the likelihood of observed use of the new community-based safe water infrastructure even decreased. This negative impact on behaviour contradicts the existing literature (Marks & Davis, 2012; Contzen & Marks, 2018, Tomberge et al. 2021) and may have several reasons: First, we find psychological ownership to be high at follow-up in the control group, which refers to a ceiling effect. Second, we find that villagers – even in the control group – shifted their use significantly to the new water source. This can be attributed to the effect of water quality testing and installation of new infrastructure (as bonafide treatment, BCT 12.1 Restructuring physical environment). Thus, fostering solely psychological ownership (with mainly acting as BCT 12.2 Restructuring social environment) is not sufficient to positively influence behaviour. A third reason could be that interventions did not affect psychological ownership at all and that the ongoing psychological ownership interventions subsequently created a push-back effect among villagers (because they did not benefit from the activities). This explanation would be in line

192

with findings from other domains, where motivations for well stewardship behaviours included reassurance, the perception of problems and knowledge of the environment. Knowing how to perform stewardship behaviours was an important prerequisite for acting. In that domain, barriers to maintaining stewardship included complacency, inconvenience, ignorance, cost and privacy concerns (Kreutzwiser et al., 2011). Therefore, to promote psychological ownership, the effectiveness of interventions needs to be revised and improved through local initiatives, better educational materials and enforcement by targeting the routes and motives of psychological ownership.

Habit interventions solely, similar to psychological ownership interventions solely, had a negative impact on observed behaviour. However, other aspects of behaviour did not show this negative impact and SRHI significantly increased in habit intervention group. Thus, the observed negative impact of habit interventions on behaviour is most likely due to circumstances such as inoperable water infrastructure (unfinished or frequently broken) so that the behaviour cannot be performed. The other possible explanation is the so-called intention-behaviour gap (Sheeran & Webb, 2016): a behaviour is not shown, because of a lack of situational cues and our method of assessment (asking for a glass of drinking water) is just a different situational cue, compared to an empty water storage bucket in the regular case. Habit interventions in this study targeted commitment strength (Inauen et al., 2013) in the framework of the theory of planned behaviour (Ajzen, 2011). However, the strength of commitment did not increase. Hence why the question arises as to what exactly was impacted by our intervention, if not only the responses to the questionnaire.

The fact that we do not find increased habit of collecting water at the shared infrastructure may have two reasons. On the one hand, our interventions did not target sufficiently habit and commitment. On the other hand, the feeling of ownership and its consequences determine behaviour via other pathways, so that the attachment involves automaticity. The second explanation is supported by findings from self-determination theory: Self-determination theory argues that by maximising the patient's experience of autonomy, competence and relatedness in health-cares settings, the regulation of health-related behaviours is more likely to be internalised and behaviour change will be better maintained (Williams et al., 1998).

In short, the single interventions did not have beneficial impacts on behavioural determinants, attitudes or commitment, which contradicts previous findings in the literature on the single constructs (e.g. Contzen & Marks, 2018; Inauen et al., 2013). We believe that these findings can be explained to some extent by the environment: for example, community interventions targeted psychological ownership by creating a water user committee which was not integrated into institutional approaches. On individual level, it can be potentially explained by the type of behaviour: increased self-efficacy and availability of the safe water lead to an automaticity, a shortcut when taking action (i.e. bypassing the intention-behaviour gap by performing behaviour automatically after exposure to contextual cues, Gardner et al., 2012). Because of the use and the reliance on the water source, a greater organizational citizenship behaviour results too (statistical tendencies hint at greater preference for the water scheme too).

Both types of interventions combined though can support each other in overcoming their limitations. Interventions targeting group dynamics (psychological ownership), in combination with interventions targeting individual behaviour (habit) fostered promotive consequences and led to an increase in behaviour as they were able to reinforce the sense of ownership of the shared resource. This is in line with previous findings: Preston and Gelman (2020) found psychological ownership to be a powerful predictor for preventive outcomes and stewardship/protection willingness. And O'Driscoll et al., (2006) linked psychological ownership for the environment with citizenship behaviour and commitment to protect, but not more frequent in role behaviour. Tomberge et al. (2021) found an association of individual psychological ownership for an open defecation space and the use of latrines.

A revised definition that states that organizational citizenship behaviour "supports the social and psychological environment in which task performance takes place" (Organ, 1997, p. 95) – but vice-versa, this means that organizational environment needs to support task performance as well. Nevertheless, we found that water quality was not affected by any of our interventions. This is consistent with other studies on psychological ownership in the water context (e.g. Ambuehl et al., 2021) and can be explained by the complex processes of water treatment by the villagers. A

technically sound infrastructure that is not under the control of the villagers is a requirement for the supply of safe drinking and cooking water via the piped scheme. However, it is the external support that provides technical assistance when reparations are needed. In secondary analyses, we found that willingness to repair was not associated with psychological ownership. Thus, water quality is more of an issue on the level of the stakeholders.

Our findings underline the importance of further research and extending the concept of psychological ownership for a shared resource not only to the users but also to the service providers. This idea corresponds with other results: Nakagawa (2019) identifies a divide between researching and decision-making on the one hand and living with and around these resources on the other hand. In a review, Curseu and Schruijer (2017) find that for environmental sustainability decisions, stakeholder diversity asks for a more trustworthy and cooperative relationship between stakeholders for environmental sustainability. We found that community and individual level interventions have to come together to causally create outcomes that are pre-conditions for sustainable integration by fostering use and organizational citizenship behaviour of individuals for shared resources in a community.

Limitations and strengths

Our study has several limitations, but the most important one is low intervention fidelity. This means that our theory-based interventions were only implemented in incomplete ways and thus effects are potentially weak. However, we took this into account and calculated a priori a sample size with regards to high dropout rates and low attrition. In dropouts, we found significantly increased arsenic contamination of water samples. If we assume that villagers dropped out because of this, we can explain it either with the concept that may explain this is deliberate ignorance so to speak, meaning people choose to ignore information as this might cause dissonance. The other explanation is that people moved away from the villages. In either case we find that the effects are very robust. Intervention fidelity could be increased by strengthening local support of implementers and number of

implementers (allowing for more time per household visit), by reducing complexity of interventions and by further tailoring interventions to the context (individual interventions were developed for switching to comparable water sources, but not to adapt behaviour to a completely newly installed water infrastructure).

Additional limitations are baseline differences of clusters. But as the differences are only causing the underestimation of potential intervention effects, we neglected the difference and assumed assignment of clusters to intervention arms to be acceptable. A third limitation is the high dropout rate, which is due to the natural fluctuation of the village population in Bihar. This is a reality which should be considered also in practical implementation projects and not only in research: It highlights that sustainability and long-term effects are not everybody's main interests.

And a last limitation to be mentioned here is the delay in intervention delivery. Due to the circumstances and to protect people's health, we interrupted our psychological ownership intervention delivery during the COVID-19 pandemic and thus infrastructure installation and psychological ownership interventions were not delivered in one shot as planned, but in many bites over a period of almost 2 years.

Our study demonstrates several strengths. It is the first study to test causality of psychological ownership interventions targeting different routes in the context of shared infrastructure, and to test causal impact of a combination of social and individual interventions. Furthermore, the interventions were developed theory-based and thus provide empirical evidence for the importance of the theory surrounding psychological ownership for shared resources. Additionally, we tested a range of outcomes that include self-reported measures, behavioural observations and objective outcomes (e.g. water quality measurement and infrastructural assessments). Large sample size and multilevel analysis, assessing intervention fidelity and cooperation with a government programme further enhance generalisability of the results in the field.

Further research

To improve the interventions, further research should aim to identify active components in social interventions and the mechanisms of interaction between social and individual interventions. By doing so, different combination of concepts should be considered. As well, identifying the active ingredients by analysing the intervention fidelity on its components could help to see how the interventions could be improved in their mode of delivery.

In the case of psychological ownership interventions concerning the route of investing the self, a financial contribution could not be involved in the intervention package of this study. However, as previous research has highlighted the importance of substantial investment (e.g. Marks et al. 2014), to include this should be a future priority. More importantly, the interventions should be extended to other antecedents of psychological ownership which are not routes: to the entire system and organizational structure, including all stakeholders contributing to the shared infrastructure. Harter et al. (2020) further emphasise the need to intervene in the general social structure, showing that community-based interventions are only successful if they are carried out with a high social identity. Lastly, psychological ownership should be researched in connection with other topics of shared resources like wastewater management or solid-waste management.

In line with agency theory, in the future the role of psychological ownership should to be researched when no type-I agency problem arises (no separation of ownership from control, (Panda & Leepsa, 2017)).

Implications for practice

Carefully applying the concept is crucial – picking only unique intervention components can lead to aversive effects: To solve the problem of shared resources and common pools, social components have to be included in interventions, but this is not sufficient. These components need to be embedded in an enabling social and technical environment, especially to guarantee proper functionality of infrastructure and self-efficacy of villagers. For the Jal Jeevan mission, we

recommend for example strengthening individual household visits in combination with an in-depth activation of water user's committee (WUSC), their support of the caretaker and their exchange with contracting companies. Further, we recommend accompanying the process of installation by significant participatory activities to foster psychological ownership for the new infrastructure.

Conclusion

Combining social and individual interventions to change behaviour and to promote stewardship is a promising approach to solving the tragedy of the commons. However, the most effective ways to combine the interventions still need to be defined – a participatory approach which needs to include the target population and the institutionalised stakeholders of the domain concerned.

4. Methods

We conducted a 2x2 factorial cluster-randomized controlled trial with baseline and follow up assessment in three intervention arms (psychological ownership only, habit only, psychological ownership + habit) and one control arm (no interventions) between October 2019 and March 2022. Random assignment of clusters to intervention and control arms happened by random number generation after conducting baseline survey.

Our study design presented here differs from the pre-registration on OSF (https://osf.io/8zukt) due to the Covid-19 pandemic.

Study area

This study was conducted in rural areas of the Bhagalpur district, Bihar, India. The Gangetic plane is one of the most prone areas to arsenic contamination of ground water (Kumar et al., 2021; Singh et al., 2014). In the recent past, there has been a lot of improvement of the condition of the roads, electricity in infrastructure and water supply. Most of the settlements are connected to the paved, blackened roads but due to the weather and construction quality, many roads have broken down. The electricity supply in the area can be described as good, as well as the electricity supply on the roads and the water supply. The government is responsible for all these basic infrastructures, but there are still shortcomings at many levels.

Under the Jal Jeevan mission, the central government of India and its public health engineering department (PHED) are working towards achieving Sustainable development goal (SDG) 6.1 and monitoring the safety of their water services (Charles et al., 2020). For this, they are planning to install safe piped water supply to every household until 2030 (Sharma et al., 2021).

Prior to this government program, most of the sources of cooking and drinking water in the study area were hand pumps installed in the bore. This infrastructure was private, shared or governmental. People stored water in buckets or boxes and used it for drinking and cooking purposes.

The main problem with water distribution was the unavailability of safe drinking water because the water in the habitations was never tested. For this reason, people used to drink water from their own hand pumps and used to cook with it.

What do PHED and Jal Jeevan mission do? Jal Jeevan mission is a scheme of the Department of Drinking Water and Sanitation / Ministry of Jal Shakti of the Central Government of India (Kumar & Singh, 2020; Sharma, 2021). The objective of the scheme is to provide safe water facilities in rural areas. As the population size increases, so does the water problem. There are many rural areas where water facilities are not available, and people have to walk long distances to fetch water. In many areas, groundwater is contaminated. In view of all these problems, the government has launched the Jal Jeevan mission to provide access to tap water. Under this mission, in the areas where there is no uncontaminated water, every household will be supplied with water through a pipeline. This mission is also called Har Ghar Nal Ka Jal Yojana by the government.

PHED has carried out various technical and regulatory works for the functionality of the infrastructure to ensure proper supply of running water by the contractor. Switch boards with GPS locators have been installed on all the infrastructures. The function of the switch boards with GPS locator is to show how long the infrastructure was in operation and at which location. PHED should technically receive this information independently. Simultaneously, arrangements have been made by PHED to keep a logbook in each infrastructure and record it regularly. In the event that the infrastructure remains closed for more than 24 hours, a fine at hourly rate for the contracted company is foreseen so that the infrastructure remains in regular operation and the people in the community get safe water without any hindrance. However, despite the technical and official efforts, success in operating this type of water plant regularly and providing people with safe water has not been achieved. Because most of the infrastructure does not function properly, many caretakers have not been properly trained, and the community has not been able to properly understand the importance of this safe water. There is a need for better monitoring system as well as greater awareness in the community to promote public health through this safe water.

Sample

Our sampling strategy was stepwise: First, we selected villages where PHED had installed new community-based safe water infrastructure after 2019. Second, we screened the quality of drinking and cooking water of households for arsenic contamination (with Merck field testing kits, Das et al., 2014) and assessed the condition of the infrastructure as a prior to microbial contamination of water (with WHO sanitary inspection forms, Kelly et al., 2020). We only included villages where at least 30 households were found to have either (i) arsenic contamination or (ii) poor infrastructure. Before conducting the interviews, we mapped the village with the help of a PRI representative to ensure that households meeting the above criteria from every part of the village were interviewed. Third, we conducted interviews only with the person who is mainly responsible for the water collection in a household.

Sample size

Sample size calculations was calculated in GPower (Faul et al., 2007) following the guidelines, based on a multi-level approach (Rutterford et al., 2015):

For effect size, we estimated Cohen's d = 0.35 (assumption based on Mathieu et al., 2012), included the design-effect due to nested study design (Eldridge et al., 2006) with N=(1+(m-1)*ICC) and assumed ICC to be very low (0.01 – 0.2) based on previous studies conducted in India (Patil et al., 2014; Pagel et al., 2011; Auplish et al., 2017). With an attrition of 25% and expected intervention uptake of 80%, minimum cluster size at baseline is 30 participants and minimum number of clusters is 64 habitations. The minimal number of clusters is defined according to Raudenbush et al. (2011). Figure 1 shows sample development at cluster and individual level.
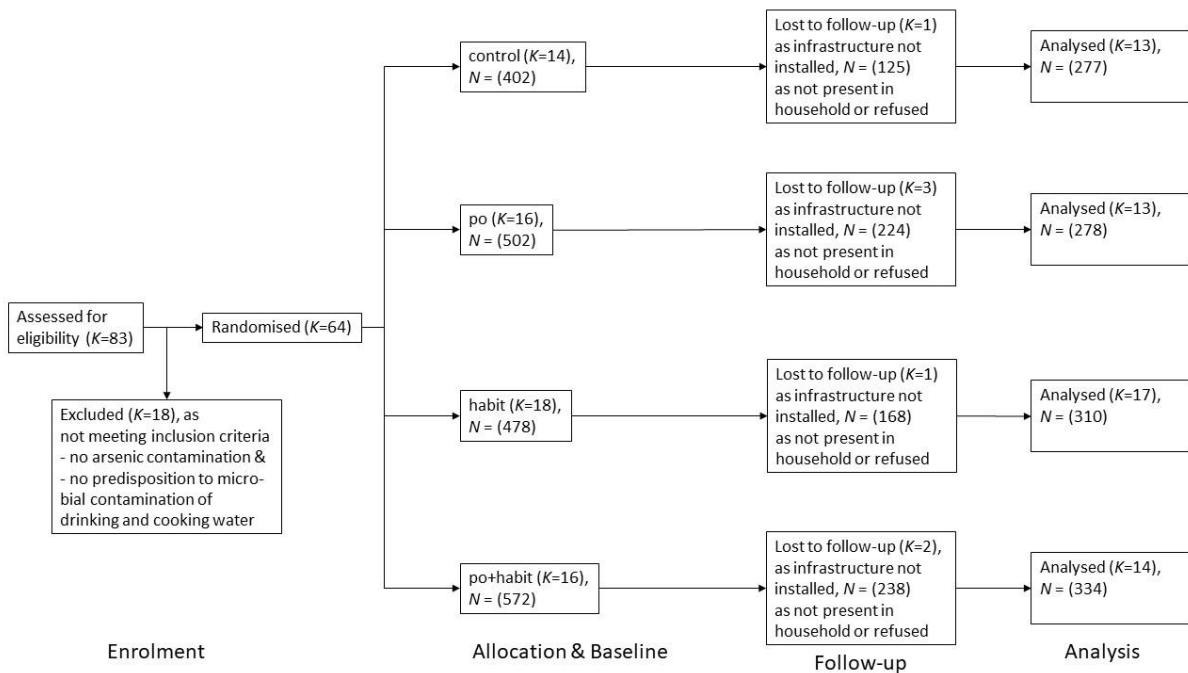
Figure 1. *CONSORT flow chart for participants and clusters (Campbell et al., 2012). Abbreviations: N = number of participants, K = number of clusters, po = psychological ownership.*

Measures

We conducted semi-structured interviews, using computer-assisted personal interviewing techniques (CAPI) with Visual Likert scales with 5 answer options (Harter et al., 2020). We piloted all measures used in a mixed-methods pilot study, where we also validated the psychological ownership questionnaires (Ambuehl et al., in review). Before baseline and follow up survey, we provided a seven-day training for interviewers to ensure the conceptual and literal understanding of the measurement scales used. Additionally, WHO sanitary inspections and water quality field testing kits were extensively applied in pilot studies.

Functionality

Functionality of the water scheme was assessed by testing the water quality with arsenic field-testing kits (Das et al., 2014), microbial field-testing kits (Tambi et al., 2016), WHO sanitary inspections of infrastructure condition (Kelly et al., 2020) and self-reported assessment of functionality in the four weeks that followed.

Psychological ownership

Individual psychological ownership for handpump and community-based water infrastructure was assessed by using a validated measurement scale (Ambuehl et al., in review, based on Van Dyne & Pierce, 2004) with internal consistency of Cronbach's alpha = 0,85[0,84;0,86] for water scheme at follow-up. Collective psychological ownership for handpump and community-based water infrastructure was assessed by using a validated measurement scale (Pierce & Jussila, 2010) with internal consistency of Cronbach's alpha = 0,82[0,8;0,83] for water scheme at follow-up.

Routes to psychological ownership

We assessed routes to psychological ownership by measuring three theory-based constructs: (i) Investing the self was assessed by 14 items (e.g. I invested money or donated land for the construction of the water system; I contributed my ideas to the water system). (ii) Having control was assessed by 17 items (e.g. I have control over the water system; I can take decisions over the water system on my own). (iii) Intimately knowing was assessed by 13 items (e.g. I am familiar with the purpose of this water system; I know where to complain when the water system is not working properly).

Habit

Self-reported habit index (SRHI) for collecting water at handpump and at community-based water infrastructure was assessed by using a validated measurement scale (Verplanken & Orbell, 2003) with internal consistency of Cronbach's alpha = 0,9[0,89;0,91] for water collection at water scheme at follow-up.

Behavioural determinants

Based on our hypotheses, we assessed several behavioural determinants and psychosocial factors as outcomes.

Positive attitudes. Positive attitudes were defined as a person's degree of favourableness or unfavourableness with respect to a psychological object (Ajzen & Fishbein, 2000). Thus, we measured acceptance of the water scheme, preference of the water scheme, benefit of the water scheme, importance of the water scheme, social status when using the water scheme, perceived behavioural control in the use of the water scheme, convenience in using the water scheme and organizational citizenship behaviour towards the water scheme (with the dimensions willingness to protect, feeling of responsibility, engage others in maintaining, caretaking and having rights).

Commitment. Commitment was measured by behavioural obligation and self-efficacy.

Behaviour

Use was measured by calculating the share of safe water collected in the previous four weeks (Inauen et al., 2013), observing where a glass of drinking water was collected and by self-reporting how often the water scheme can be used.

Demographics & Covariates

For demographical information, we assessed socio-economic status by using a validated measurement scale for India (Saleem & Jan, 2019). Further we assessed religion, age, and caste. As covariates, we assessed trust in the community using a validated measurement scale (Costa & Anderson, 2011) with internal consistency of Cronbach's alpha = 0,93[0,92;0,93] at baseline and social identity within the community using a validated measurement scale (Cameron, 2004) with internal consistency of Cronbach's alpha = 0,92[0,91;0,92] at baseline.

For a complete overview on operationalisation and items, please consult Table 2 in supplementary materials.

Intervention fidelity

For process evaluation of intervention delivery, we used reporting, observations and questionnaires according to the fidelity framework (Toomey et al. 2019).

To assess intervention delivery, we combined four elements of intervention fidelity: The reports were rated according to their i) adherence to protocol. Observations were used to assess ii) outreach and iii) time spent in a village. Semi-structured interviews provided information on iv) participants' responsiveness to the interventions. All four elements were then combined in a single score of intervention fidelity per intervention arm.

Interventions

General interventions

General interventions were health information campaigns (5.1 Information about health consequences), water quality measurement conducted by members of the local association Paridhi and construction work of new community-based safe water infrastructure, led by the PHED of the State of Bihar, India and its contractors. We developed interventions together with Paridhi staff as well as representatives of PHED and villages (PRI members) and aligned them with the general Jal Jeevan program. We monitored the implementation of the interventions by checking the activities according to their protocol and through observations (photos, videos).

Habit interventions

For habit, we replicated an intervention from Inauen and Mosler (2014), Inauen et al. (2013), and Inauen & Mosler (2016) using public-commitment (BCT 1.9 Commitment), action plans (BCT 1.4 Action planning) and reminders (BCT 7.1 Prompts/cues) as behaviour change techniques (BCTs; Michie et al., 2013) to enhance commitment strength. These interventions should foster habit because habit is the automatic link between intention and behaviour. In a model of the theory of planned

behaviour, the above-mentioned BCTs were shown to increase intention and strength of commitment, thus fostering behaviour (Ajzen & Fishbein, 2005).

For an overview of the interventions, please consult Table 8, phases 7-8.

Psychological ownership interventions

For psychological ownership, we newly developed theory-based intervention activities, targeting routes to psychological ownership (intimately knowing, having control, investing the self, BCT 12.1 restructuring the physical environment, BCT 12.2 restructuring the social environment, 5.2 salience of consequences). The interventions were aligned with the Jal Jeevan programme, so that, for example, financial contribution was not included in the intervention.

For an overview of the interventions, please consult Table 8, phases 1-6.

Delivery of interventions

The interventions differed for the four conditions and were delivered in phases: First, reporting of water quality from baseline assessment to households took place immediately after testing. Second, construction work was initiated and accompanied by psychological ownership intervention + health information campaigns or health information campaigns only. And third, after successful construction and once new infrastructure was functional, habit interventions + health information campaigns or health information campaigns only were applied.

For an overview of the intervention phases, please consult Table 8.

Table 8

Summary of interventions for all four intervention arms

Phase	Activity	Targeted factor	Communication channel	Description of activity	BCTs (Michie et al., 2015)	O	H	O + H	C
0	Baseline survey		Household visit	Baseline survey with water quality testing and feedback for households, introduction of community-based water supply as arsenic mitigation option.	5.1 Information about health consequences	X	X	X	X
1	Screening of video (the video can be provided upon request: benjamin.ambuehl@eawag.ch)	Intimate Knowledge (Psychological Ownership)	Mass media	The screening of a documentary about the community-based piped water supply scheme which is going to be built over the next six months. The different structures are explained as well as the purpose of the scheme. The caretaker (I am here to supervise the system, running it and to do minor repairs on my own) introduces his role.		X		X	
	Information about construction		Community meeting	The population is informed about upcoming construction work.		X	X	X	X
	Health information	Vulnerability (RANAS), Knowledge (RANAS), Severity (RANAS)	Community meeting	Together with community-based health staff, people are informed about arsenic and microbiological contamination of drinking water, its health effects and mitigation options as	5.1 Information about health consequences	X	X	X	X

				well as chlorination as preventive action.					

		CONSTRUCTION WORK BEGINS (ADD INFRASTRUCTURE IN ALL INTERVENTION ARMS)							
2	Form water users committee (WUSC) 5 members - at least 1 woman - at least 1 representative from all social groups (e.g. castes)	Having Control (Psychological Ownership), Self-Investment (Psychological Ownership)	Community meeting	An unofficial panchayat-body is formed at the ward level with equal representation of gender, caste and religion. The positions are allocated by votes of the population. The purpose of a WUSC is to have a self-organized user group to monitor and supervise the construction work of the contracting company, to support the caretaker in coordinating the work needed to maintain and repair infrastructure, to address the needs and express the wishes of the users towards different stakeholders (especially the local government bodies and PHED). WUSC can monitor the water supply (including water quality monitoring) in the village, setting monetary / labour contribution in case of bigger failures to a vote of all the people in the village, tailor the rules of use and running of the scheme according to needs and conditions locally and sanction violence against the rules. If possible, the caretaker position can be advertised through the WUSC.	12.2 restructuring the social environment	X		X	

3	We-plan (Thürmer et al., 2017)	Action planning Having Control (Psychological Ownership), Intimate Knowledge (Psychological Ownership)	Community meeting with focus groups	This step is in line with WHO guidelines for developing water safety planning (WSP) for water supply schemes. A collective IF-THEN-action plan is developed under the lead of the WUSC so that users know exactly what they will do as a community in the process of construction, operation and maintenance of the community-based piped water supply. In focus-group discussions the contract specifications (*Pflichtenheft* with tasks and responsibilities) are discussed and agreed on. We are claiming to achieve a common goal.	1.1 goal setting (behaviour) 1.9 commitment	X		X	
	Voting under supervision of WUSC	Having Control (Psychological Ownership)	Community meeting	Several aspects of the construction of the community-based piped water supply scheme are voted on by the population (e.g. labour or cash contribution, location to install the tap-stands at the house, …). The caretaker is elected.		X		X	
	Information on ongoing construction work		Community meeting	In a community visit, population is orally informed about the progress of ongoing construction work.			X		X
4	Labour contribution with tap stands,	Self-Investment (Psychological Ownership),	Community activity	According to WHO guidelines, every tap stand must have a concrete foundation with a	12.1 restructuring the physical environment	X		X	

	Activity	Psychological ownership	Method	Description	Infrastructure / SDG				
	Monetary contributions for material	Having control (Psychological Ownership), Intimate Knowledge (Psychological Ownership)		proper drainage channel and a concrete standpost. This can for example (if the laying of the pipeline is preferred, this also can be done) be built by the community. The tap can also be installed on private ground if it is the wish of the homeowner. Flowmeters are installed by the community to monitor water use on habitation level. 1. Assessment: What is needed to achieve the recommendations of the guidelines? 2. Who is working on missing pieces? 3. IF-THEN planning 4. Implementation	12.5 adding objects to the environment				
	Provide tap stands						X		X
	Question & Answer Session	Having Control (Psychological Ownership), Intimate Knowledge (Psychological Ownership)	Community meeting	In Q&A sessions, people can ask anything and get responses from different stakeholders (WUSC, Junior Engineer PHED, Paridhi, Health Representatives, …).		X		X	
	Information on ongoing construction work		Community meeting	In a community visit, population is orally informed about the progress of ongoing construction work.			X		X
	Installation of flowmeters				Provide infrastructure	X	X	X	X

5	Design Workshop on standposts and filtration unit Monetary contributions for material	Self-Investment (Psychological Ownership), Intimate Knowledge (Psychological Ownership)	Community activity	In a design workshop, Manduscha pictures are painted on the central filtration unit and overhead tanks, standposts are painted to personalise the whole infrastructure to the community. The material for the paintings is paid by contribution of villagers. Content: safe water messages	5.2 salience of consequences	X		X	
	Question & Answer Session	Having Control (Psychological Ownership), Intimate Knowledge (Psychological Ownership)	Community meeting	In Q&A sessions, people can ask anything and get responses from different stakeholders (WUSC, Junior Engineer PHED, Paridhi, Health Representatives, …).		X		X	
	Information on ongoing construction work		Community meeting	In a community visit, population is orally informed about the progress of ongoing construction work.			X		X
	Voting under supervision of WUSC			Voting on running times and other running-related issues of the water scheme and O&M plan.		X		X	
CONSTRUCTION WORK COMPLETED, NOW A TRIAL RUNNING BY PHED BEGINS									
6	Guided tour through village for the water scheme	Intimate Knowledge (Psychological Ownership), Having Control (Psychological Ownership)	Community meeting with focus groups	The caretaker gives guided tours through the whole village several times during a day to show people all the infrastructure, explain the functionality of the water scheme as well as explanations how to use it.	4.1 instruction on how to perform the behaviour 6.1 demonstration of the behaviour	X		X	

#	Activity	Behavioral factor	Setting	Description	Technique				
	Focus group discussion	Having Control, Intimately Knowing		In focus group discussions the contract specifications (*Pflichtenheft*) of the caretaker, the WUSC and the users is discussed and voted on, as well what to do in case of a broken scheme, etc.		X		X	
	Other cultural activities	Risk perception & knowledge promoting Self-efficacy & injunctive norm		Street plays are performed, cartoons can be seen and songs are sung, drama workshops are organized.					
	Question & Answer Session	Having Control (Psychological Ownership), Intimate Knowledge (Psychological Ownership)	Community meeting	In Q&A sessions, people can ask anything and get responses from different stakeholders (WUSC, Junior Engineer PHED, Paridhi, Health Representatives, …).		X		X	
	Information on ongoing construction work		Community meeting	In a community visit, population is orally informed about the progress of ongoing construction work.			X		X
7	Distribution of prompts & cues	Habit, remembering (RANAS)	Household based	In a household prompts & cues are distributed, explained, and put in place on standposts, the handpumps and on the wall of the storage place of water-collection containers.	7.1 prompts/cues		X	X	
	Implementation intention	Action planning (RANAS), Habit	Personal visit	As well, for every household the person responsible for water collection is asked to fill the action planning form and to sign	1.4 action planning		X	X	

				it and it is then again put in place on the wall of the storage place of water-collection containers.					
	Information on health		Community meeting	In a community visit, population is orally informed about arsenic, microbiology & health consequences again.		X	X	X	X
8	Replacement of prompts & cues		Household based	In a household prompts & cues are replaced where missing, again explained, and put in place on standposts, the handpumps and on the wall of the storage place of water-collection containers when missing.	7.1 prompts/cues		X	X	
	Information on completed construction work		Community meeting	In a community visit, population is orally informed about the completion of ongoing construction work.		X	X	X	X
						O	H	O + H	C

Note. Abbreviations: O = psychological ownership, H = habit, O+H = psychological ownership + habit, C = control, WUSC = water users committee.

Analyses

Multi-level structure of data

Overall, we conducted data analysis using multi-level models to separate effects of nested data (Figure 2).
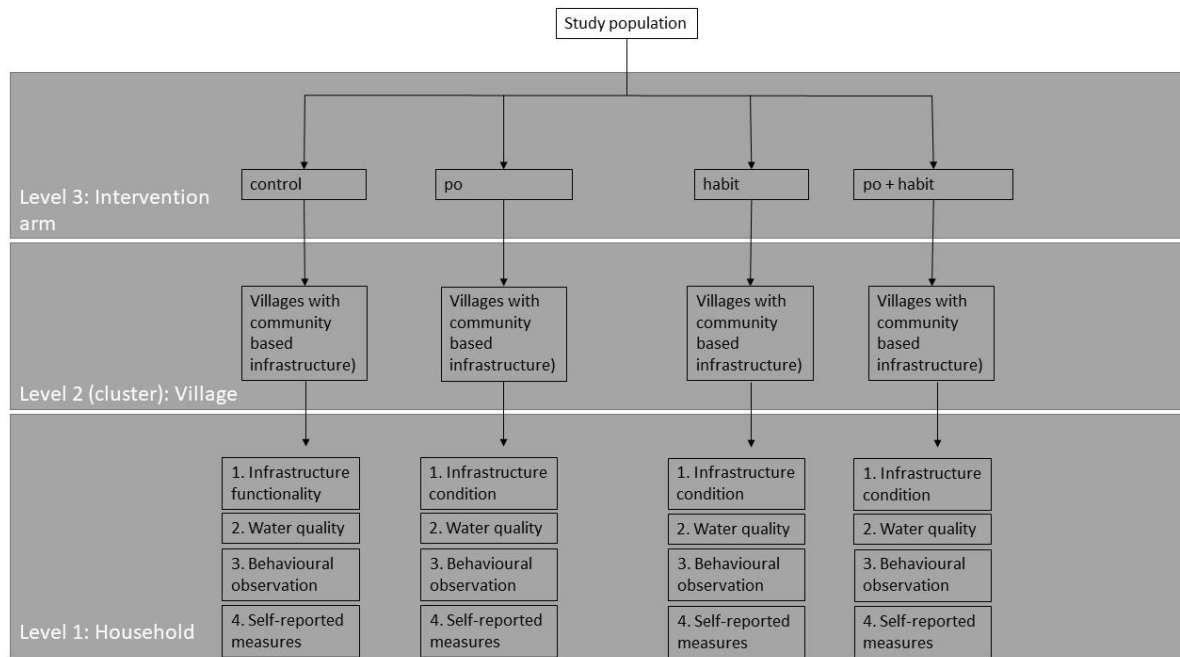
Figure 2. *Display of multi-level structure of data*

Measurement models

We used measurement models accounting for random intercepts (variance between clusters) and random slopes (variance within a cluster):

OUTCOME = 1 + level3 + (1 + level3 |level2)

Distribution of variance between Level 1 and Level 2, as well as ICC (Dreibelbis et al., 2013) were calculated using Null-models where only cluster-variable could explain variance:

OUTCOME = 1 + (1 |level2)

As effect size measures for dichotomous outcomes, we calculated odds ratios (ORs) with asymptotic Wald 95% confidence intervals (CIs). They are interpreted as the percentage increase

(values >1) or decrease (values <1) in the outcome for a unit increase in the predictor (Atkins et al., 2013).

All analyses were conducted in R using the package lme4.

Preliminary analysis

After assessing randomization check and checking for reasons of missing data by comparing intervention arms following Bell et al. (2014), we concluded that data is missing at random and conducted multi-level analysis using complete cases (Armijo-Olivo et al., 2009; Fielding et al., 2012).

For adherence to protocol (intervention fidelity) two evaluators rated all villages and the interrater reliability was calculated for every rating system separately. Interrater reliability overall was high for all control and intervention arms:

Additionally, we performed manipulation check by testing the effect of intervention arm on the target construct and related, but non-targeted constructs.

Analysis of main intervention effects

We excluded villages from analysis where no infrastructure was installed. This means however, that some questions could not be answered by those respondents and appeared as slightly differing sample sizes for different tests.

To answer research question 1-3, we conducted multiple multi-level models with fixed and random effects on several dependent variables in R using the packing lmer (De Boeck et al., 2011). For dichotomous outcomes, we calculated a logit-link function.

To answer research question 4, we conducted multi-level models with fixed and random intercept on the dependent variable individual psychological ownership for the community-based safe water infrastructure in R using the packing lmer.

To answer research question 5, we conducted a multi-level model with fixed effects and random intercept on the dependent variable self-reported habit index for water collection at the community-based safe water infrastructure in R using the packing lmer.

Ethics approval

Ethics approval was received from the ethics committee of the Faculty of Human Sciences, University of Bern, Switzerland, as well as the ethics committee of Mahavir Cancer Sansthan, Bihar, India.

5. References

Aga, D. A., Noorderhaven, N., & Vallejo, B. (2018). Project beneficiary participation and behavioural intentions promoting project sustainability: The mediating role of psychological ownership. *Development Policy Review, 36*(5), 527-546.

Ajzen, I. (2011). The theory of planned behaviour: Reactions and reflections. *Psychology & health, 26*(9), 1113-1127.

Ajzen, I., & Fishbein, M. (2000). Attitudes and the attitude-behavior relation: Reasoned and automatic processes. *European review of social psychology, 11*(1), 1-33.

Ambuehl, B., Tomberge, V. M. J., Kunwar, B. M., Schertenleib, A., Marks, S. J., & Inauen, J. (2021). The role of psychological ownership in safe water management: A mixed-methods study in Nepal. *Water, 13*(5), 589.

Armijo-Olivo, S., Warren, S., & Magee, D. (2009). Intention to treat analysis, compliance, drop-outs and how to deal with missing data in clinical research: a review. *Physical therapy reviews, 14*(1), 36-49.

Atkins, D. C., Baldwin, S. A., Zheng, C., Gallop, R. J., & Neighbors, C. (2013). A tutorial on count regression and zero-altered count models for longitudinal substance use data. *Psychology of Addictive Behaviors, 27*(1), 166.

Auplish, A., Clarke, A. S., Van Zanten, T., Abel, K., Tham, C., Bhutia, T. N., ... & Firestone, S. M. (2017). Estimating the intra-cluster correlation coefficient for evaluating an educational intervention program to improve rabies awareness and dog bite prevention among children in Sikkim, India: A pilot study. *Acta tropica, 169*, 62-68.

Bain, R., Cronk, R., Hossain, R., Bonjour, S., Onda, K., Wright, J., ... & Bartram, J. (2014). Global assessment of exposure to faecal contamination through drinking water based on a systematic review. *Tropical Medicine & International Health, 19*(8), 917-927.

Bain, R., Johnston, R., & Slaymaker, T. (2020). Drinking water quality and the SDGs. npj Clean *Water, 3*(1), 1-3.

Bandura, A. (2006). Guide for constructing self-efficacy scales. *Self-efficacy beliefs of adolescents, 5*(1), 307-337.

Bartram, J., Lewis, K., Lenton, R., & Wright, A. (2005). Focusing on improved water and sanitation for health. *The Lancet, 365*(9461), 810-812.

Bell, M. L., Fiero, M., Horton, N. J., & Hsu, C. H. (2014). Handling missing data in RCTs; a review of the top medical journals. *BMC medical research methodology, 14*(1), 1-8.

Briscoe, C., & Aboud, F. (2012). Behaviour change communication targeting four health behaviours in developing countries: a review of change techniques. *Social science & medicine, 75*(4), 612-621.

Brown, G., & Zhu, H. (2016). 'My workspace, not yours': The impact of psychological ownership and territoriality in organizations. *Journal of environmental psychology, 48*, 54-64.

Brozyna, C., Guilfoos, T., & Atlas, S. (2018). Slow and deliberate cooperation in the commons. *Nature Sustainability, 1*(4), 184-189.

Cameron, J. E. (2004). A three-factor model of social identity. *Self and identity, 3*(3), 239-262.

Campbell, M. K., Piaggio, G., Elbourne, D. R., & Altman, D. G. (2012). Consort 2010 statement: extension to cluster randomised trials. *Bmj, 345*.

Carden, L., & Wood, W. (2018). Habit formation and change. *Current opinion in behavioral sciences, 20*, 117-122.

Carey, R. N., Connell, L. E., Johnston, M., Rothman, A. J., De Bruin, M., Kelly, M. P., & Michie, S. (2019). Behavior change techniques and their mechanisms of action: a synthesis of links described in published intervention literature. *Annals of Behavioral Medicine, 53*(8), 693-707.

Castilla-Rho, J. C., Rojas, R., Andersen, M. S., Holley, C., & Mariethoz, G. (2017). Social tipping points in global groundwater management. *Nature Human Behaviour, 1*(9), 640-649.

Charles, K. J., Nowicki, S., & Bartram, J. K. (2020). A framework for monitoring the safety of water services: from measurements to security. *NPJ Clean Water, 3*(1), 1-6.

Cislaghi, B., & Heise, L. (2019). Using social norms theory for health promotion in low-income countries. *Health promotion international, 34*(3), 616-623.

Contzen, N., & Marks, S. J. (2018). Increasing the regular use of safe water kiosk through collective psychological ownership: A mediation analysis. *Journal of Environmental Psychology, 57*, 45-52.

Costa, A. C., & Anderson, N. (2011). Measuring trust in teams: Development and validation of a multifaceted measure of formative and reflective indicators of team trust. *European Journal of Work and Organizational Psychology, 20*(1), 119-154.

Cronin, A. A., Prakash, A., Sridhar, P., & Coates, S. (2016). *Drinking water supply in India: context and prospects.* In Indian water policy at the crossroads: Resources, technology and reforms (pp. 49-71). Springer, Cham.

Curșeu, P. L., & Schruijer, S. G. (2017). Stakeholder diversity and the comprehensiveness of sustainability decisions: the role of collaboration and conflict. *Current Opinion in Environmental Sustainability, 28*, 114-120.

Das, J., Sarkar, P., Panda, J., & Pal, P. (2014). Low-cost field test kits for arsenic detection in water. *Journal of Environmental Science and Health, Part A, 49*(1), 108-115.

De Boeck, P., Bakker, M., Zwitser, R., Nivard, M., Hofman, A., Tuerlinckx, F., & Partchev, I. (2011). The estimation of item response models with the lmer function from the lme4 package in R. *Journal of Statistical Software, 39*, 1-28.

Dreibelbis, R., Greene, L. E., Freeman, M. C., Saboori, S., Chase, R. P., & Rheingans, R. (2013). Water, sanitation, and primary school attendance: A multi-level assessment of determinants of

household-reported absence in Kenya. *International Journal of Educational Development, 33*(5), 457-465.

Diener, E., Pressman, S. D., Hunter, J., & Delgadillo-Chase, D. (2017). If, why, and when subjective well-being influences health, and future needed research. *Applied Psychology: Health and Well-Being, 9*(2), 133-167.

Diener, A., Schertenleib, A., Daniel, D., Kenea, M., Pratama, I., Bhatta, M., … Marks, S. J. (2017). *Adaptable drinking-water laboratory unit for decentralised testing in remote and alpine regions.* 40th WEDC International Conference, Loughborough, UK, 1–6.

Dobson, A. D., De Lange, E., Keane, A., Ibbett, H., & Milner-Gulland, E. J. (2019). Integrating models of human behaviour between the individual and population levels to inform conservation interventions. *Philosophical Transactions of the Royal Society B, 374*(1781), 20180053.

Eldridge, S. M., Ashby, D., & Kerry, S. (2006). Sample size for cluster randomized trials: effect of coefficient of variation of cluster size and analysis method. *International journal of epidemiology, 35*(5), 1292-1300.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior research methods, 39*(2), 175-191.

Fielding, S., Fayers, P., & Ramsay, C. R. (2012). Analysing randomised controlled trials with missing data: choice of approach affects conclusions. *Contemporary clinical trials, 33*(3), 461-469.

Gardner, B., Arden, M. A., Brown, D., Eves, F. F., Green, J., Hamilton, K., ... & Lally, P. (2021). Developing habit-based health behaviour change interventions: Twenty-one questions to guide future research. *Psychology & health*, 1-23.

Gardner, B., Lally, P., & Wardle, J. (2012). Making health habitual: the psychology of 'habit-formation'and general practice. British Journal of General Practice, 62(605), 664-666.

Gleick, P. H. (1998). The human right to water. *Water policy, 1*(5), 487-503.

Harter, M., Inauen, J., & Mosler, H. J. (2020). How does Community-Led Total Sanitation (CLTS) promote latrine construction, and can it be improved? A cluster-randomized controlled trial in Ghana. *Social science & medicine, 245*, 112705.

Hillenbrand, C., & Money, K. G. (2015). Unpacking the mechanism by which psychological ownership manifests at the level of the individual: A dynamic model of identity and self. *Journal of Marketing Theory and Practice, 23*(2), 148-165.

Horton, R., & Lo, S. (2015). Planetary health: a new science for exceptional action. *The Lancet, 386*(10007), 1921-1922.

Inauen, J., Hossain, M. M., Johnston, R. B., & Mosler, H. J. (2013). Acceptance and use of eight arsenic-safe drinking water options in Bangladesh. *PLoS One, 8*(1), e53640.

Inauen, J., & Mosler, H. J. (2016). Mechanisms of behavioural maintenance: Long-term effects of theory-based interventions to promote safe water consumption. *Psychology & health, 31*(2), 166-183.

Inauen, J., Tobias, R., & Mosler, H. J. (2014). The role of commitment strength in enhancing safe water consumption: Mediation analysis of a cluster-randomized trial. *British journal of health psychology, 19*(4), 701-719.

Jakobsen, J. C., Gluud, C., Wetterslev, J., & Winkel, P. (2017). When and how should multiple imputation be used for handling missing data in randomized clinical trials–a practical guide with flowcharts. *BMC medical research methodology, 17*(1), 1-10.

Jiménez, A., & Pérez-Foguet, A. (2010). Challenges for water governance in rural water supply: lessons learned from Tanzania. *International Journal of Water Resources Development, 26*(2), 235-248.

Kelly, E. R., Cronk, R., Kumpel, E., Howard, G., & Bartram, J. (2020). How we assess water safety: A critical review of sanitary inspection and water quality analysis. *Science of the Total Environment, 718*, 137237.

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of chiropractic medicine, 15*(2), 155-163.

Kumar, A., Ali, M., Kumar, R., Kumar, M., Sagar, P., Pandey, R. K., ... & Ghosh, A. K. (2021). Arsenic exposure in Indo Gangetic plains of Bihar causing increased cancer risk. *Scientific Reports, 11*(1), 1-16.

Kumar, S., & Kant, S. (2006). Organizational resistance to participatory approaches in public agencies: an analysis of forest department's resistance to community-based forest management. *International Public Management Journal, 9*(2), 141-173.

Kumar, S., & Singh, R. (2020). Strategies of Implementating Drinking Water Project under Jal Jeevan Mission in Bihar. *Journal of Natural Remedies, 20*(4), 28-35.

Kreutzwiser, R., de Loe, R., Imgrund, K., Conboy, M. J., Simpson, H., & Plummer, R. (2011). Understanding stewardship behaviour: factors facilitating and constraining private water well stewardship. *Journal of environmental management, 92*(4), 1104-1114.

Kwasnicka, D., Dombrowski, S. U., White, M., & Sniehotta, F. (2016). Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories. *Health psychology review, 10*(3), 277-296.

Lally, P., & Gardner, B. (2013). Promoting habit formation. *Health psychology review, 7*(1), S137-S158.

Linder, N., Giusti, M., Samuelsson, K., & Barthel, S. (2022). Pro-environmental habits: An underexplored research agenda in sustainability science. *Ambio, 51*(3), 546-556.

Marks, S. J., & Davis, J. (2012). Does user participation lead to sense of ownership for rural water systems? Evidence from Kenya. *World Development, 40*(8), 1569-1576.

Marks, S. J., Komives, K., & Davis, J. (2014). Community participation and water supply sustainability: evidence from handpump projects in rural Ghana. *Journal of Planning Education and Research, 34*(3), 276-286.

Marks, S. J., Onda, K., & Davis, J. (2013). Does sense of ownership matter for rural water system sustainability? Evidence from Kenya. *Journal of Water, Sanitation and Hygiene for Development, 3*(2), 122-133.

Mathieu, J. E., Aguinis, H., Culpepper, S. A., & Chen, G. (2012). Understanding and estimating the power to detect cross-level interaction effects in multilevel modeling. *Journal of Applied Psychology, 97*(5), 951–966. https://doi.org/10.1037/a0028380

Matilainen, A., Koch, M., Zivojinovic, I., Lähdesmäki, M., Lidestav, G., Karppinen, H., ... & Scriban, R. E. (2019). Perceptions of ownership among new forest owners–A qualitative study in European context. *Forest Policy and Economics, 99*, 43-51.

Matilainen, A., & Lähdesmäki, M. (2021). Who does the moose belong to?–Legitimation of collective psychological ownership. *Journal of Rural Studies, 86*, 236-246.

Matilainen, A., Pohja-Mykrä, M., Lähdesmäki, M., & Kurki, S. (2017). "I feel it is mine!"–Psychological ownership in relation to natural resources. *Journal of Environmental Psychology, 51*, 31-45.

Michie, S., Wood, C. E., Johnston, M., Abraham, C., Francis, J., & Hardeman, W. (2015). Behaviour change techniques: the development and evaluation of a taxonomic method for reporting and describing behaviour change interventions (a suite of five studies involving consensus methods, randomized controlled trials and analysis of qualitative data). *Health technology assessment, 19*(99).

Moriarty, P., Smits, S., Butterworth, J., & Franceys, R. (2013). Trends in rural water supply: Towards a service delivery approach. *Water alternatives, 6*(3).

Mosler, H. J. (2012). A systematic approach to behavior change interventions for the water and sanitation sector in developing countries: a conceptual model, a review, and a guideline. *International journal of environmental health research, 22*(5), 431-449.

Mosler, H. J., Kraemer, S. M., & Johnston, R. B. (2013). Achieving long-term use of solar water disinfection in Zimbabwe. *Public Health, 127*(1), 92-98.

Nakagawa, M. (2019). Trust in sustainable natural resource development. *Nature human behaviour, 3*(6), 542-542.

Nowicki, S., Koehler, J., & Charles, K. J. (2020). Including water quality monitoring in rural water services: Why safe water requires challenging the quantity versus quality dichotomy. *NPJ Clean Water, 3*(1), 1-9.

O'Driscoll, M. P., Pierce, J. L., & Coghlan, A. M. (2006). The psychology of ownership: Work environment structure, organizational commitment, and citizenship behaviors. *Group & Organization Management, 31*(3), 388-416.

Onda, K., LoBuglio, J., & Bartram, J. (2012). Global access to safe water: accounting for water quality and the resulting impact on MDG progress. *International journal of environmental research and public health, 9*(3), 880-894.

Organ, D. W. (1997). Organizational citizenship behavior: It's construct clean-up time. *Human performance, 10*(2), 85-97.

Ostrom, E. (2000). Collective action and the evolution of social norms. *Journal of economic perspectives, 14*(3), 137-158.

Ostrom, E. (2002). Common-pool resources and institutions: Toward a revised theory. *Handbook of agricultural economics, 2*, 1315-1339.

Panda, B., & Leepsa, N. M. (2017). Agency theory: Review of theory and evidence on problems and perspectives. *Indian Journal of Corporate Governance, 10*(1), 74-95.

Pagel, C., Prost, A., Lewycka, S., Das, S., Colbourn, T., Mahapatra, R., ... & Osrin, D. (2011). Intracluster correlation coefficients and coefficients of variation for perinatal outcomes from five cluster-randomized controlled trials in low and middle-income countries: results and methodological implications. *Trials, 12*(1), 1-12.

Patil, S. R., Arnold, B. F., Salvatore, A. L., Briceno, B., Ganguly, S., Colford Jr, J. M., & Gertler, P. J. (2014). The effect of India's total sanitation campaign on defecation behaviors and child health in rural Madhya Pradesh: a cluster randomized controlled trial. *PLoS medicine, 11*(8), e1001709.

Peck, J., Kirk, C. P., Luangrath, A. W., & Shu, S. B. (2021). Caring for the commons: Using psychological ownership to enhance stewardship behavior for public goods. *Journal of Marketing, 85*(2), 33-49.

Pierce, J. L., & Jussila, I. (2010). Collective psychological ownership within the work and organizational context: Construct introduction and elaboration. *Journal of Organizational Behavior, 31*(6), 810-834.

Pierce, J. L., & Jussila, I. (2011). *Psychological ownership and the organizational context: Theory, research evidence, and application.* Edward Elgar Publishing.

Pierce, J. L., Kostova, T., & Dirks, K. T. (2001). Toward a theory of psychological ownership in organizations. *Academy of management review, 26*(2), 298-310.

Preston, S. D., & Gelman, S. A. (2020). This land is my land: Psychological ownership increases willingness to protect the natural world more than legal ownership. *Journal of environmental psychology, 70*, 101443.

Raudenbush, S. W., Spybrook, J., Congdon, R., Liu, X. F., Martinez, A., & Bloom, H. (2011). *Optimal design software for multi-level and longitudinal research (Version 3.01)* [Software].

Rutterford, C., Copas, A., & Eldridge, S. (2015). Methods for sample size determination in cluster randomized trials. *International journal of epidemiology, 44*(3), 1051-1067.

Saleem, S. M., & Jan, S. S. (2019). Modified Kuppuswamy socioeconomic scale updated for the year 2019. *Indian J Forensic Community Med, 6*(1), 1-3.

Schill, C., Anderies, J. M., Lindahl, T., Folke, C., Polasky, S., Cárdenas, J. C., ... & Schlüter, M. (2019). A more dynamic understanding of human behaviour for the Anthropocene. *Nature Sustainability, 2*(12), 1075-1082.

Schwarzenbach, R. P., Egli, T., Hofstetter, T. B., Von Gunten, U., & Wehrli, B. (2010). Global water pollution and human health. *Annual review of environment and resources, 35,* 109-136.

Sharma, A. (2021). *Meeting SDG6: Ensuring Safe Drinking Water for All in Rural India.* In The Palgrave Encyclopedia of Urban and Regional Futures (pp. 1-6). Cham: Springer International Publishing.

Sharma, S. K., Seetharaman, A., & Maddulety, K. (2021). Framework for Sustainable Urban Water Management in Context of Governance, Infrastructure, Technology and Economics. *Water Resources Management, 35*(12), 3903-3913.

Sheeran, P., & Webb, T. L. (2016). The intention–behavior gap. *Social and personality psychology compass, 10*(9), 503-518.

Singh, S. K., Ghosh, A. K., Kumar, A., Kislay, K., Kumar, C., Tiwari, R. R., ... & Imam, M. D. (2014). Groundwater arsenic contamination and associated health risks in Bihar, India. *International Journal of Environmental Research, 8*(1), 49-60.

Suessenbach, S., & Kamleitner, B. (2018). *Psychological Ownership as a Facilitator of Sustainable Behaviors.* In J. Peck & S. B. Shu (Eds.), Psychological Ownership and Consumer Behavior (pp. 211–225). Springer International Publishing. https://doi.org/10.1007/978-3-319-77158-8_13

Tambi, A., Brighu, U., & Gupta, A. B. (2016). A sensitive presence/absence test kit for detection of coliforms in drinking water. Water Science and Technology: *Water Supply, 16*(5), 1320-1326.

Thacker, S., Adshead, D., Fay, M., Hallegatte, S., Harvey, M., Meller, H., ... & Hall, J. W. (2019). Infrastructure for sustainable development. *Nature Sustainability, 2*(4), 324-331.

Thürmer, J. L., Wieber, F., & Gollwitzer, P. M. (2017). Planning and performance in small groups: Collective implementation intentions enhance group goal striving. *Frontiers in Psychology, 8*, 603.

Tomberge, V. M. J., Harter, M., & Inauen, J. (2021). The importance of collective and individual psychological ownership for safe sanitation: A multilevel analysis in rural Ghana. *Global Public Health,* 1-16.

Toomey, E., Matvienko-Sikar, K., Heary, C., Delaney, L., Queally, M., Hayes, C. B., ... & Choosing Healthy Eating for Infant Health (CHErIsH) study team. (2019). Intervention fidelity within trials of infant feeding behavioral interventions to prevent childhood obesity: a systematic review. *Annals of Behavioral Medicine, 53*(1), 75-97.

Van Dyne, L., & Pierce, J. L. (2004). Psychological ownership and feelings of possession: Three field studies predicting employee attitudes and organizational citizenship behavior. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior, 25*(4), 439-459.

Verplanken, B. (2018). Promoting sustainability: Towards a segmentation model of individual and household behaviour and behaviour change. *Sustainable Development, 26*(3), 193-205.

Verplanken, B., & Orbell, S. (2003). Reflections on past behavior: a self-report index of habit strength 1. *Journal of applied social psychology, 33*(6), 1313-1330.

Verplanken, B., & Roy, D. (2016). Empowering interventions to promote sustainable lifestyles: Testing the habit discontinuity hypothesis in a field experiment. *Journal of Environmental Psychology, 45*, 127-134.

Whittington, D., Davis, J., & McClelland, E. (1998). Implementing a demand-driven approach to community water supply planning: A case study of Lugazi, Uganda. *Water International, 23*(3), 134–145. https://doi.org/10.1080/02508069808686760

Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., ... & Yach, D. (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The lancet, 386*(10007), 1973-2028.

Wilkie, S., Townshend, T., Thompson, E., & Ling, J. (2018). Restructuring the built environment to change adult health behaviors: a scoping review integrated with behavior change frameworks. *Cities & health, 2*(2), 198-211.

Williams, G. C., Rodin, G. C., Ryan, R. M., Grolnick, W. S., & Deci, E. L. (1998). Autonomous regulation and long-term medication adherence in adult outpatients. *Health Psychology, 17*(3), 269.

Chapter 4: Discussion

Main findings and answers to research questions

To begin with, the main findings are presented. In figure 5, all answers to the research questions of both research projects REACH and PACT are displayed in connection with the theoretical foundations. Overall, we find similar routes and consequences, as well as mechanisms of the role of psychological ownership in the new context of community-based safe water infrastructure compared to the original research on this concept in an organizational context.

Firstly, findings from qualitative and quantitative analyses showed that community members' decision-making, investment of labour and money as well as knowledge about the water system were associated with greater psychological ownership. Qualitative evidence indicates that assignment of ownership and the use of the target of ownership influence the sense of ownership positively. Psychological ownership was related to greater acceptance and responsibility for maintenance and use as well as greater confidence in functionality of the water system, but not to its actual functionality.

Secondly, we investigated the adaptation of the construct of psychological ownership with its core of possessiveness to a shared infrastructure in a non-western cultural context. We found that it can be reliably measured with a short version of the Van Dyne and Pierce (2004) self-reported index, and concluded that, if carefully adapted in several steps, measurement scales can be transferred between contexts.

Thirdly, we investigated routes fostering psychological ownership in a non-randomized pre-post intervention study and found that various forms of participation affected acceptance, use and functionality of a shared resource and some of the effects are mediated by psychological ownership. Participatory activities such as influence in decision-making, contributing materials and labour favourably affected self-reported outcomes and use of the water supply infrastructure but not observed functionality, nor drinking water quality.

Finally, we tested in a cluster-randomized controlled trial several theory-based interventions targeting the routes for psychological ownership in combination with an intervention targeting commitment strength. We find that interventions on the three routes caused greater psychological ownership, but only in combination with an individual behaviour change intervention. If combined with an individual level intervention, psychological ownership was leading to increased use of the safe community-based water infrastructure and fostering organizational citizenship behaviour, and other psychosocial outcomes, but not to improved functionality of infrastructure, nor to safer water quality.

Figure 5

Schematic overview over the results
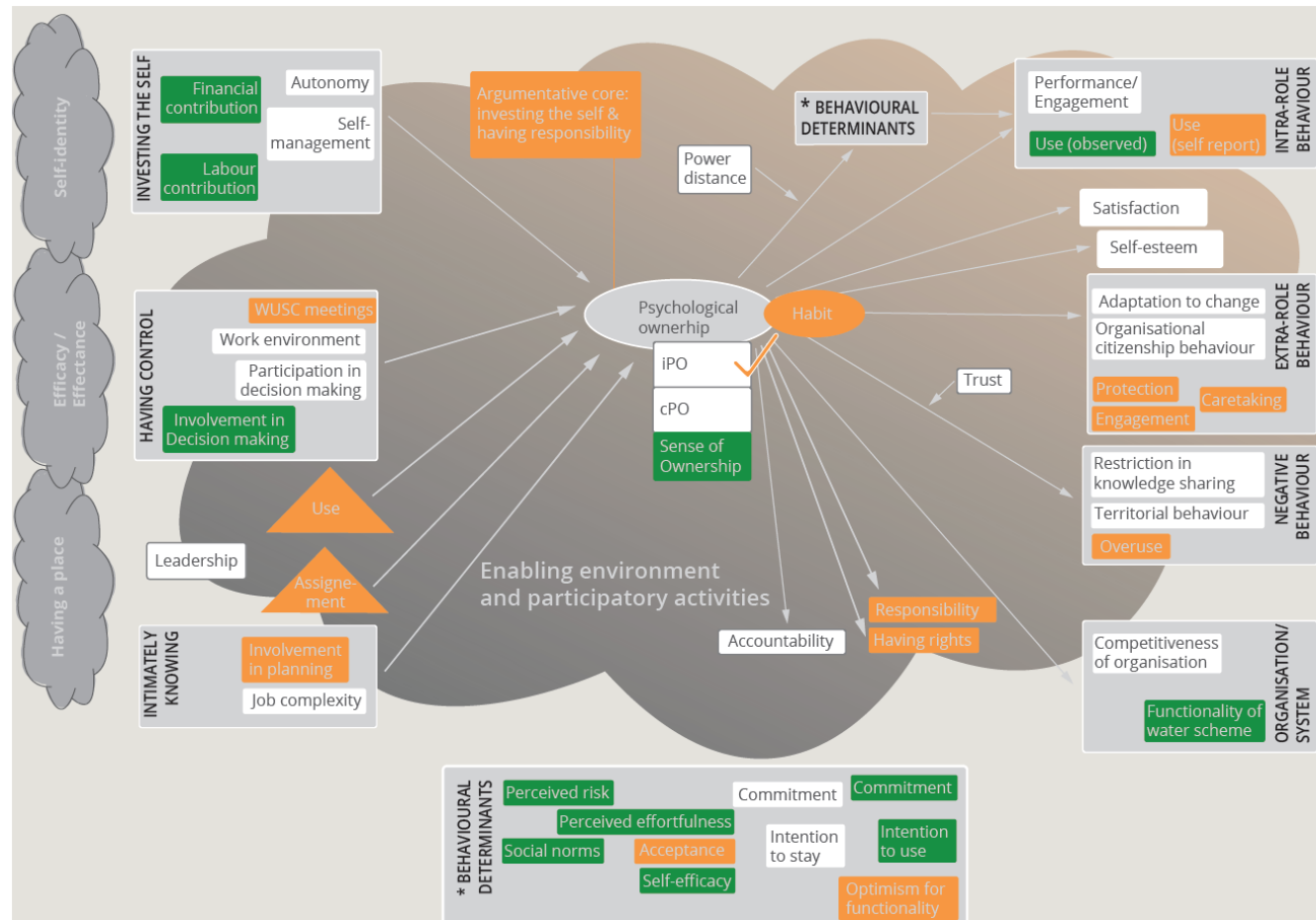
Note. Schematic overview over the results to the research questions (orange), suggestions for further research (grey), embedded in the existing framework of psychological ownership from the organizational context (white) and community-based water infrastructure (green).

To answer research question 1 and 2, psychological ownership for shared infrastructure was investigated in a cross-sectional mixed-methods study. Results show convergent evidence and psychological ownership can be conceptualized as a multidimensional feeling with a core of possessiveness, that came to light when respondents substantiated their feelings. Villagers understand the concept of psychological ownership and argue with the possessive core when describing it, and demarcating it towards others. We find consistent results that psychological ownership is a social phenomenon and thus only exists in social context, such as in the community. The reasons provided why psychological ownership for community-based shared safe water infrastructure is important differs from situation to situation and represent the multi-dimensionality of the concept. In addition we successfully validated the measurement scale on possessiveness for psychological ownership in the context of community-based water infrastructure on its psychometric properties in an applied research setting with a cross-sectional two-wave study design and can thus report high ecological validity which allows to compare findings from different research studies using the validated questionnaire.

In depth discussion of selected findings

In order to answer research questions 3A and 3B in more detail, a selection of the results will be discussed in depth: (i) the role of routes fostering psychological ownership; (ii) the consequences influenced by psychological ownership; (iii) the importance of an enabling environment for psychological ownership; (iv) adaptation of the theoretical concept to another context:

(i)   The role of routes fostering psychological ownership

In this research, theory-based interventions were developed, targeting the three routes leading to psychological ownership (coming to intimately know, investing the self and controlling). However, measuring different elements of these routes in three studies, we find mixed evidence for their impact. For example, in Article 1 (qualitative evidence) investing the self was positively associated with a feeling of ownership, whereas in Article 3 it was negatively associated. In the fourth study, in combination with an individual behaviour change intervention targeting commitment strength and by that habit, we did not find an effect at all. In correlational studies, the three routes found in the Indo-Asian context also reproduce the results concerning the routes found in the African context (Marks et al., 2014). Examining successful interventions promoting psychological ownership in previous literature (e.g. Peck et al., 2021), it is striking that they do not target the routes to psychological ownership, but the roots of the concept. This does not mean that routes to psychological ownership cannot foster this feeling, but merely that it is not sufficient to target the routes without considering the roots. Linking back to the theoretical foundations of psychological ownership and the three

motives why psychological ownership exists (Pierce et al., 2001), it becomes obvious that routes cannot affect the fostering of psychological ownership if the psychological foundations (i.e. motives) are not present in the interventions. If for instance the water users do not perceive themselves as self-effective and water taps are not part of their self-identity, then all the activities targeting the routes will not foster psychological ownership for the water system. This is in line with the evidence from organizational psychology such as how labourers in a factory feel: If they separate their identity from their work, no psychological ownership for their work is found (Rousseau, 1998). Hence, interventions to foster psychological ownership need to be tailored specifically to the target group and include their motivation.

Developing this specific focus on the target group further, findings from previous qualitative research hint at the importance of aiming at different aspects of the routes to psychological ownership and the dosage of interventions, depending on the proximity of the target group and their link with the target of ownership (Matilainen et al., 2017; Matilainen & Lähdesmäki, 2021; and Marks et al., 2013 in the context of community-based water supply). Also, we find qualitative evidence that 'use' is leading to psychological ownership for the object in question. Thus, the effectivity of interventions could be improved by adapting interventions specifically to the target group or, more broadly speaking, the context on the one hand and on the other hand, by including behaviour change techniques targeting the use of the shared resource.[1]

This finding is worth discussing on the level of the overarching approach to the project organization: In the two research projects, the partnering organizations played a crucial role. They were familiar with the local context in detail, ensured a fluid exchange with the communities, were sensitised as well as in a position to alert issues concerning the community at an early stage and had a stellar reputation in the communities, which allowed us to tailor theory-based interventions optimally to the local context. In the literature about community development, several participatory approaches are established under the framework of community-based participatory research (CBPR; Salimi et al., 2012). These approaches are an instrument to better anchor applied research projects in their context. By integrating communities in the research procedures, research quality gains not only from an ethical point of view, but also from a methodological: For example, the setting and characteristics of the

---

[1] A similar approach is used in the adaptation of the measurement scale in chapter 5.

target group influence the content and mode of delivery of behaviour change techniques and they become this more specific when conducting CBPR. This method expands the role from mere subjects research to actors of research (Sharma, 2000). To sum up, in a CBPR approach to implement a psychological ownership intervention, the community itself decides on the routes that contribute to the fostering of psychological ownership. Likewise, the community develops psychological ownership by having control over the activities, intimately knowing what is happening and why, and invests itself. At the same time, such a process of bringing together the efforts of people at grassroots level with those of the government (Zadeh & Ahmad, 2010) and making the selection of interventions more comprehensible to villagers, further strengthens the routes to and possibly enhances psychological ownership.

I advocate further, that with a pre-study survey, ideally based on a CBPR approach as well, individual routes to psychological ownership should be assessed on their efficacy. Subsequently, selected ones from every routes-block should be combined so that the optimal participatory approach can be found for enhancing psychological ownership. This methodology should ensure to foster psychological ownership specifically and effectively for a target group and context, similarly to the methodology used in the Risks, Attitudes, Norms, Abilities and Self-regulation (RANAS) approach for systematic behaviour change (Mosler, 2012).

To put it simply, WUSC members, contracting company members, government engineers and users of the piped water supply schemes need to be involved in the ownership interventions and targeted individually with the chosen routes appropriate to their respective role – in line with Marks et al. (2013). To conclude, if participation is implemented as an end and not as a mean, it automatically targets roots as well as routes to psychological ownership and therefore strengthens it.

(ii) The consequences influenced by psychological ownership

As just stated, psychological ownership is linked to motivation. It is also a theoretical framework that allows for the systematic assessment of participatory activities in community-based interventions for the sustainable management of shared resources and leads to a variety of outcomes and consequences. In our studies, we have found that mostly behavioural determinants and changed behaviour are outcomes influenced by psychological ownership, but not water quality or infrastructure functionality. This means that psychological ownership can pave the way for behaviour change interventions towards a specific target, it can prepare the community for and push it towards behaviour change interventions. This is in line with previous findings that understand psychological ownership as a concept related to the protection and sharing of possessions if the target of ownership offers potential utility in the future for the owner (Rudmin, 2016).

However, to achieve behaviour change, we found evidence in the cluster-randomized controlled trial (c-RCT) that the driving force amongst the change interventions is the combination of habit intervention with psychological ownership intervention and not the psychological ownership intervention solely. This finding points at the presence of the intention-behaviour gap (Mazar & Wood, 2022, Sheeran & Webb, 2016), that describes how psychosocial factors might change an intention, but for an effect in behaviour, other factors need to support the intention. Thus, in order to influence more distant outcomes and consequences such as behaviour, we propose to pair psychological ownership interventions with individual behaviour change interventions.

Furthermore, we see coherently and congruently across the findings from qualitative studies, that consequences of psychological ownership mainly concern stewardship, caretaking, and organizational citizenship behaviour. This is in-line with findings in organizational context (Ullah et al., 2021) and can be explained by the self-determination theory of Ng et al., (2012) who find that health behaviour changes and prosocial behaviours in social contexts are driven by human motivation and personality. We find that generally speaking, psychological ownership plays a global role as mediating construct for a broad range of outcomes. However, looking at the mechanism in more detail, we find that only a few effects are mediated and only to a small extent by psychological ownership. Thus, other concepts need to be considered when researching the consequences of the mechanism of actions and participatory activities. For example, self-determination theory and agency theory both provide alternative explanations for changes over the feeling of autonomy, and thus potentially psychological ownership.

Again, our findings resemble the consequences of psychological ownership shown by Madajewicz et al. (2021), in the African context by Marks et al. (2013) as well as in the organizational context. In contrast to previous findings, we did not find effects of psychological ownership on territoriality. This leads to the conclusion that, if successfully promoted, psychological ownership has beneficial outcomes and consequences for sustainability and shared resources because they both depend on volunteerism and extra role behaviour.

Consequences for community-based safe water infrastructure in Nepal and India were increased use, greater confidence in functionality, more willingness to care, increased commitment to stewardship behaviour and greater organizational citizenship behaviour. Furthermore, using the source as a route to psychological ownership hints at the circularity of the process of psychological ownership, if embedded in a suitable environment.

However, acceptance and attitudes towards the community-based water infrastructure were more positive only in Nepal. Overall functionality was influenced neither in Nepal nor in India. To shed more light on this finding, the settings in which the studies took place will be discussed in more details below.

(iii) Importance of an enabling environment for psychological ownership

Moving on from the discussion of the three research questions to the broader context, it should be considered how the social context and the environment of our studies influences psychological ownership. Previous research has shown that the social context moderates the effects of social interventions on its outcomes (Harter et al., 2020). In our studies, we find the social context to be very coherent and supportive in Nepal on the one hand, and to be fragmented and quite disputed in India, on the other hand (respondents reporting low levels of trust and social identity). Further, qualitative interviews with caretakers and qualitative network analysis (Ahrens, 2018; figure 6) corroborated these indicators. Having a look at the effects of these different contexts and environments (and comparing it with the revised job characteristics model; Pierce et al., 2009), we conclude that in the Indian context an enabling environment which supports psychological ownership is missing.

Historically, community-based water supply in India was only successful if there had been external support for the communities, enhancing an enabling environment and therefore psychological ownership. A systematic review (Hutchings et al., 2015) analysed the development pattern of case studies of 174 successful community management projects. The synthesis confirms that for community management to be sustained at scale, community institutions need long-term external support, with the majority of high-performing cases involving financial support, technical advice, and managerial advice. Particular internal community characteristics were also found to influence success, including collective initiative, strong leadership, and institutional transparency.

There are three typologies that describe the instalment of a successful and sustainable water supply system (Hutchings et al., 2017). In all three, an enabling support environment with external support entities was found: professionalised community-based management and complex technical installations (pump system with distribution network), community management with high level of voluntary participation and simple technical installations and direct provision with limited community involvement. Qualitative evidence from our research project in Nepal also shows that by further strengthening of the enabling environment, greater effects of psychological ownership on functionality could have been expected. To sum up, an enabling environment is an important factor to foster psychological ownership as well as to achieve sustainability and success in both research projects.

Figure 6

Qualitative network analysis of the organisation of the community-based water supply
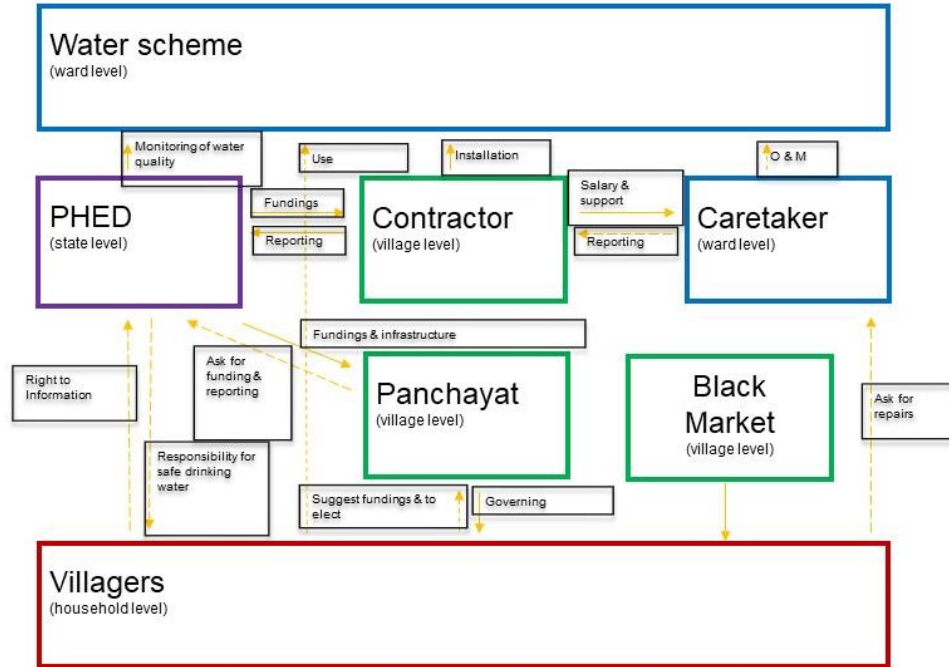
infrastructure

Note. Drawing evidence from qualitative interviews, conducted in study 3, the network and interactions of stakeholder in the organisation of the community-based water supply in Bihar is very complex and implemented only in parts. Red-coloured squares are individual villagers, blue-coloured squares are on ward level, green-coloured squares are on village (habitation) level, and purple-coloured square is on state level. Abbreviation: O&M = Operation & Maintenance.

This is confirmed by Anthonj et al. (2018), who name the speed of repairs, which is part of the external support and therefore of an enabling environment, as the most significant predictor for sustainability and behaviour. Anthonj et al. mention water quality as a crucial predictor for sustainability and behavior too, linking back to the theory, which says that an enabling environment should have a standardised organizational structure with formalised interactions between entities and centralisation of authority (Pierce et al., 2004).

However, in a system as complex as the organization of piped water supply, the problem of diffusion of the responsibilities arises. The diffusion of responsibilities is caused by a lack of external support and complex interactions of the stakeholders. In our context, institutional barriers such as a lack of money contribution were present and institutional ownership was limited. Community

ownership was understood as a dead end rather than collective self-determination (Moore, 2012). This had the implication that we focused on specific interventions for certain different target groups (for instance end-users versus WUSC) to avoid diffusion of responsibilities and to acknowledge the different tasks and responsibilities of stakeholders. Thus, creating an enabling environment involves stakeholders working together, clearly understanding their roles and recognising their responsibilities.

An introspection by Karnilowicz (2011, p. 281) puts aspects (i) to (iii) in a nutshell:[2]

'A broader change in the characteristics of the relationship between the practitioner and expert with the person and their disease or illness is necessary to the extent that *the process be collaborative and empowering*. It is about *creating conditions enabling and promoting psychological ownership* as an important component in dealing with chronic illness and life-threatening disease. Change is also *more likely to be maintained when consistent with what a person believes and desires*, when the changes are integrated into the person's sense of self *and when the changes are orchestrated in the person's 'own way'* rather than when motivated by external forces. *Motivation is a key factor* in continuing an engagement with maintaining health-related behaviour. The motivations may be autonomous or controlled with the latter pressured or coerced by an external force. In contrast, healthcare professionals need to help patients internalise and integrate new health behaviours *without employing directives.*'

(iv) Adaptation of the theoretical concept

The overarching theme of the present body of work is the adaptation of the theoretical concept of psychological ownership, which originally stems from the organizational context to another context – the safe water context. For that purpose, we adapted a concept developed for the job or the organization a person works for to another target of ownership – to shared infrastructure. Despite the transfer from a capitalistic to a communitarian context, from a non-tangible to a tangible target of ownership and from a hierarchical, structured organization to grassroots, bottom-up organization, the results in the context of shared resources and safe water infrastructure show almost complete

[2] Highlights in italic were made by the author of the present dissertation.

congruence with the results from the organizational context (figure 5). We found the routes leading to psychological ownership, the consequences of psychological ownership to be very similar as well as the core of the concept to be the same. This shows that not only measurement scales (see Article 1) but also theories can be adapted to new context, if the transfer is carefully and holistically done.

A step-by-step guideline for adaptation was presented in chapter 5 and a brief reflection of our adaptation of the concept of psychological ownership to a new context now follows.

Complementing the results of already existing research, we found that first; the understanding of a theory in a new context needs to be examined. Concerning shared infrastructure and psychological ownership, the limitations of personal action to improve the functionality of safe water supply were frequently mentioned. Additionally, the lack of respect for responsibility was mentioned frequently as well. In the Indian context, it was mainly the contracting company that was blamed for not responding to demands and not supporting the village in maintaining the infrastructure (see iii). This implicates that we did not fundamentally understand the theory in this new context and did not adapt our interventions profoundly. Hence, our research findings are limited.

Limitations and strengths

The main strengths of the research conducted concern the point of view. In these two projects applied research in combination with theory-based foundations is carried out: In Nepal as well as in India, the research is based on existing development programmes financed by governments and NGOs. As we evaluated existing strategies in rural water supply development, policies can be improved immediately, based on our and the scientific communities' robust findings.

The second main strength is that the research was conducted methodologically rigorous and stepwise. It is built on qualitative grounded-theory approaches, then measurement scales with mixed-methods and think-aloud approaches are investigated, extending this to a correlational and a cross-sectional quantitative study. Finally, causal effects in a cluster-randomized controlled trial are tested, which corresponds with state-of-the-art research (Banerjee et al., 2016).

The other side of the coin is that we only had limited choice when designing the theory-based interventions: The route of investing the self via financial contribution / collecting water tariff is missing in the c-RCT in India, even though literature (Marks & Davis, 2012) and also simulation studies have proved its potential for sustainable water treatment (German et al., 2019). Micro-entrepreneurship is an interesting economic prospect for villages and empirical evidence from Nepal (we found that financial investment was a direct predictor of safe water outcomes) underlines its effectiveness. The reason why we could not include it is that water supply infrastructure is a service of

the Indian government through its institution PHED. Therefore, we had to conduct research according to its policies.

The second limitation concerns the infrastructure bottleneck: For consuming safe water, it is not enough to collect water at the correct source only, but the water also needs to be provided in the correct quality. However, we did not find that psychological ownership is associated with technical functionality. As technical functionality of shared infrastructure is key, the dual process model postulated by Morewedge (2021) provides a possible explanation why psychological ownership was not associated with functionality of the infrastructure such as safe water quality: The legal and explicit ownership of the infrastructure rests with PHED and the contracting company. Psychological ownership, however, rests with the community (caretaker, WUSC and villagers). The feeling of psychological ownership is not sufficient to challenge the structure of legal ownership. If both types of ownerships align, then positive effects can be expected – villagers increased positive psychosocial factors and behavioural determinants related to caretaking behaviour and use of safe water infrastructure.

Further research

Based on the strengths and limitations of the research conducted, future studies should address the following three aspects to begin with: First, because the data in this research covers only twelve months future studies should research long-term effects and find the trajectories of how psychological ownership develops in the different stakeholders, using an intense longitudinal design. Second, future research should assess the financial impact of 'investing the self' on psychological ownership and other routes individually to psychological ownership for different targets and in different environments. The approach 'one participatory intervention fits all' does not work – just as companies and organizations differ in their hierarchy, organizational culture and environment, shared resources and community infrastructures vary in these aspects too. Third, a selection of theory-based interventions fostering psychological ownership in combination with only one component of individual level behaviour change was tested: habit. We propose that future research includes other individual-level interventions in combination with psychological ownership interventions to enhance the effect on outcomes and find if there is an optimal combination of individual and community level interventions.

Broadening the perspective, cultural limitations concerning psychological ownership could be worth exploring. Gjersoe et al. (2014) find that respondents from the United States value authentic items associated with individual persons (a sweater or an artwork) more than Indian respondents, but that respondents from both cultures value authentic objects which are not associated with persons (a dinosaur bone or a moon rock) equally. These differences cannot be attributed to more general

cultural differences in the value assigned to authenticity. Rather, the results support the hypothesis that individualistic cultures place a greater value on objects associated with individuals and in doing so, offers first evidence of how valuation of certain authentic items may vary cross-culturally. Hence why the importance of psychological ownership might also vary across cultures, and it should be further examined how psychological ownership can be fostered through its motives in different cultures.

There is also a temporal connecting point for further research. The timing of a psychological ownership intervention can be important as a challenge of our research shows: Our intervention embraced the installation process, where delays and poor work probably impacted the villagers' perception severely. Thus, temporal circumstances may have impacted our interventions negatively. For future research, we suggest examining the development and evolution of psychological ownership in longitudinal study designs over several measurement time points. For example, a step-wedged randomized design could be applied to find out at which point during the installation psychological ownership fosters most efficiently the beneficial outcomes.

Lastly, we hypothesize that psychological ownership has wide-ranging consequences, especially in the context of fostering organizational citizenship behaviour, which may not be most effective in construction, but rather in operation and maintenance of infrastructure. Direct consequences of psychological ownership on improved functionality are therefore not expected mandatory and cannot be understood as a determinant of behaviour. For this reason, we believe that the consequences should be studied in more detail, for example in combination with the RANAS approach, which specifically promotes behavioural determinants.

Implications for practice

First, community participation is an approach that was found to be associated with several positive development-project outcomes and consequences: For instance, there were differences in technological outcomes (mainly the percentage of taps working), in the extent to which the beneficiaries had switched to the safe drinking and cooking water provided by the project, in the reasons for such a change, in the adjustments of health habits, in the continued engagement of the community, in the initiative taken by the community to ensure that facilities work satisfactorily, in the ability to exert pressure and in the degree of satisfaction of the beneficiaries (Manikutty, 1997). However, the relevance of these findings is mitigated by severe methodological limitations. Research was conducted in an environment with strong enabling local institutions. In this context, it is argued that the tendency to treat the challenge of rural water supply as one of either a community-participation or collective-action problem (that only the community can address) and hampers problem solving. Recasting the primary challenge of rural water service delivery as improved

cooperation and coordination between the state and citizen, Hutchings (2018) proposes a more substantial focus on factors influencing routes to ownership to tackle sustainability problems.

Second, psychological ownership interventions should aim to change the three roots of psychological ownership. Madajevicz et al. (2017) found that psychological ownership is best promoted through using local information and community action as well as by limiting the elite decision-making (when the broad population is leading decision-making). The regulated community approach expands and diversifies the group of people who participate in decision-making by lowering the participation requirement and dissolving the unanimity of the decisions. This approach is even stronger in the safe drinking and cooking water provision rather than when the community itself organises the decision-making. Psychological ownership and its consequences transferred to the WaSH context could bring people to take care of the safe water infrastructure and maintain it as well as use and accept it as their own infrastructure. However, from the context of organizations, we have learned that favourable influences on behavioural outcomes are of mixed evidence. Thus, a combination of theory-based and evidence-based behaviour change interventions (Sonego et al., 2013) to strengthening the effects on behaviour could be a solution. Theory-based and evidence-based behaviour change interventions can successfully promote the immediate adoption of existing arsenic-safe water infrastructure, as shown in a study in Bangladesh (Inauen & Mosler, 2014). Less is known, however, about the establishment of long-term behaviour change to achieve sustainable repair and maintenance of the safe water options to guarantee their long-term functionality. But the problem of the often very complex interaction of the people and organizations involved in such this infrastructure remains.

Conclusion

The published literature assumes homogeneity of ownership feelings across all members of a community and suggests a consistent and positive association between a household's sense of ownership and sustainability. Kyessi and Ka'Bange (2014) warn about possible negative effects and the resulting trap of community participation, in line with the findings from Marks et al. (2013) that stand in contrast with much of the published literature on rural water planning. Based on our findings, I can only repeat this warning. At the same time, I would like to emphasize how promising psychological ownership theory is to systematically understand the concept of participation in more detail, to better understand, to systematically assess and to quantify participation effects. This is becoming increasingly important, as the most recent trends toward system-level intervention in water supply development programmes see participation and ownership issues playing an important role in the sustainable implementation of shared infrastructure.

References

Aga, D. A., Noorderhaven, N. & Vallejo, B. (2018). Project beneficiary participation and behavioural intentions promoting project sustainability: The mediating role of psychological ownership. *Development Policy Review, 36*(5), 527-546.

Ahrens, P. (2018). Qualitative network analysis: A useful tool for investigating policy networks in transnational settings?. *Methodological Innovations, 11*(1), 2059799118769816.

Anthonj, C., Fleming, L., Cronk, R., Godfrey, S., Ambelu, A., Bevan, J., ... & Bartram, J. (2018). Improving monitoring and water point functionality in rural Ethiopia. *Water, 10*(11), 1591.

Avey, J. B., Avolio, B. J., Crossley, C. D. & Luthans, F. (2009). Psychological ownership: Theoretical extensions, measurement and relation to work outcomes. Journal of Organizational Behavior: *The International Journal of Industrial, Occupational and Organizational Psychology and Behavior, 30*(2), 173-191.

Avey, J. B., Wernsing, T. S., & Palanski, M. E. (2012). Exploring the process of ethical leadership: The mediating role of employee voice and psychological ownership. *Journal of Business Ethics, 107*(1), 21-34.

Bänziger C, Schertenleib A, Kunwar BM, Bhatta MR and Marks SJ (2022) Assessing Microbial Water Quality, Users' Perceptions and System Functionality Following a Combined Water Safety Intervention in Rural Nepal. Front. *Water 3*:750802. doi: 10.3389/frwa.2021.750802

Bartunek, J. M., Rousseau, D. M., Rudolph, J. W., & DePalma, J. A. (2006). On the receiving end: Sensemaking, emotion, and assessments of an organizational change initiated by others. *The Journal of applied behavioral science, 42*(2), 182-206.

Baer, M. & Brown, G. (2012). Blind in one eye: How psychological ownership of ideas affects the types of suggestions people adopt. *Organizational Behavior and Human Decision Processes, 118*(1), 60-71.

Bain, R., Cronk, R., Hossain, R., Bonjour, S., Onda, K., Wright, J., ... & Bartram, J. (2014). Global assessment of exposure to faecal contamination through drinking water based on a systematic review. *Tropical Medicine & International Health, 19*(8), 917-927.

Banerjee, A. V., Duflo, E. & Kremer, M. (2016). The influence of randomized controlled trials on development economics research and on development policy. *The state of Economics, the state of the world*, 482-488.

Bartram J, Corrales L, et al. 2009). *Water Safety Plan Manual: Step-by-Step Risk Management for Drinking Water Suppliers.* Geneva: World Health Organization

Barrington, D., Fuller, K. & McMillan, A. (2013). Water safety planning: adapting the existing approach to community-managed systems in rural Nepal. *Journal of water, sanitation and hygiene for development, 3*(3), 392-401.

Basu, M., DasGupta, R., Hashimoto, S. & Hoshino, S. (2021). A multi-actor and bottom-up perspective on attaining rural water security: qualitative evidence from India. *Environment, Development and Sustainability, 23*(2), 1461-1484.

Baumeister, R. F., & Leary, M. R. (2017). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Interpersonal development*, 57-89.

Beggan, J. K., & Brown, E. M. (1994). Association as a psychological justification for ownership. *The Journal of psychology, 128*(4), 365-380.

Bernhard, F. & O'Driscoll, M. P. (2011). Psychological ownership in small family-owned businesses: Leadership style and nonfamily-employees' work attitudes and behaviors. *Group & Organization Management, 36*(3), 345-384.

Black, M. & Talbot, R. (2005). *Water, a matter of life and health: water supply and sanitation in village India.* Oxford University Press.

Brown, S. P., Cron, W. L., & Slocum Jr, J. W. (1998). Effects of trait competitiveness and perceived intraorganizational competition on salesperson goal setting and performance. *Journal of Marketing, 62*(4), 88-98.

Brown, G., Crossley, C. & Robinson, S. L. (2014). Psychological ownership, territorial behavior, and being perceived as a team contributor: The critical role of trust in the work environment. *Personnel psychology, 67*(2), 463-485.

Brown, G., Pierce, J. L., & Crossley, C. (2014). Toward an understanding of the development of ownership feelings. *Journal of Organizational Behavior, 35*(3), 318-338.

Brown, G., & Zhu, H. (2016). 'My workspace, not yours': The impact of psychological ownership and territoriality in organizations. *Journal of environmental psychology, 48*, 54-64.

Charles, K. (2015). *Water safety plans.* In J. Bartram, R. Baum, P. A. Coclanis, D. M. Gute, D. Kay, S. McFadyen, K. Pond, W. Robertson & M. J. Rouse (Eds.), Routledge handbook of water and health (pp. 245–252). Routledge.

Chi, N. W., & Han, T. S. (2008). Exploring the linkages between formal ownership and psychological ownership for the organization: The mediating role of organizational justice. *Journal of Occupational and Organizational Psychology, 81*(4), 691-711.

Choi, H. S., & Levine, J. M. (2004). Minority influence in work teams: The impact of newcomers. *Journal of experimental social psychology, 40*(2), 273-280.

Cleaver, F. (1999). Paradoxes of participation: questioning participatory approaches to development. *The Journal of the Development Studies Association, 11*(4), 597-612.

Cleroux, A., Peck, J. & Friedman, O. (2022). Young children infer psychological ownership from stewardship. *Developmental Psychology, 58*(4), 671–679. https://doi.org/10.1037/dev0001325

Cocieru, O. C., Delia, E. B. & Katz, M. (2019). It's our club! From supporter psychological ownership to supporter formal ownership. *Sport Management Review, 22*(3), 322-334.

Contzen, N. & Marks, S. J. (2018). Increasing the regular use of safe water kiosk through collective psychological ownership: A mediation analysis. *Journal of Environmental Psychology, 57*, 45-52.

Cram, F., & Paton, H. (1993). Personal possessions and self-identity: The experiences of elderly women in three residential settings. *Australian Journal on Ageing, 12*(1), 19-24.

Csikszentmihalyi, M., & Rochberg-Halton, E. (1981). *The meaning of things: Domestic symbols and the self*. Cambridge University Press. Cambridge, England.

Daniel, D.; Prawira, J.; Al Djono, T.P.; Subandriyo, S.;Rezagama, A.; Purwanto, A. (2021). A System Dynamics Model of the Community-Based Rural Drinking Water Supply Program (PAMSIMAS) in Indonesia. *Water, 13*, 507. https://doi.org/10.3390/w1304050

Daniel, D., Diener, A., van de Vossenberg, J., Bhatta, M. & Marks, S. J. (2020). Assessing drinking water quality at the point of collection and within household storage containers in the hilly rural areas of mid and far-western Nepal. *International journal of environmental research and public health, 17*(7), 2172.

Dawkins, S., Tian, A. W., Newman, A., & Martin, A. (2017). Psychological ownership: A review and research agenda. *Journal of Organizational Behavior, 38*(2), 163-183.

De La Rosa, W., Sharma, E., Tully, S. M., Giannella, E. & Rino, G. (2021). Psychological ownership interventions increase interest in claiming government benefits. *Proceedings of the National Academy of Sciences, 118*(35).

Dittmar, H. (1992). Perceived material wealth and first impressions. *British Journal of Social Psychology, 31*(4), 379-391.

Dunford, B. B., Schleicher, D. J., & Zhu, L. (2009). *The relative importance of psychological versus pecuniary approaches to establishing an ownership culture.* In Advances in industrial & labor relations. Emerald Group Publishing Limited.

Druskat, V. U., & Pescosolido, A. T. (2002). The content of effective teamwork mental models in self-managing teams: Ownership, learning and heedful interrelating. *Human relations, 55*(3), 283-314.

Elimelech, M. (2006). The global challenge for adequate and safe water. *Journal of Water Supply: Research and Technology—AQUA, 55*(1), 3-10.

Furby, L. (1991). Understanding the psychology of possession and ownership: A personal memoir and an appraisal of our progress. *Journal of social behavior and personality, 6*(6), 457.

Fielmua, N. (2020). Myth and reality of community ownership and control of community-managed piped water systems in Ghana. *Journal of Water, Sanitation and Hygiene for Development, 10*(4), 841-850.

Fiske, A. P. (1992). The four elementary forms of sociality: framework for a unified theory of social relations. *Psychological review, 99*(4), 689.

Friedman, O., & Neary, K. R. (2008). Determining who owns what: Do children infer ownership from first possession?. *Cognition, 107*(3), 829-849.

Gardner, D. G., & Cummings, L. L. (1988). Activation theory and job. *Research in organizational behavior, 10*, 81-122.

German, M. S., Watkins, T. A., Chowdhury, M., Chatterjee, P., Rahman, M., Seingheng, H. & SenGupta, A. K. (2019). Evidence of economically sustainable village-scale microenterprises for arsenic remediation in developing countries. *Environmental science & technology, 53*(3), 1078-1086.

Gibson, C. C. 2001. *Forest resources: institutions for local governance in Guatemala.* Pages 71-89 *in* J. Burger, E. Ostrom, R. B. Norgaard, D. Policansky, and B. D. Goldstein, editors. *Protecting the commons: a framework for resource management in the Americas.* Island Press, Washington, D.C., USA.

Gibson, C. B., & Earley, P. C. (2007). Collective cognition in action: accumulation, interaction, examination, and accommodation in the development and operation of group efficacy beliefs in the workplace. *Academy of management review, 32*(2), 438-458.

Gjersoe NL, Newman GE, Chituc V, Hood B (2014) Individualism and the Extended-Self: Cross-Cultural Differences in the Valuation of Authentic Objects. *PLoS ONE 9*(3): e90787. https://doi.org/10.1371/journal.pone.0090787

Gordon, H. S. (1954). *The economic theory of a common-property resource: the fishery.* In Classic papers in natural resource economics (pp. 178-203). Palgrave Macmillan, London.

Groesbeck, R. L. (2001). *An empirical study of group stewardship and learning: Implications for work group effectiveness* (Doctoral dissertation, Virginia Polytechnic Institute and State University).

Hardin, G. (1968). The tragedy of the commons: the population problem has no technical solution; it requires a fundamental extension in morality. *Science, 162*(3859), 1243-1248.

Harter, M., Inauen, J., & Mosler, H. J. (2020). How does Community-Led Total Sanitation (CLTS) promote latrine construction, and can it be improved? A cluster-randomized controlled trial in Ghana. *Social science & medicine, 245*, 112705.

Han, T. S., Chiang, H. H., & Chang, A. (2014). *Employee participation in decision making, psychological ownership and knowledge sharing: mediating role of organizational commitment in Taiwanese high-tech organizations.* In Confucian HRM in Greater China (pp. 174-189). Routledge.

Handberg, Ø. N. (2018). No sense of ownership in weak participation: A forest conservation experiment in Tanzania. *Environment and Development Economics, 23*(4), 434-451.

Heider, F. (1958). *The psychology of interpersonal relations.* New York: Wiley

Henssen, B., Voordeckers, W., Lambrechts, F., & Koiranen, M. (2014). The CEO autonomy–stewardship behavior relationship in family firms: The mediating role of psychological ownership. *Journal of Family Business Strategy, 5*(3), 312-322.

Hutchings, P. (2018). Community Management or Coproduction? The Role of State and Citizens in Rural Water Service Delivery in India. *Water Alternatives, 11*(2).

Hutchings, P., Chan, M. Y., Cuadrado, L., Ezbakhe, F., Mesa, B., Tamekawa, C. & Franceys, R. (2015). A systematic review of success factors in the community management of rural water supplies over the past 30 years. *Water Policy, 17*(5), 963-983.

Hutchings, P., Franceys, R., Mekala, S., Smits, S. & James, A. J. (2017). Revisiting the history, concepts and typologies of community management for rural drinking water supply in India. *International Journal of Water Resources Development, 33*(1), 152-169.

Hutchings, P., Parker, A. & Jeffrey, P. (2016). The political risks of technological determinism in rural water supply: A case study from Bihar, India. *Journal of Rural Studies, 45*, 252-259.

Ikävalko, M., & Jussila, I. (2006). *Collective psychological ownership–A new perspective on family business definitions.* In Proceedings of the 51st ICSB World Conference, Melbourne, Australia.

IMHE (2010). *GBD Profile: Nepal.* Institute for Health Metrics and Evaluation, Seattle, WA.

Inauen, J., & Mosler, H. J. (2014). Developing and testing theory-based and evidence-based interventions to promote switching to arsenic-safe wells in Bangladesh. *Journal of health psychology, 19*(12), 1483-1498.

Jami, A., Kouchaki, M. & Gino, F. (2021). I own, so I help out: How psychological ownership increases prosocial behavior. *Journal of Consumer Research, 47*(5), 698-715.

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of financial economics, 3*(4), 305-360.

Jussila, I., Kotonen, U. and Tuominen, P. (2007), "Customer-owned Firms and the Concept of Regional Responsibility: Qualitative Evidence from Finnish Co-operatives" *(3)*3, 35-43. https://doi.org/10.1108/17471110710835563

Kalish, C. W., & Anderson, C. D. (2011). Ownership as a social status. *New directions for child and adolescent development, 2011*(132), 65-77.

Kanngiesser, P., Gjersoe, N., & Hood, B. M. (2010). The effect of creative labor on property-ownership transfer by preschool children and adults. *Psychological science, 21*(9), 1236-1241.

Karnilowicz, W. (2011). Identity and psychological ownership in chronic illness and disease state. *European journal of cancer care, 20*(2), 276-282.

Kaur, D., Sambasivan, M. & Kumar, N. (2013). Effect of spiritual intelligence, emotional intelligence, psychological ownership and burnout on caring behaviour of nurses: A cross-sectional study. *Journal of clinical nursing, 22*(21-22), 3192-3202.

Kirk, C. P., McSherry, B. & Swain, S. D. (2015). Investing the self: The effect of nonconscious goals on investor psychological ownership and word-of-mouth intentions. *Journal of Behavioral and Experimental Economics, 58*, 186-194.

Kirk, C. P., Peck, J. & Swain, S. D. (2018). Property lines in the mind: Consumers' psychological ownership and their territorial responses. *Journal of Consumer Research, 45*(1), 148-168.

Kelly, E., Lee, K., Shields, K. F., Cronk, R., Behnke, N., Klug, T. & Bartram, J. (2017). The role of social capital and sense of ownership in rural community-managed water systems: Qualitative evidence from Ghana, Kenya, and Zambia. *Journal of Rural Studies, 56*, 156-166.

Knapp, J. R., Smith, B. R., & Sprinkle, T. A. (2014). Clarifying the relational ties of organizational belonging: Understanding the roles of perceived insider status, psychological ownership, and organizational identification. *Journal of Leadership & Organizational Studies, 21*(3), 273-285.

Kostova, T. (1996). *Success of the transnational transfer of organizational practices within multinational companies.* University of Minnesota.

Kubzansky, P. E., & Druskat, V. U. (1993). *Psychological sense of ownership in the workplace: Conceptualization and measurement.* In annual meeting of the American Psychological Association, Toronto, Ontario.

Kumar, A., Ali, M., Kumar, R., Kumar, M., Sagar, P., Pandey, R. K., ... & Ghosh, A. K. (2021). Arsenic exposure in Indo Gangetic plains of Bihar causing increased cancer risk. *Scientific Reports, 11*(1), 1-16.

Kumar, S., & Singh, R. (2020). Strategies Of Implementating Drinking Water Project Under Jal Jeevan Mission In Bihar. *Journal of Natural Remedies, 20*(4), 28-35.

Kuo, H. M., Su, J. Y., Wang, C. H., Kiatsakared, P. & Chen, K. Y. (2021). Place Attachment and Environmentally Responsible Behavior: The Mediating Role of Destination Psychological Ownership. *Sustainability*, *13*(12), 6809.

Kyessi, A. & Ka'Bange, A. (2014). Sense of ownership in municipal water provision and Management: The case of Tabata community water supply in Dar es Salaam. *African Resources Development Journal, 1*.

Kwon, S. (2020). Understanding user participation from the perspective of psychological ownership: The moderating role of social distance. *Computers in Human Behavior, 105*, 106207.

Lachapelle, P. R. & McCool, S. F. (2005). Exploring the concept of "ownership" in natural resource planning. *Society and Natural resources, 18*(3), 279-285.

Ladan, S., Nordin, N. B., & Belal, H. M. (2017). Does knowledge based psychological ownership matter? Transformational leadership and knowledge hiding: A proposed framework. *Journal of Business and Retail Management Research, 11*(4), 60-67.

Lee, H., Yang, S. B. & Koo, C. (2019). Exploring the effect of Airbnb hosts' attachment and psychological ownership in the sharing economy. *Tourism Management, 70*, 284-294.

LePine, J. A., Erez, A., & Johnson, D. E. (2002). The nature and dimensionality of organizational citizenship behavior: a critical review and meta-analysis. *Journal of applied psychology, 87*(1), 52.

Lerner, J. S., & Tetlock, P. E. (1999). Accounting for the effects of accountability. *Psychological bulletin, 125*(2), 255.

Lessard-Bonaventure, S. & Chebat, J. C. (2015). Psychological ownership, touch, and willingness to pay for an extended warranty. *Journal of Marketing Theory and Practice, 23*(2), 224-234.

Li, J., Yuan, L., Ning, L. & Li-Ying, J. (2015). Knowledge sharing and affective commitment: the mediating role of psychological ownership. *Journal of Knowledge Management, 19*(6), 1146-1166. https://doi.org/10.1108/JKM-01-2015-0043

Litwinski, L. (1947). The psychology of "mine". *Philosophy, 22*(83), 240-251.

Liu, J., Wang, H., Hui, C. & Lee, C. (2012). Psychological ownership: How having control matters. *Journal of Management Studies, 49*(5), 869-895.

Liu, Y., Qu, Z., Meng, Z. & Kou, Y. (2021). Environmentally responsible behavior of residents in tourist destinations: the mediating role of psychological ownership. *Journal of Sustainable Tourism*, 1-17.

Madajewicz, M., Tompsett, A., & Habib, M. A. (2021). How does delegating decisions to communities affect the provision and use of a public service? Evidence from a field experiment in Bangladesh. *Journal of Development Economics, 150*, 102609.

Malolo, R., Kumwenda, S., Chidziwisano, K., Kambala, C. & Morse, T. (2021). Social outcomes of a community-based water, sanitation and hygiene intervention. *Journal of Water, Sanitation and Hygiene for Development, 11*(3), 483-493.

Manikutty, S. (1997). Community participation: so what? Evidence from a comparative study of two rural water supply and sanitation projects in India. *Development Policy Review, 15*(2), 115-140.

Marks, S. J. & Davis, J. (2012). Does user participation lead to sense of ownership for rural water systems? Evidence from Kenya. *World Development, 40*(8), 1569-1576.

Marks, S. J., Komives, K., & Davis, J. (2014). Community participation and water supply sustainability: evidence from handpump projects in rural Ghana. *Journal of Planning Education and Research, 34*(3), 276-286.

Marks, S. J., Onda, K. & Davis, J. (2013). Does sense of ownership matter for rural water system sustainability? Evidence from Kenya. *Journal of Water, Sanitation and Hygiene for Development*, *3*(2), 122-133.

Martínez-Santos, P. (2017). Does 91% of the world's population really have "sustainable access to safe drinking water"?. *International Journal of Water Resources Development, 33*(4), 514-533.

Matilainen, A. & Lähdesmäki, M. (2021). Who does the moose belong to?–Legitimation of collective psychological ownership. *Journal of Rural Studies*, *86*, 236-246.

Matilainen, A., Pohja-Mykrä, M., Lähdesmäki, M. & Kurki, S. (2017). "I feel it is mine!"– Psychological ownership in relation to natural resources. *Journal of Environmental Psychology*, *51*, 31-45.

Mayhew, M. G., Ashkanasy, N. M., Bramble, T. & Gardner, J. (2007). A study of the antecedents and consequences of psychological ownership in organizational settings. *The Journal of social psychology, 147*(5), 477-500.

Mazar, A. & Wood, W. (2022). Illusory Feelings, Elusive Habits: People Overlook Habits in Explanations of Behavior. *Psychological Science*, 09567976211045345.

McIntyre, N., Srivastava, A., & Fuller, J. A. (2009). The relationship of locus of control and motives with psychological ownership in organizations. *Journal of Managerial Issues 21*(3), 383-401.

Menard, P., Warkentin, M. & Lowry, P. B. (2018). The impact of collectivism and psychological ownership on protection motivation: A cross-cultural examination. *Computers & Security, 75*, 147-166.

Meyer, J. P., & Allen, N. J. (1991). A three-component conceptualization of organizational commitment. *Human resource management review, 1*(1), 61-89.

Meyer, J. P., & Herscovitch, L. (2001). Commitment in the workplace: Toward a general model. *Human resource management review, 11*(3), 299-326.

Mishra, S., Malhotra, G., Chatterjee, R. and Kareem Abdul, W. (2022), "Ecological consciousness and sustainable purchase behavior: the mediating role of psychological ownership", Asia Pacific Journal of Marketing and Logistics, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/APJML-08-2021-0591

Mohan, R. R. (2009). Rural water supply in India: Trends in institutionalizing people's participation. *Water international, 28*(4), 442-453.

Moore, M. (2012). Natural resources, territorial right, and global distributive justice. *Political Theory, 40*(1), 84-107.

Morewedge, C. K. (2021). Psychological ownership: Implicit and explicit. *Current opinion in psychology, 39*, 125-132.

Mosler, H. J. (2012). A systematic approach to behavior change interventions for the water and sanitation sector in developing countries: a conceptual model, a review, and a guideline. *International journal of environmental health research, 22*(5), 431-449.

Ng, J. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-determination theory applied to health contexts: A meta-analysis. *Perspectives on Psychological Science, 7*(4), 325-340.

Ng, S. M., & Su, X. (2018). An investigation into the correlates of collective psychological ownership in organizational context. *Cogent Psychology, 5*(1), 1470484.

Nijs, T., Martinovic, B., Verkuyten, M. & Sedikides, C. (2021). 'This country is OURS': The exclusionary potential of collective psychological ownership. *British Journal of Social Psychology, 60*(1), 171-195.

O'Driscoll, M. P., Pierce, J. L., & Coghlan, A. M. (2006). The psychology of ownership: Work environment structure, organizational commitment, and citizenship behaviors. *Group & Organization Management, 31*(3), 388-416.

Olckers, C. (2013). Psychological ownership: Development of an instrument. *SA Journal of Industrial Psychology, 39*(2), 1-13.

Olckers, C. & Du Plessis, Y. (2012). The role of psychological ownership in retaining talent: A systematic literature review. *SA Journal of Human Resource Management, 10*(2), 1-18.

Olckers, C., & Zyl, L. V. (2017). Measuring psychological ownership: A critical review. *Theoretical orientations and practical applications of psychological ownership*, 61-78.

Ormsby, A. A. & Bhagwat, S. A. (2010). Sacred forests of India: a strong tradition of community-based natural resource management. *Environmental Conservation, 37*(3), 320-326.

Paige, S. R., Miller, M. D., Krieger, J. L., Stellefson, M. & Cheong, J. (2018). Electronic health literacy across the lifespan: measurement invariance study. *Journal of medical Internet research, 20*(7), e10434.

Pant Y. *The Effectiveness and Outcomes of Approaches to Functionality of Drinking Water and Sanitation Schemes*: Water and Infrastructure Series 2013/1. Lalitpur, Nepal; 2014.

Paré, G., Sicotte, C. & Jacques, H. (2006). The effects of creating psychological ownership on physicians' acceptance of clinical information systems. *Journal of the American Medical Informatics Association, 13*(2), 197-205.

Paundra, J., Rook, L., van Dalen, J. & Ketter, W. (2017). Preferences for car sharing services: Effects of instrumental attributes and psychological ownership. *Journal of environmental psychology, 53*, 121-130.

Peck, J., Kirk, C. P., Luangrath, A. W. & Shu, S. B. (2021). Caring for the commons: Using psychological ownership to enhance stewardship behavior for public goods. *Journal of Marketing, 85*(2), 33-49.

Peck, J., & Luangrath, A. W. (2018). *Looking ahead: Future research in psychological ownership.* In Psychological ownership and consumer behavior (pp. 239-258). Springer, Cham.

Podgorski, J. & Berg, M. (2020). Global threat of arsenic in groundwater. *Science, 368*(6493), 845-850.

Pierce, J. L., & Jussila, I. (2010). Collective psychological ownership within the work and organizational context: Construct introduction and elaboration. *Journal of Organizational Behavior, 31*(6), 810-834.

Pierce, J. L., Jussila, I., & Cummings, A. (2009). Psychological ownership within the job design context: Revision of the job characteristics model. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior, 30*(4), 477-496.

Pierce, J. L., Jussila, I., & Li, D. (2018). Development and validation of an instrument for assessing collective psychological ownership in organizational field settings. *Journal of Management & Organization, 24*(6), 776-792.

Pierce, J. L., Kostova, T. & Dirks, K. T. (2001). Toward a theory of psychological ownership in organizations. *Academy of management review, 26*(2), 298-310.

Pierce, J. L., Kostova, T. & Dirks, K. T. (2003). The state of psychological ownership: Integrating and extending a century of research. *Review of general psychology, 7*(1), 84-107.

Pierce, J. L., O'Driscoll, M. P. & Coghlan, A. M. (2004). Work environment structure and psychological ownership: The mediating effects of control. *The Journal of social psychology, 144*(5), 507-534.

Pierce, J. L., & Rodgers, L. (2004). The psychology of ownership and worker-owner productivity. *Group & Organization Management, 29*(5), 588-613.

Pierce, J. L., Rubenfeld, S. A., & Morgan, S. (1991). Employee ownership: A conceptual model of process and effects. *Academy of Management review, 16*(1), 121-144.

Poutsma, E., & Kaarsemaker, E. (2015). Added value of employee financial participation. In *Human Resource Management Practices* (pp. 181-196). Springer, Cham.

Prasain, J. N. (2003). Development of water supply and sanitation facility in the rural areas of Nepal: An overview. *Occasional Papers in Sociology and Anthropology, 8*, 105-127.

Preston, S. D. & Gelman, S. A. (2020). This land is my land: Psychological ownership increases willingness to protect the natural world more than legal ownership. *Journal of environmental psychology, 70*, 101443.

Raffelsberger, H., & Hällbom, M. (2009). *Components of identity and the family firm: An exploratory study of influences on the micro-process of strategy and firm level outcomes*. Jönköping University, Jönköping, Sweden.

Rantanen, N., & Jussila, I. (2011). F-CPO: A collective psychological ownership approach to capturing realized family influence on business. *Journal of Family Business Strategy, 2*(3), 139-150.

Richards, L. A., Parashar, N., Kumari, R., Kumar, A., Mondal, D., Ghosh, A. & Polya, D. A. (2022). Household and community systems for groundwater remediation in Bihar, India: Arsenic and inorganic contaminant removal, controls and implications for remediation selection. *Science of The Total Environment*, 154580.

Risse, M. (2015). The human right to water and common ownership of the Earth. *Political Theory Without Borders, 9*, 46.

Robinson, S. L., & Bennett, R. J. (1995). A typology of deviant workplace behaviors: A multidimensional scaling study. *Academy of management journal, 38*(2), 555-572.

Rochat, P. (2011). Possession and morality in early development. *New directions for child and adolescent development, 2011*(132), 23-38.

Rochat, P., Robbins, E., Passos-Ferreira, C., Oliva, A. D., Dias, M. D., & Guo, L. (2014). Ownership reasoning in children across cultures. *Cognition, 132*(3), 471-484.

Rousseau, D. M. (1998). Why workers still identify with organizations. *Journal of Organizational Behavior*, 217-233.

Rossano, F., Rakoczy, H., & Tomasello, M. (2011). Young children's understanding of violations of property rights. *Cognition, 121*(2), 219-227.

Rudmin, F. W. (1988). Dominance, social control, and ownership: A history and a cross-cultural study of motivations for private property. *Behavior Science Research, 22*(1-4), 130-160.

Rudmin, F. W. (1991). " To Own is to be Perceived to Own": A Social Cognitive Look at the Ownership of Property. *Journal of Social Behavior and Personality, 6*(6), 85.

Rudmin, F. W. (1994a). Cross-cultural psycholinguistic field research: Verbs of ownership and possession. *Journal of cross-cultural psychology, 25*(1), 114-132.

Rudmin, F. W. (1994b). Gender differences in the semantics of ownership: A quantitative phenomenological survey study. *Journal of Economic Psychology, 15*(3), 487-510.

Rudmin, F. (2016). The consumer science of sharing: A discussant's observations. *Journal of the Association for Consumer Research, 1*(2), 198-209.

Rudmin, F. W. & Berry, J. W. (1987). Semantics of ownership: A free-recall study of property. *The Psychological Record, 37*(2), 257-268.

Salimi, Y., Shahandeh, K., Malekafzali, H., Loori, N., Kheiltash, A., Jamshidi, E., ... & Majdzadeh, R. (2012). Is community-based participatory research (CBPR) useful? A systematic review on papers in a decade. *International journal of preventive medicine, 3*(6), 386.

Salinger, A. P., Sclar, G. D., Dumpert, J., Bun, D., Clasen, T. & Delea, M. G. (2020). Sanitation and Collective Efficacy in Rural Cambodia: The Value Added of Qualitative Formative Work for the Contextualization of Measurement Tools. *International journal of environmental research and public health, 17*(1), 1.

Sarkar, S. K., & Bharat, G. K. (2021). Achieving Sustainable Development Goals in water and sanitation sectors in India. *Journal of Water, Sanitation and Hygiene for Development, 11*(5), 693-705.

Sharma, S. (2000). Managerial interpretations and organizational context as predictors of corporate choice of environmental strategy. *Academy of Management journal, 43*(4), 681-697.

Sheeran, P., & Webb, T. L. (2016). The intention–behavior gap. *Social and personality psychology compass, 10*(9), 503-518.

Shu, S. B. & Peck, J. (2011). Psychological ownership and affective reaction: Emotional attachment process variables and the endowment effect. *Journal of Consumer Psychology, 21*(4), 439-452.

Shukla, A., & Singh, S. (2015). Psychological ownership: scale development and validation in the Indian context. *International Journal of Indian Culture and Business Management, 10*(2), 230-251.

Sieger, P., Zellweger, T. & Aquino, K. (2013). Turning agents into psychological principals: aligning interests of non-owners through psychological ownership. *Journal of Management Studies, 50*(3), 361-388.

Singh, S. K., Ghosh, A. K., Kumar, A., Kislay, K., Kumar, C., Tiwari, R. R., ... & Imam, M. D. (2014). Groundwater arsenic contamination and associated health risks in Bihar, India. *International Journal of Environmental Research, 8*(1), 49-60.

Singh, S. K. (2015). *Assessing and mapping vulnerability and risk perceptions to groundwater arsenic contamination: Towards developing sustainable arsenic mitigation models.* Montclair State University.

Singh, S. K. (2017). An analysis of the Cost-effectiveness of Arsenic mitigation technologies: Implications for public policy. *International Journal of Sustainable Built Environment, 6*(2), 522-535.

Sonego, I. L., Huber, A. C. & Mosler, H. J. (2013). Does the implementation of hardware need software? A longitudinal study on fluoride-removal filter use in Ethiopia. *Environmental Science and Technology, 47*(22), 12661-12668. https://doi.org/10.1021/es402787s

Storz, N., Martinović, B., Verkuyten, M., Žeželj, I., Psaltis, C. & Roccas, S. (2020). Collective psychological ownership and reconciliation in territorial conflicts. *Journal of Social and Political Psychology, 8*(1), 404-425.

Sudbury-Riley, L., FitzPatrick, M. & Schulz, P. J. (2017). Exploring the measurement properties of the eHealth literacy scale (eHEALS) among baby boomers: a multinational test of measurement invariance. *Journal of Medical Internet Research, 19*(2), e5998.

Süssenbach, S., & Kamleitner, B. (2018). *Psychological Ownership as a Facilitator of Sustainable Behaviors.* In J. Peck & S. B. Shu (Eds.), Psychological Ownership and Consumer Behavior (pp. 211–225). Springer International Publishing. https://doi.org/10.1007/978-3-319-77158-8_13

Suhardiman, D., Clement, F. & Bharati, L. (2015). Integrated water resources management in Nepal: key stakeholders' perceptions and lessons learned. *International Journal of Water Resources Development, 31*(2), 284-300.

Tajfel H. (1981) *Human groups and social categories: Studies in social psychology.* Cambridge, England: Cambridge University Press.

Tomberge, V. M. J., Harter, M. & Inauen, J. (2021). The importance of collective and individual psychological ownership for safe sanitation: A multilevel analysis in rural Ghana. *Global Public Health*, 1-16.

Tosi Robinson, D., Schertenleib, A., Kunwar, B. M., Shrestha, R., Bhatta, M. & Marks, S. J. (2018). Assessing the impact of a risk-based intervention on piped water quality in rural communities: The case of mid-western Nepal. *International journal of environmental research and public health, 15*(8), 1616.

Ullah, I., Wisetsri, W., Wu, H., Ali Shah, S. M., Abbas, A., & Manzoor, S. (2021). Leadership styles and organizational citizenship behavior for the Environment: The mediating role of self-efficacy and psychological ownership. *Frontiers in Psychology, 12*, 2484.

Vandewalle, D., Van Dyne, L. & Kostova, T. (1995). Psychological ownership: An empirical examination of its consequences. *Group & Organization Management, 20*(2), 210-226.

Van Dyne, L., & Pierce, J. L. (2004). Psychological ownership and feelings of possession: Three field studies predicting employee attitudes and organizational citizenship behavior. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior, 25*(4), 439-459.

Verkuyten, M. & Martinovic, B. (2017). Collective psychological ownership and intergroup relations. *Perspectives on Psychological Science, 12*(6), 1021-1039.

Viglia, G., Tassiello, V., Gordon-Wilson, S. & Grazzini, L. (2019). Predicting consumers' cheating behavior. The role of mental representation of goods and psychological ownership. *Psychology & Marketing, 36*(11), 1039-1045.

Villanueva, C. M., Kogevinas, M., Cordier, S., Templeton, M. R., Vermeulen, R., Nuckols, J. R., ... & Levallois, P. (2014). Assessing exposure and health consequences of chemicals in drinking water: current state of knowledge and research needs. *Environmental health perspectives, 122*(3), 213-221.

Wagner, S. H., Parker, C. P., & Christiansen, N. D. (2003). Employees that think and act like owners: Effects of ownership beliefs and behaviors on organizational effectiveness. *Personnel Psychology, 56*(4), 847-871.

Wang, L., Law, K. S., Zhang, M. J., Li, Y. N., & Liang, Y. (2019). It's mine! Psychological ownership of one's job explains positive and negative workplace outcomes of job engagement. *Journal of Applied Psychology, 104*(2), 229.

Webster, J., Brown, G., Zweig, D., Connelly, C.E., Brodt, S. and Sitkin, S. (2008), "Beyond knowledge sharing: Withholding knowledge at work", Martocchio, J.J. (Ed.) *Research in Personnel and Human Resources Management (Research in Personnel and Human Resources Management, Vol. 27*), Emerald Group Publishing Limited, Bingley, pp. 1-37. https://doi.org/10.1016/S0742-7301(08)27001-5

Whittington, D., Davis, J., & McClelland, E. (1998). Implementing a demand-driven approach to community water supply planning: A case study of Lugazi, Uganda. *Water International, 23*(3), 134–145. https://doi.org/10.1080/02508069808686760

World Health Organization. (2011). *Guidelines for drinking-water quality*. WHO.

World Health Organization, & UNICEF. (2017). *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baseline*. UNICEF & World Health Organization.

Zadeh, B. S., & Ahmad, N. (2010). Participation and community development. *Current Research Journal of Social Sciences, 2*(1), 13-14.

Zuzani, P. N., Ackim, R., & Kalulu, K. (2013). Sustainability of piped water supply schemes in rural Malawi through community management. *Journal of Basic and Applied Scientific Research, 3*(10), 113-118.

Supplementary materials

Supplementary materials of the articles and original articles published can be found online:

https://osf.io/kcf6j/

S1: Supplementary materials to Article 1: The Role of Psychological Ownership in Safe Water Management: A Mixed-methods Study in Nepal

S2: Supplementary materials to Article 2: Contextualized Measurement Scale Adaptation: A 4-Step Tutorial for Health Psychology Research

S3: Supplementary materials to Article 3: Can Participation Promote Psychological Ownership of a Shared Resource? An Intervention Study of Community-based Safe Water Infrastructure

S4: Supplementary materials to Article 4: Individual Behaviour and Communal Effort Combined Provide Best Chances for Sustainability of Shared Resources: A Cluster-randomized Controlled Trial from Bihar, India

S1) Supplementary materials to Article 1: The Role of Psychological Ownership in Safe Water Management: A Mixed-methods Study in Nepal

The Role of Psychological Ownership in Safe Water Management:

A Mixed-methods Study in Nepal

ANNEX

APPENDIX TABLE A1.

Items included for data analysis

Concept	Items
Psychological ownership	How much do you agree with the following statement? 1 = agree not at all to 5 = agree very much - This is MY water system - This is out COMMUNITYS water system. - My family is one of the owners of the water system - The water system is owned by all the people who live in this village.

Routes	
Involvement HH in water supply system	Is anyone in this household involved in the water supply system in this community? Female community health volunteer Village maintenance worker Member of WSP team[a] Member of WUSC[b] No other
Decision making on level of service	During PLANNING of the water system, did anyone in your family participate in deciding about the level of service to be delivered by the system? yes I don't know no
Perceived influence during planning and construction	Overall, who do you think had the MOST influence over decisions about the water system during planning and construction? Donor or Ngo[c] Local government Village leaders All users of the scheme Water committee Other
WUSC meeting discussions on water scheme	How often does WUSC meet with water users to discuss issues about the water system? Bi-monthly Once every 3 months Once every 6 months As needed Once per year Monthly Never Don't know
Knowledge existence of VMW	Is there a village maintenance worker (VMW) to look after your main drinking water scheme? Yes/ No

Concept	Items
Contribution cash Contribution labor Contribution materials	Did your family contribute any of the following toward the construction of the village's water system? cash labor materials meals / lodging nothing I don't know
Consequences	
Self-reported functionality	Is your main drinking water source functioning now? No, not functioning Yes, functioning but not well Yes, functioning well
Expected functionality	Do you think the main drinking water source will be functional one year from now? Yes/ No
Interruption:	In the last 6 months, were there any times when water from main drinking water source was not available for more than one week? Yes/ No
Confidence in reparation:	If main drinking water scheme needed repairs, how confident are you that the problem could be fixed within 1 week? 1 = not at all confident to 5 = very confident
Perceived safeness of main water source	How safe do you think your main drinking water source is for drinking? -2 = Very safe to 2 = Very risky How do you perceive the taste of drinking water from your main drinking water source right now?
Perceived water taste:	Good Rusty Salty soil Varies from rainy to dry months Which water source do you use as MAIN drinking water source? Do you also use other water sources for drinking?
Exclusive use of water scheme	Piped water in the house or yard (Private tap) Piped water in the village Rainwater harvesting Open source (dug well, pond, spring) Protected source (well, spring) Unmanaged piped system River, Stream or Canal Lake Bottled Water
Treatment after collection from water scheme	*Filtered for water system users:* Do you use any method to treat your drinking water? Yes / No

Note. [a] WSP team = water safety planning team [b] WUSC = water users committee [c] NGO = non-governmental organization

APPENDIX TABLE A2.

Sample guideline for qualitative interview.

Introduction and inclusion criterion

Hello. My name is … and this is …. I am working with [BLINDED FOR REVIEW] on a study of water services and quality of life here in Mid-Western Region.

1. Are you responsible for water supply for this family? [*If individual is not responsible, ask to speak to a head of household and begin introduction again*.]

2. For the interview we need families with water filters at home therefore we would like to know if you have a water filter at home? *[If no, come to an end and find a new household] [If yes, proceed to consent]*

Date:

ID of respondent:

Thank you for taking the time for this interview. As mentioned, my name is _____ and this is _____ We work for [BLINDED FOR REVIEW].

Observation

Is the filter broken? Does it look in use? How is the behavior of the respondent?

Part 0: Stakeholder

[These questions just have to be asked if the respondent has a special position in the community]

1) What is your position? And since when are you in that position?
2) What are your responsibilities, your tasks? Do you have special tasks and rights regarding the water system than the other people of the community?
3) Why did you want the position and how did you get the position (election etc.)?
4) What changes did you make and what changes do you want to make?
5) In the PAST YEAR, about how many meeting did the water committee hold amongst itself to discuss matters related to the water system?

Part 1: Free Exploration Water System

First, we would like you to explain **where your drinking water is from.**

Knowledge and Involvement
Can you explain me how your water system works? When was it built and finished? What was there before the actual system?
WHO was it that INITIATED the water project? During the planning phase of the water system, in what decisions could you participate? (level of service delivered, Water tariff design, Contribution level) Who was responsible for building it. Which parties have been involved in the building process? What decisions were made during the construction and who could finally decide? Who is responsible for ensuring that the systems properly works? Who maintain the system? When it is broken would YOU fix it or are there other people responsible?(Who)

Where do you get the money from, when there is any problem in the system?

Self-investment and contribution
What are your tasks and responsibilities for the system? How much money and how much labor did you contribute? What did families and/or village leaders contribute toward the construction of the water system If you have any problems with the system, who would you ask for help? How high is the chance that your problems will be solved?

Attitude, Conflicts and restrictions
Do you use different system or just one? What were your fears and hopes before they started the project? What are your feelings now? How important is it to have that water system for you and why?
Do you think the system meets ALL the water demands of the village members? Are there any RESTRICTIONS on how water from the piped system can be used? Are there any water-related conflicts in the village?

Free Exploration Water Filter

Can you explain me, **what was the reason to buy a filter?**

Investment
When and where did you buy it? How much did you pay? Who decide to get a filter? Who gave it to you? Who is in charge for maintenance of the filter?
Knowledge
Can you explain me, how the filter works? Where did you get the information from?
Attitude
What are your feelings about the filter? Do you feel safe to drink from the filter? How often do you use it? How often do you clean it? Which aspects of the water service are you dissatisfied with?

Part 2: Exploration of Ownership

1) **In your own words, can you tell me what ownership means to you?**
   Further questions you might ask:

   - What items belong to you personally/ family/ village/ greater public?
   - What is the difference between items that belong to you personally and to your family or to the community?
   - Some items may not belong to you, but you may feel as if though they also belonged to you (e.g. because you use them often) any items where you have this feeling? E.g. husband's mobile phone, field is on the name of your husband bur you maintain it?

2) **Let's think of the drinking water system in your village: Can you explain, who owns it?**
   Further questions you might ask:

- Who owns the land where the water system is? Are different owners for the land where the pipelines go through, Source, RVT?
- Do people have different rights, if the water filter is on their land?
- Who pays for the water system? Who paid initially? Who pays for use?
- Who may use the water system? Who may not use it?
- Do you feel responsible that the water system works properly?

3) How IMPORTANT would you say the water system is to the LIVELIHOODS of people in this village?

Further questions you might ask:

- Why is it important / not important?

- What else is important for the LIVELIHOODS of people in this village?

- What is the most important thing for you and your family?

4) Now, let's think of the drinking water filter in your home: Can you explain, who owns it?
Further questions you might ask:

- Is your water filter working? Do you have problems to use it?
- Who is responsible for ensuring the water filter works properly? Do you feel responsible?
- Who may use the water filter? Who may not use it?
- Are there different tasks between different people of the family? (Husband/ Wife/ Children)

5) How IMPORTANT would you say the water filter is to the LIVELIHOODS of you and your family?

Further questions you might ask:

- Why is it important / not important?

- Which problems can be caused without having the filter? Which benefits?

- Are other treatments important for the livelihood? Do you use other treatments? Which is more effective?

- How many people are using the filter in your community?

Part 3: Picture Task Items

How true is it that: This is my…

How much do you own the following things? Please assign the pictures to the dots. The dots indicate how much you feel that you own an item. The bigger the dot, the greater the feeling of ownership. Multiple pictures can be assigned to the same dot. Please note that these pictures are just examples of items. Think of your personal items (e.g. your own water filter), the questions should be answered for your personal items.

[Attention! People tend to rank the items according to the importance]

Picture Task: Forced Choice

Please rank the following items from the one you own the most to the least.

- This is my water filter (Filter)
- This is my mobile phone (Phone)
- This is my Tap (Tap)
- This is my Water System (Water System)
- This is my Toothbrush (Toothbrush)
- This is my School (School)
- This is my House (House)

Picture Task: Owners

Which party owns the system the most? Please rank the following pictures.

- Helvetas
- Local NGO
- Government
- I
- Family
- Community

Part 4: Think Aloud

Now, we would like to talk to you about your and your family's "feeling of ownership" towards your water system and your water filter. We would like to understand **how you choose your answer**. To do this, I am going to ask you to "think-aloud" as you complete the questionnaires. I want you to tell me everything that you are thinking as you hear each question and **decide how to answer it**. Please try to explain how and why you choose your answer I will ask you some further questions, if you are silent for any longer period of time.

We will move on to the questions, please keep in mind, that you should tell me everything that you are thinking.

Instruction

Think about the home, animals or furniture that you own or co-own with someone, and the experiences and feelings associated with the statement 'THIS IS MY (OUR) HOUSE!' The next questions deal with the 'sense of ownership' that you feel for the water system in your village.

1) **This is MY water system.** *[Use scale]*
   - What do you understand with under the term water system? (tap, whole system, RVT)
   - Is everything that belongs to you also belonging to your family?
   - What makes it to YOUR system? (Labor, money, importance, decisions about it.)
   - Why do you think the water system is (not at all....very) YOURS?
   - Did you always find the water system as yours? Or has it changed over time?

   2) **This is OUR COMMUNITY`s water system.** *[Use scale]*
- Is there something (else) that belongs to everybody (school/temple etc.)?
- Is there a difference of the feeling of Ownership between your system and your community's system?
- Why is it (not at all…very) your community`s water system? What makes it the system belonging to all the community?

   3) **It is hard for me to think about this water system as MINE.** *[Use scale]*
- Would it be different if you could decide more / less about the system?
- What do you think about the water system? Do you like it / dislike it, is it safe, enjoyable?
- Are you agree with all decisions about the water system?
- Do you want to change something? (Private / public tap? Nearer tap stand? Treatment in system level? Better maintenance?)

   4) **My family is one of the owners of the water system.** *[Use scale]*
- Why is it (not at all-very) true that your family is one of the owners?
- Are other families more responsible for the system?
- Are there other owners? NGO, elite, WUSC, etc.?
- Does your family's opinion about the system has any influence?
- Are there any health issues related to your drinking water system?

Now let's talk about your water filter you have in your home.

   5) **This is my water filter.***[Use scale]*
- What are the benefits / problems of having a filter?
- Is the water from your filter safe to drink?
- Is the water without filter safe to drink?

   6) **This is OUR FAMILY`s water filter.** *[Use scale]*
- Are all members of your family using the filter?
- How often are you using the filter?
- To which occasions are you using the filter?
- How important is it for your children to drink treated water?
- Is your filter in good conditions?

   7) **It is hard for me to think about this water filter as MINE.** *[Use scale]*
- Would you repair / buy a new filter when it breaks?
- Why is it (not at all…very) hard for you to think about this water filter as YOURS?
- Did you treat the water before having a filter? How?

Part 5: Probing

1)   Which questions were difficult for you to answer?

2)   Did you have challenges in rating the level of agreement?

3)   Is any questions irrelevant in your opinion?

4)   Is any questions missing in your opinion?

Part 6: Sociodemographic questions

Finally, I have some personal questions. Again, we will keep this information strictly anonymous:

What is your ethnicity?

How old are you?

What are your household's monthly expenses?:

What is your highest education?

Gender:

Name:

District:

Municipality:

Phone Number:

We are nearing the end of this interview. Thank you very much for your time. You have helped us a lot in better understanding the process of answer choosing. Is there anything we did not mention yet you would like to add? Do you have any questions for us?

Settings, water quality and functioning of community-based water system

Settings, Water quality and Functioning of Community

In this part, the three investigated villages will be briefly described based on the impressions about the village`s condition by the interviewers.

WS_good

The water system "WS_good" is located in the middle of the Surkhet district. In comparison to other villages in the REACH project this was the most developed one, i.e. with a comparatively high socioeconomic status. Most of the houses were made out of stone or wood. A lot of the people are cooking with gas and not with fire. In the village center is an N-cell tower located which enables the villagers to use internet. Most of the interviewed people in the village were Buddhists.

According to the chairperson, 216 families were living in this village. 207 out of the 216 households were facilitated by private taps supplied by one water scheme. This water scheme with private taps had been built three months before we started the interviews (29.05.2018). As this system was very new, the villagers had not faced any problems so far. Only two days before our arrival a heavy rain caused trees to fall and leaves to chock the source. The chairman conducted a community meeting to solve the problem and the villagers cleaned the source four days later. It seemed as if the the whole villagers had a very good relation with the local NGO, which had helped them to get the private taps. Before the new water supply the household had been supplied by 15 public taps whereas the new water system supplied nearly every household with private taps.

The water system was looking very new and modern. No sign of breaking or no damage in the tank. The RVT was properly fenced and locked. Inspection area and cover from the RVT was closed and there is less possibility to enter runoff water during rainy season. The intake, the outlet pipe, the washout and the overflow pipe looked in good condition. There was an air vent in the structure. It had a little leakage in the outlet. The RVT was near to human settlement, so they are facing hazards like toilet nearby, open grazing, cultivation, waste and animal dung.

During the community meeting were just women attending. The woman told us, that 80% of the men are working abroad or in the military and living far away. It was a very welcoming atmosphere. I recognized a very strong community feeling in the meeting.

WS_intermd

The water system "WS_intermd" was located in the Jajarkot district. The 54 Households had 14 public taps. People had quite big houses in this village and most of the houses were made out of mud, some houses were made out of stone. The village looked rather dirty, there was a lot of waste on the ground and a lot of animal dung everywhere. There was some internet connection in the village but not everywhere and it was very slow.

The chairperson seemed drunk. During the interviews a lot of people were complaining about the chairpersons corruption and perceived about his behavior regarding the water scheme to be incompetent. Additionally, he was accused for sexist behavior. The source of the village was in the chairperson's land. Normally, the community buys the land of the source before the construction of the water system. In some cases, the community pays annually a fee to the landowner. This can cause problems, because the property owner can rise the payment.

Four out of the 14 taps were not functioning and seven were leaking. The pipe was exposed on three places as well as leaking in one part. In total approximately 210 meters of the pipe were exposed. Four of the ten sanitary structures were broken.

Tap:

Tap	E.coli	Risk e.coli	Total colif.	Risk total colif.
S2-TAP1	2	Low risk	TNTC	high risk
S2-TAP12	31	intermediate risk	TNTC	high risk
S2-TAP8	18	intermediate risk	TNTC	high risk
S2-TAP9	32	intermediate risk	TNTC	high risk
S2-TAP4	12	intermediate risk	TNTC	high risk
S2-TAP10	24	intermediate risk	TNTC	high risk

Reservoir tank:

Scheme	ID	E.coli	Risk e.coli	Total Colif.	Risk total colif.
S2	S22-RVT1	2	low	TNTC	high
S2	S22-RVT2	23	intermediate	TNTC	high
S2	S22-RVT2-d	27	intermediate	TNTC	high

Household:

Scheme	Household-ID	Sample taken from Filter	Comments	E. coli [CFU/100 ml]	Risk e.coli	Coliforms [CFU/100 ml]	Risk total colif.
2	PS-HH11-S2	Filter		3	low	126	high
2	PS-HH12-S2	No Filter	NO FILTE	TNTC	high	TNTC	high
2	PS-HH13-S2	No Filter	Filter bro	55	intermediate	41	high
2	PS-HH14-S2	Filter		TNTC	high	TNTC	high
2	PS-HH15-S2	Filter		0	low	TNTC	high
2	PS-HH20-S2	Filter		0	low	19	intermediate
2	PS-HH21-S2	Filter		90	intermediate	200	high
2	PS-HH22-S2	Filter		30	intermediate	TNTC	high
2	PS-HH23-S2	No Filter		55	intermediate	41	intermediate

WS_poor

The water system "WS_poor" was located in the Jajarkot district. Households supplied by this water system seemed to be of an average socioeconomic status. Some Villagers had internet connection. The system was eight to nine years old. Many things were not working. 51 households were supplied by eight taps. Three of these were not working and two were leaking. There was a water shortage in the village at the time of the interview. Villagers had to go to another source to fulfill their water demands. The general atmosphere in the village was quite displeased due to the dysfunctions. The chairman seemed quite informed, he had ordered a very good filter from India (0 e.coli and 0 coliforms). The village maintenance worker had no filter at home. During the community meeting, mostly men were attending.

Six out of nine of the sanitary structures were broken and two were leaking. The general impression of the structures was somewhat clean. The pipe was exposed in two places due to landslide and road construction. In total, approximately 210m of the pipeline was exposed. The intake had no protection dam and no cover. It had a crack in the structure and was damaged.

Tap:

Tap	E.coli	Risk e.coli	Total colif.	Risk total colif.
S3-TAP8	36	intermediate risk	TNTC	high risk
S3-TAP7	29	intermediate risk	TNTC	high risk
S3-TAP1	48	intermediate risk	TNTC	high risk
S3-TAP6	27	intermediate risk	TNTC	high risk
S3-TAP5	26	intermediate risk	TNTC	high risk

Reservoir tank:

Scheme	ID	E.coli	Risk e.coli	Total Colif.	Risk total colif.
S3	S23-RVT1	11	intermediate	160	high
S3	S23-RVT1-d	7	low	280	high
S3	S23-RVT2	12	intermediate	240	high

Household:

Scheme	Household-ID	Sample taken from (filter, gagri, gallon, …)	E. coli [CFU/100ml]	Risk e.coli	Coliforms [CFU/100ml]	Risk total colif.
3	PS-HH16-S3	No Filter	3	low	9	low
3	PS-HH17-S3	No Filter	17	intermedia	TNTC	high
3	PS-HH18-S3	Filter	0	low	0	low
3	PS-HH19-S3	No Flter	TNTC	high	TNTC	high

S2) Supplementary materials to Article 2: Contextualized Measurement Scale Adaptation: A 4-Step

Tutorial for Health Psychology Research

Contextualized Measurement Scale Adaptation: A 4-Step Tutorial for Health Psychology Research

Electronic Supplementary Material

Interview guideline grounded theory

Water concerns

-        3) What are the water related problems you are most concerned about?

In the following section the main goal is to have a conversation with the respondent. There are questions (indicated in bold) which have to be asked in this very exact way. And then there are a lot of sub-questions prepared to sum up, what the content of the response should include. The goal now is to let the respondent talk freely and provide us with the information that comes into his mind and at the same time to lead the talk so that we get what we want to learn.

Organization of water system

In this first part of the interview, we'd like to learn from you about the water supply in your village.

-        5) Can you tell me, how water supply is organized?

o   How is the water system during dry season? How is it during rainy season?

o   Who is responsible for collecting water?

o   How many times do you collect water a day at this source?

o   When do you collect the water?

o   What triggers you to go and collect water? What do you do most of the times directly before collecting water?

-        4) What is your first thought when you think of water collection?

o   Where is the closest community filter for you?

o   Why do/don't you collect water there?

o   Who decided that you collect/don't collect water there?

-        7) What is the procedure when you are going to collect water?

o   How long does it take you to collect water?

o   Who else uses this water source?

o   Who takes care of this water source?

o   Do you meet other people when collecting water?

o   What are the benefits of using this water source?

o   What are the disadvantages of using this water source?

- 8) How is this system organized? Who is responsible for which task?

o How much does it cost to collect water?

o Do you think this is a fair fare?

o How much do you pay for maintenance of this water source?

o Who else pays for maintenance of this water source?

o How much did you pay for the installation of this water source?

o Who installed this water source?

o How was the system installed? Can you tell me, how this came about?

o Who looks after the system?

o Who may use the water system? Who may not use it?

o How many people are using the filter in your community?

o What happened to the water before collecting?

- 9) How do you rate the organization of this system?

o How easy is it to access and to use?

o What could be better?

o What is the most preferred water collection option for you? Why?

o If you saw someone damaging or vandalizing the water system, what would you do?

o How IMPORTANT would you say the water filter is to the LIVELIHOODS of you and your family?

o How IMPORTANT would you say the water system is to the LIVELIHOODS of people in this village?

o What else is important for the LIVELIHOODS of people in this village?

- 10) What was there before?

o Were you ever visited by people from NGOs or the government who talked to you about water-related issues?

o What kind of community or group activity regarding water-related issues have been going on in your village?

o What were your fears and hopes before they started the project? What are your feelings now?

o How did you get the filter?

o Who was involved in the construction?

o How useful is it to collect water at this source?

o How easy is it to use?

o   What are barriers for using this water source?

o   What would make the use more convenient for you?

o   What water source did you use before?

o   What is better now? What was better before?

-        11a) What do you think of the water you collect?

o   Do you believe this water source is safe?

o   Has this source ever been tested for arsenic?

o   By whom?

o   Is this source contaminated with other things (e.g. bacteria)?

o   Has this source ever been tested for other indicators of water quality?

o   For which ones?

o   Is this source contaminated with arsenic?

o   Do you think you are at low or high risk to develop an illness when drinking water from this source?

o   How high/low do you think is the risk?

o   What is the risk?

o   Do you think there is something harmful in the water collected from this source?

o   What is it?

o   What does it do that you perceive as harmful?

o   How does it get into the water?

o   How can you clean the water?

o   Which of these substances does the water from this source contain?

o   Is it necessary to purify the water form this substance?

o   How can you purify it?

o   Do you think there is something harmful in the food you cooked with this water?

o   What is it?

o   What does it do that you perceive as harmful?

o   How does it get into the water?

o   How can you clean the water?

o   Which of these substances does the food cooked with water from this source contain?

o   Is it necessary to purify the water form this substance?

o   How can you purify it?

- 11b) How would a water-collection option best be organized for you?

Ownership towards this water system

- 122) Can you give me some examples of what you would say, that you own?

- 121) In your own words, can you tell me what you feel, when you think about these things?

o Can you imagine not actually owning something, but feeling like it's yours?

o What is important to you to feel a certain level of security over a thing: investing the self, knowledge or being in control?

o What is the meaning or the importance of owning?

o What advantages has it, that it is your own?

o What disadvantages has it, that it is your own?

o What items belong to the members of your family together? What items belong to the members of your village together?

o Can you tell me why/how something just belongs to you and other things to your family or village? What is the difference?

- 13) You said you feel you are / are not one of the onwers of the community water filter. Can you explain what makes you feel that the community filter belongs / doesn't belong to you?

o Who decided or decides about the community filter? Can you influence this?

o Can you explain to me, how the drinking water system works? Can you explain me, how the filter works?

o How much did you or how much do you invest into the system?

14) And what are the consequences, when you say the community filter is your own?

o Let's think of the drinking water system in your village: Can you explain, who owns it? Who is responsible for ensuring the system works properly? Do you feel responsible?

o What are your responsibilities for the functioning of the community filter?

☐ E.g. paying money for maintenance and use, making repairs, perhaps also social responsibilities etc.

o What rights do you have when it comes to the community filter?

☐ E.g. using it anytime you like, or fixed amount of water you can get etc.

o   Who else is responsible for the community filter?

☐   What are their tasks? How well are they doing them?

o   Individual and collective ownership – what are your different associations with possession of yourself and shared possession? How do you distinguish these two levels?

Supplementary materials S2:

Interview guideline think aloud reasoning

I am now reading you a couple of statements and sentences on your water system, which you can please complete or tell us what goes through your head. Please think aloud – tell us everything that goes through your mind. It is very important to emphasize that you cannot say anything wrong. What you are thinking is what we are interested in.

-        151: This is my water system.

-        152: This is our community's water system.

-        153: It is hard for me to think about this water system as mine.

-        154: My family is one of the owners of the water system.

-        155. The water system is owned by all the people who live in this village

-        156. This is my filter

-        157. This is OUR FAMILY`s water filter

-        158. It is hard for me to think about this water filter as MINE.

-        159. MY favourite water collection option is…

-        1510. MY FAMILY's favourite water collection option is…

-        1511. OUR favourite water collection option is…

Supplementary materials S3:

Questionnaire

The questionnaire with all the items included in the survey is attached in separate Excel file (PACT_A_HH_Qabbr_V3_retest.xlsx).

Supplementary materials S4:

Fit indices of three dimensional psychological ownership scale

The three-dimensional measurement scale showed acceptable fit indices: a significant chi-square ($\chi 2$ = 187.699, 77 d.f., p < .001), low RMSEA = 0.077 [.063; .091], and moderate CFI = 0.865. Completely standardized factor loadings ranged from 0.305 to 0.725.

After one step of modifications, the shortened three-dimensional measurement scale showed good fit indices: a significant chi-square ($\chi 2$ = 67.419, 27 d.f., p < .001), low RMSEA = 0.082 [.058; .106], and moderate to high CFI = 0.93. Completely standardized factor loadings ranged from 0.454 to 0.769.

S3) Supplementary materials to Article 3: Can Participation Promote Psychological Ownership of a Shared Resource? An Intervention Study of Community-based Safe Water Infrastructure

Can Participation Promote Psychological Ownership of a Shared Resource? An Intervention Study of Community-based Safe Water Infrastructure

Electronic Supplementary Material

1   1. Description of integrated water resources management (IWRM) programme of Helvetas

2   Note that coding of the intervention activities according to behaviour change technique (BCT) taxonomy (Michie et al., 2013) was not fully applicable for this
3   intervention, as not all activities targeted individual behaviour. Further, some intervention components were not accessible in sufficient detail to allow coding
4   the content.

5   Table S1. Integrated water resources management (IWRM) programme of Helvetas

Intervention package	Intervention modules	Description	Behaviour Change Techniques (BCTs)	Participation of Communities
general health and hygiene promotion	Total Sanitation campaign	Sanitation and hygiene education activities are adapted to the local situation (e.g. promotion by household visits or small group meetings), usually focusing on the 5 + 1 indicators of "total sanitation", introduced by the Department of Water Supply and Sewerage (DWSS) in 2012 (http://origin.searo.who.int/nepal/areas/Strategic_Priority_6/en/ http://lib.icimod.org/record/34321/files/Flyer_3.pdf): Use of toilets (awareness of transmission routes of water-borne diseases) Use of safe water (household water treatment and storage) Use of safe food Practice of hand washing with soap Practice of cleaning the household and surroundings Environmental sanitation/keeping the environment clean	1.3 goal setting (outcome) 4.1 instruction on how to perform the behaviour 5.1 information about health consequences 9.1 credible source	NGO: intervention design and training of the target community members, dissemination of information in the community Community: Water Users Committee (WUSC) & Female Community Health Volunteer (FCHV) performing activities and participation *Remark: The campaign was implemented by NGO before this study.*
	Sanitation campaign plus	Additional steps to the Total Sanitation campaign after the whole community is declared as total sanitation village (5+1 indicators completed). Activities include awareness raising, behavior interventions, female community health volunteer (FCHV) hygiene literacy classes and door-to-door visits.	2.1 monitoring of behaviour by others without feedback	

			3.2 social support (practical)	
water supply infrastructure upgrades	Community meetings	Community always more concerned about quantity than quality of water. In community meetings, full support of the community to WUSC and NGO was aimed for, by presenting and explaining why quantity and quality of water supply are important. Skilled manpower selected by the community so differences in construction can happen.	1.9 Commitment	
	Risk assessment / Sanitary inspection	Sanitary inspection and detail survey for the structures were conducted: Selection of skilled manpower and categorization of the work happened.	5.1 information about health consequences 10.2 material reward	NGO: provides information and then leads it with the WUSC. Community: learn from NGO about the structures, they also provide system upgrades suggestions (e.g. when the source protection is discussed) in a collaborative process.
	Source protection	In a risk assessment analysis, the community and NGO jointly analysed what kind of source protection is needed. After, the specific protection is installed.	12.1 restructuring physical environment 12.5 adding objects to the environment	NGO: preparation work, technical design, material supply, construction supervision, training of user's committee for construction Community: preparation work, construction, 20% cash contribution, chlorination management

	Rapid sand filter installation	The size of the chamber, media used, and materials are designed in NGO office and same models are constructed in different schemes. The construction works were carried out through skilled and unskilled human resource of respective village.	2.1 monitoring of behaviour by others without feedback	NGO: Few visits from NGO to the construction sites to minimize the mistakes.
			12.1 restructuring physical environment	Community: WUSC decides among the community who can work in what area/domain. WUSC monitors the work and makes the payment.
			12.5 adding objects to the environment	
	Pipeline and scheme maintenance	Burial of exposed pipes, repair of fittings for leakages, maintenance of cracks in structures, removal of standing water, fences for structures, painting of the structures	12.1 restructuring physical environment	NGO: Supervision
			12.5 adding objects to the environment	Community: WUSC leads the work
	Chlorination	Scheme-level chlorination in selected schemes, assessed by NGO to have a community management good enough to implement this upgrade. Manual chlorination: village maintenance worker (VMW) in charge of daily pouring of proper amount of processed liquid from bleaching powder in reservoir tanks. In-line chlorination: passive chlorination device installed, regular adjustments and chlorine measurements by trained local staff.	12.1 restructuring physical environment 12.5 adding objects to the environment	
managerial practices	Water users' committee support	Assessment of the WUSC in the communities by NGO and support in their role, reform it when needed. NGO advises and organizes meetings, but then the committee is reformed by the community.	12.2 restructuring the social environment	NGO: supports in the formation and training of the committees. Community: WUSC (9-11 members): formation and functioning of committees, health workers and teachers' involvement for laboratory work. Need to take care of the infrastructure, collect water

				tariff, regular monitoring and make the scheme functional.
	Water safety task force (WSTF) support	Assessment of the WSTF in the communities by NGO and support in their role, reform it when needed or form it when non-existent. WSTF leads the water safety planning (WSP).	12.2 restructuring the social environment	NGO: advises and organizes meetings, but then the committee is reformed by the community. Community: WSTF attend WUSC meetings 1per month, check all parts of the schemes.
	Water safety plan preparation	Direct participation of the WUSC and WSTF in the supervision of NGO personnel. Sanitary inspection followed by a formal documentation projecting the corrective measures for water safety within a targeted time frame. Corrective measures identified on existing structures from Source to point of use (i.e, structural safety plan to household water treatment interventions)	12.1 restructuring physical environment 12.5 adding objects to the environment	NGO: staff advises and organizes meetings, but then the identification and implementation is carried by the committee.
	Scheme risks observation training	Training of the communities on behavioral aspects of water users, infrastructure protection and maintenance. Training provided by NGO and DWSS.		NGO: supports the trained staff by regular phone calls/random visits to remind the activities and discuss challenges; the NGO staff pays regular visits to the trained staff to supervise and support the work. Community: The local trained staff is in charge of performing the regular activities (monthly water quality testing and scheme observations every 3 months). The results are

		logged in a notebook to inform the WUSC.
Laboratory coverage	Installation of field laboratories equipped for water quality testing. Training of local staff for water quality sampling and testing, results reporting to WUSC.	

6 *Note:* This table highlights the components of the IWRM programme and how the activities can be coded with regards to behaviour change technique
7 taxonomy and participation of the communities

2. Results: Descriptive statistics for all items

Table S2. Descriptive statistics of all items

	M	*SD*	*f*	*f%*	Coding
Psychological ownership for the water system					
Psychological ownership (baseline)	0.87	0.11			0-1
This is MY drinking water system .	4.75	0.59			0-5
This is OUR COMMUNITY'S drinking water system.	4.57	0.61			0-5
My family is one of the owners of the water system	4.42	0.83			0-5
The water system is owned by all the people who live in this village.	4.25	0.84			0-5
Psychological ownership (endline)	0.81	0.15			0-1
This is MY drinking water system .	4.30	0.78			0-5
This is OUR COMMUNITY S drinking water system.	4.20	0.85			0-5
My family is one of the owners of the water system	4.31	0.71			0-5
The water system is owned by all the people who live in this village.	4.06	0.77			0-5
Psychological ownership as difference (endline-baseline)	-0.07	0.18			0-1
Participatory activities					
Influence					
Committee (Donor, NGO, local government, leaders, WUSC)			163	44.20	0.00
All users			206	55.80	1.00
Decision-making					
No			107	29.00	0.00
Yes			262	71.00	1.00
Involvement of household in planning of water supply					
No			262	71.00	0.00
Yes (FCH volunteer, VMW, WST, WUSC)			107	29.00	1.00
Village maintenance worker					
No			70	19.00	0.00

Yes			299	81.00	1.00
Water users' committee meetings					
Never/Don't know			76	20.60	0.00
As needed			107	29.00	0.33
1 to 6 meetings a year			57	15.40	0.66
Monthly meetings			129	35.00	1.00
Contribution Labour					
No			27	7.30	0.00
Yes			342	92.70	1.00
Contribution Materials					
No			361	97.80	0.00
Yes			8	2.20	1.00
Contribution Cash					
No			155	42.00	0.00
Yes			214	58.00	1.00
Outcomes					
Acceptance					
Perceived water taste	.75	.21			0-1
Liking treated water	.52	.41			-1 - 1
Satisfaction					
Dissatisfied			67	18.20	0.00
Satisfied			302	81.80	1.00
Safeness	-0.03	.73			-1 - 1
Preparatory behaviour					
Caretaking	.81	.19			0-1
Responsibility	.77	.21			0-1
Health behaviour					
Use					
other (Rainwater harvesting, open unprotected source, open protected source, unmanaged piped scheme, river, lake, bottled water)			10	2.70	0.00
piped water scheme (Private tap, community tapstand)			359	97.30	1.00
Exclusive use					
No			24	6.50	0.00
Yes			345	93.50	1.00
Treatment					
Never/Don't know			152	41.20	0.00
Always			217	58.80	1.00
Importance of treatment	.80	.16			0-1

Negative behaviour

	M/f	SD/%f			n	Range/value
Overuse	.27	.32				0-1
Territoriality	.44	.31				0-1
Source switching						
Never/Don't know			213	57.70		0.00
Rarely			54	14.60		0.25
Half of the times			22	6.00		0.50
Most of the times			52	14.10		0.75
Always			28	7.60		1.00
Functionality						
Self-reported functionality						
No (not, not well)			40	10.80		0.00
Yes			329	89.20		1.00
Availability						
No (never, sometimes)			70	19.00		0.00
Yes			299	81.00		1.00
Expected functionality	.68	.27				0-1
Interruption	14.89	12.23				
Confidence in reparation						
Not confident (not at all, somewhat confident)			219	59.3		0.00
Very confident			150	40.7		1.00
Water quality						
E.coli Cat 1 (# = 0)			65	17.60		1.00
E.coli Cat 2 (# = 1-10)			78	21.10		2.00
E.coli Cat 3 (# = 11-100)			130	35.20		3.00
E.coli Cat 4 (# = 101-TNTC)			95	25.70		4.00
Covariate						
Socio-economic status	10144.48	6280.52				

Note: N = 369, f = absolute frequency, %f = relative frequency, n = Total Sample size; M = Mean; SD = Standard deviation; Abbreviations: CFU = Coliform units; FCH = female community health ; TNTC = too numerous to count; VMW = village maintenance worker; WUSC = water user committee; WSTF = water safety task force.

S4) Supplementary materials to Article 4: Individual Behaviour and Communal Effort Combined Provide Best Chances for Sustainability of Shared Resources: A Cluster-randomized Controlled Trial from Bihar, India

Individual Behaviour and Communal Effort Combined Provide Best Chances for Sustainability of Shared Resources: A Cluster-randomized Controlled Trial from Bihar, India

SUPPLEMENTARY MATERIALS

Supplementary materials S1: Intervention Protocol

Village Name		Ward No.		Panchayat Name			Block	
Booklet Colour		Date		Name of interviewer &signature				
Time when left		Arrival time in village		Km travelled		Costs for travel		

Visit No. 1, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1a	Two days before visiting the village: • inform Mukiyah, ward members and PRI members to announce a community meeting on the day of your arrival. • Ask the local health staff for support. • Prepare together with Bharat ji tablets to show the video • Prepare the booklet on arsenic, microbiological contamination of water, & health		

35

1b	Prepare 3 tablets: • Fully charged • Video is showing Prepare health booklet Prepare additional sheets No. 1 & No. 2		
2	Initiate the community meeting by mobilizing the community.		
3	Present yourself and Paridhi, PHED and explain why you visit the community according to the sheet No. 1 provided.		
4	Show the video. **RECORD A VIDEO OF THIS PERFORMANCE!** How many people are present? _____		
5	Inform about arsenic and microbiology. **RECORD A VIDEO OF THIS PERFORMANCE!** • Present health booklet • Tell the villagers all of the information provided on the backpage of the booklet		
6	Inform about upcoming activities & multiple visits of the community according to the sheet No. 2. Thanks to the community you and see you soon!		
7	Repeat the community meeting in other parts of the ward, so that all people can attend and profit from this important information! How many community meetings have you performed in this ward? Number of community meetings: _____		

	Map of the ward:		

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour		Date		Name of interviewer &signature					
Time when left		Arrival time in village		Km travelled			Costs for travel		

Visit No. 1, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members to announce a community meeting on the day of your arrival. • Ask the local health staff for support. • Prepare the booklet on arsenic, microbiological contamination of water, & health		
2	Initiate the community meeting by mobilizing the community.		

3	Present yourself and Paridhi, PHED and explain why you visit the community according to the sheet No. 1 provided. You can mention, that we were already there for the baseline water checking.		
4	Show the pictures. **RECORD A VIDEO OF THIS PERFORMANCE!** How many people are present? _____		
5	Inform about arsenic and microbiology. **RECORD A VIDEO OF THIS PERFORMANCE!** • Present health booklet • Tell the villagers all of the information provided on the backpage of the booklet		
6	Inform about upcoming activities & multiple visits of the community according to the sheet No. 2. Thanks to the community you and see you soon!		
7	Repeat the community meeting in other parts of the ward, so that all people can attend and profit from this important information! How many community meetings have you performed in this ward? Number of community meetings: _____ Map of the ward:		

Sheet No. 1 (Blue & Green)

Thank you for attending this community meeting!

My name is ….. and I come from Bhagalpur. I am member of Paridhi. Paridhi is working together with local health staff and Mahavir Cancer Sansthan, PHED and BSPCB with the kind support of Panchayat Raj. We all together, you and me, we drink water every day. We hope to drink pure water that is clean and safe and of good taste! Unfortunately, it isn't always the case:

Water can be unsafe due to many reasons. Here, in your area, mainly two ways of pollution are often the case:

- Arsenic pollution
- Microbiological contamination

We came already once to this Ward to test some of your water and also to ask you some questions. In the following weeks, there will be construction work on a new safe water scheme going on. During this time of construction, we will come 6 times to visit your community and perform different activities! First of all, we would like to show you, what is going to be constructed:

In a short film, we visit altogether another already constructed water supply scheme and we follow the caretaker, who guides us through all the important parts of the scheme….

Show video.

As you have heard, the filters remove Arsenic and chlorination in case, inactivates microbiological life in water. But why has this to be done?

Show health booklet and read text that is provided.

Sheet No. 1 (Yellow & White)

Thank you for attending this community meeting!

My name is ….. and I come from Bhagalpur. I am member of Paridhi. Paridhi is working together with local health staff and Mahavir Cancer Sansthan, PHED and BSPCB with the kind support of Panchayat Raj. We all together, you and me, we drink water every day. We hope to drink pure water that is clean and safe and of good taste! Unfortunately, it isn't always the case:

Water can be unsafe due to many reasons. Here, in your area, mainly two ways of pollution are often the case:

- Arsenic pollution
- Microbiological contamination

We came already once to this Ward to test some of your water and also to ask you some questions. In the following weeks, there will be construction work on a new safe water scheme going on. During this time of construction, we will come 6 times to visit your community and perform different activities! First of all, we would like to show you, what is going to be constructed:

In this picture, we can see altogether another already constructed water supply scheme and its tapstands where to collect the water.

Show pictures.

As you have heard, the filters remove Arsenic and chlorination in case, inactivates microbiological life in water. But why has this to be done?

Show health booklet and read text that is provided.

Sheet No. 2 (Blue & Green)

- Second visit:

In the second visit, you will decide on 5 people that will form a Water Users Committee to supervise the installation of the infrastructure and that will coordinate complaints and requests of you all to the contracting company that is installing the safe water scheme.

- Third visit

In the third visit, you will decide on several things and vote on different specifications of the safe water scheme, such as the running times when safe water can be collected and you will discuss and decide on how the community and the caretaker share responsibilities for certain repairing & maintenance work.

- Fourth visit

In a fourth visit, you will improve the security of the safe water scheme by installing fences to protect the infrastructure from the animals.

- Fifth visit

In a fifth visit, you will be able to customize your tapstands and the central container of the safe water scheme in their design.

- Sixth visit

In the sixth visit, when all the construction work is completed, you will have the opportunity to talk to an engineer from PHED and the caretaker and other facilitators will give you a guided tour to show and explain you all the infrastructure.

Sheet No. 2 (Yellow & White)

In the future 5 visits, we will visit you regularly, we are always updating you, how the construction work is going on and what the current work is about and how the schedule looks like.

Village Name		Ward No.		Panchayat Name			Block	
Booklet Colour		Date		Name of interviewer &signature				
Time when left		Arrival time in village		Km travelled			Costs for travel	

Visit No. 2, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1a	Two days before visiting the village: • inform Mukiyah, ward members and PRI members to announce a community meeting on the day of your arrival.		
1b	Prepare the checklist for the Water Users Committee (WUSC).		
2	Initiate the community meeting by mobilizing the community.		
3	Inform the community about the current status of construction work.		

	• What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done?		
4a	Form a water users committee (WUSC) according to the sheet No.3. **RECORD A VIDEO OF THIS PERFORMANCE!**		
4b	Write down the name and phone number of every member of the WUSC & the caretaker. Member 1: Name:_____ Phone:_____ Member 2: Name:_____ Phone:_____ Member 3: Name:_____ Phone:_____ Member 4: Name:_____ Phone:_____ Member 5: Name:_____ Phone:_____		

	Caretaker: Name:_____ Phone:_____ **CREATE TOGETHER WITH RAHUL JI A BANNER FOR EVERY HABITATION AND HAND IT OVER TO THE RESPONSIBLE ENUMERATOR!**		
4c	Take a picture of every member of the WUSC & the caretaker.		
4d	Explain the checklist to the WUSC.		
5	Announce the position of caretaker.		
6	Inform about upcoming activities & multiple visits of the community according to the sheet No. 2. Thanks to the community you and see you soon! How many people are present? _____		
7	Meeting with newly elected WUSC, Caretaker, Mukiyah, & Ward members. **RECORD A VIDEO OF THIS PERFORMANCE!** • Explain again the role of the WUSC. • Introduce as a first task the checklist for the WUSC.		

Sheet No. 3

WUSC is a body of 5 representatives of the village. It is not an official PRI body, but it is there to supervise the water supply, coordinate the communication to the contracting company and represent the villagers. If you have ideas or complaints, you can contact the WUSC and the WUSC will then contact the contracting company.

WUSC meets maybe once a week and exchanges what is going on at the safe water scheme. If needed, they will also contact the caretaker and coordinate efforts to contact the contracting company.

There is key role for this community based ware supply scheme: the caretaker. Caretaker is the daily operator of the plant and also is responsible for maintenance work on the plant, such as backwashing, minor repairing work, etc.

WUSC is a complementary committee to the caretaker and is representing all of you, all of the villagers. That is, why WUSC is formed by voting and consist of 5 members: one of every social group needed and at least 1 woman. We are now looking for 5 members of the community that are willing to participate in WUSC.

Initiate voting on WUSC members.

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour		Date		Name of interviewer &signature					
Time when left		Arrival time in village		Km travelled			Costs for travel		

Visit No. 2, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members to announce a community meeting on the day of your arrival.		
2	Initiate the community meeting by mobilizing the community.		
3	Inform the community about the current status of construction work. • What has been done so far? • What were problems in the process? Or what is going on at the moment?		

	• What is going to be done? **RECORD A VIDEO OF THIS PERFORMANCE!**		
4	Inform about upcoming activities & multiple visits of the community according to the sheet No. 2. Thanks to the community you and see you soon! How many people are present? _____		

Village Name		Ward No.		Panchayat Name			Block	
Booklet Colour		Date		Name of interviewer &signature				
Time when left		Arrival time in village		Km travelled			Costs for travel	

Visit No. 3, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1a	Two days before visiting the village: • inform Mukiyah, ward members, WUSC members and PRI members to announce a community meeting on the day of your arrival.		
1b	Prepare the poster of the WUSC & the caretaker to bring to the village.		
1c	Prepare all the material for an IF-THEN plan: • pens • 5 chart paper		
1d	Prepare sheet No. 4 & No. 5.		

2	Meet with the WUSC to exchange information about how the infrastructure installation is going according to sheet No. 4. • Discuss the checklist. • Are there any difficulties with the construction? • How is the contact & exchange with the contracting company going? **RECORD A VIDEO OF THIS PERFORMANCE!** How many times and in what frequency does the WUSC meet?		
3	Initiate the community meeting by mobilizing the community.		
4	Let the WUSC inform community about the ongoing work. • What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done? **RECORD A VIDEO OF THIS PERFORMANCE!**		
5	WUSC should initiate information & voting on several aspects of the community based water scheme. • Every household can choose the spot for installation of tapstands. • Supplementary infrastructure installations of fences & paintings: Ask the community for contribution of cash to organise all the material needed or whether they organise the material for fence-construction themselves. **RECORD A VIDEO OF THIS PERFORMANCE!** Community decides to: O contribute cash -> How much per household?		

	O organise the material themselves. • How many times will the scheme be run per day? _____ • Running times of scheme. At what times will the scheme be run? _____		
6	Create a collective IF-THEN plan according to sheet No. 5 for special incidences. **RECORD A VIDEO OF THIS PERFORMANCE!**		
7	Inform about upcoming activities & multiple visits of the community according to the sheet No. 2. Thanks to the community you and see you soon! How many people are present? _____		

Sheet No. 4

What is the current status of construction work?

How do you describe the relationship to the contracting company?

How do you describe the relationship to PHED?

How do you describe the relationship to the people in the habitation?

Do you feel it is your safe water scheme? Why?

Do you feel it is the safe water scheme of the villagers? Why?

Do you feel it is the safe water scheme of PHED? Why?

What are current challenges in the construction process?

How many times do you meet and what do you discuss?

Sheet No. 5

An IF-THEN plan will help you as a community to deal with a difficult situation at the safe water scheme. Imagine, there has to be done:

- Minor repairs at infrastructure (e.g. a screw is missing, a wire is incomplete, …)
- Major repairs at infrastructure (e.g. leaking pipe)
- Repairs at filter
- Cleaning work
- Change of filter media
- Repairs at tapstands (e.g. broken tap)
- Water is not provided at times.
- Water is of poor quality.

Or many other things! Some of them, the caretaker can do alone. Some of them not. For some of them, the contracting company is responsible.

Develop now a working protocol on the chart paper with tasks & responsibilities of the caretaker:

Page 1: What are the tasks & responsibilities of the Caretaker?

Page 2: What are the tasks & responsibilities of the community?

Page 3: What are the tasks & responsibilities of the WUSC?

Page 4: What is the role of the Contracting company? What is the role of PHED?

Now, you as a community decide, how you all will deal when one of the following things happen:

- Minor repairs at infrastructure (e.g. a screw is missing, a wire is incomplete, …)
- Major repairs at infrastructure (e.g. leaking pipe)
- Repairs at filter
- Cleaning work
- Change of filter media
- Repairs at tapstands (e.g. broken tap)
- Water is not provided at times.
- Water is of poor quality.

And on Page 5 & 6, please write down for all of the cases an IF-THEN plan, what you are going to do.

IF _____ , THEN _____ .

e.g. aus baseline survey

IF _____ , THEN _____ .

IF _____ , THEN _____ .

IF _____ , THEN _____ .

IF _____ , THEN _____ .

IF _____ , THEN _____ .

IF _____ , THEN _____ .

IF _____ , THEN _____ .

IF _____ , THEN _____ .

IF _____ , THEN _____ .

CREATE TOGETHER WITH RAHUL JI A BANNER FOR EVERY HABITATION AND HAND IT OVER TO THE RESPONSIBLE ENUMERATOR!

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour		Date		Name of interviewer &signature					
Time when left		Arrival time in village		Km travelled				Costs for travel	

Visit No. 3, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members to announce a community meeting on the day of your arrival.		
2	Initiate the community meeting by mobilizing the community.		
3	Inform about the ongoing work. • What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done?		

	RECORD A VIDEO OF THIS PERFORMANCE!		
4	Inform about upcoming activities & multiple visits of the community according to the sheet No. 2. Thanks to the community you and see you soon! How many people are present? _____		

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour		Date		Name of interviewer &signature					
Time when left		Arrival time in village		Km travelled				Costs for travel	

Visit No. 4, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1a	Two days before visiting the village: • inform Mukiyah, ward members, WUSC members and PRI members to announce a community meeting on the day of your arrival.		
1b	Prepare the IF-THEN plan to bring to the ward.		
1c	Prepare sheet No. 4.		
2	Meet with the WUSC to exchange information about how the infrastructure installation is going according to sheet No. 4.		

	• Discuss the checklist. • Are there any difficulties with the construction? • How is the contact & exchange with the contracting company going? **RECORD A VIDEO OF THIS PERFORMANCE!**		
3	Initiate the community meeting by mobilizing the community.		
4	Let the WUSC inform community about the ongoing work. • What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done? **RECORD A VIDEO OF THIS PERFORMANCE!**		
5	Inititate together with the WUSC the communities labour contribution and provide the material: • Installation of fences for every tapstand, executed by the villagers. • Installation of flow-meters at the central container, executed by the contracting company. **RECORD A VIDEO OF THIS PERFORMANCE!**		
6	Inform about upcoming activities & multiple visits of the community according to the sheet No. 2. Thanks to the community you and see you soon! How many people are present?		

Village Name		Ward No.		Panchayat Name			Block	
Booklet Colour		Date		Name of interviewer &signature				
Time when left		Arrival time in village		Km travelled			Costs for travel	

Visit No. 4, describe current status of infrastructure work:

Borewell:

Container:

Motorpump:

Filtration unit:

Filter media:

Chlorination unit:

Overhead metal construction & overhead tank:

Backwashing chamber:

Pipelines in village:

Household based tapstands:

General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members to announce a community meeting on the day of your arrival.		
2	Initiate the community meeting by mobilizing the community.		
3	Inform about the ongoing work. • What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done?		

61

	Inform the villagers about the running times and frequency of running of the scheme, as per information of the caretaker. **RECORD A VIDEO OF THIS PERFORMANCE!**		
4	Inform about upcoming activities & multiple visits of the community according to the sheet No. 2. Thanks to the community you and see you soon! How many people are present? _____		
5	Installation of flow meters together with contracting company.		

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour	▮▮	Date		Name of interviewer &signature					
Time when left		Arrival time in village		Km travelled				Costs for travel	

Visit No. 5, describe current status of infrastructure work:

Borewell:

Container:

Motorpump:

Filtration unit:

Filter media:

Chlorination unit:

Overhead metal construction & overhead tank:

Backwashing chamber:

Pipelines in village:

Household based tapstands:

General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members, WUSC members and PRI members to announce a community meeting on the day of your arrival.		
2	Meet with the WUSC to exchange information about how the infrastructure installation is going according to sheet No. 4. • Discuss the checklist. • Are there any difficulties with the construction?		

63

	• How is the contact & exchange with the contracting company going? **RECORD A VIDEO OF THIS PERFORMANCE!**		
3	Initiate the community meeting by mobilizing the community.		
4	Let the WUSC inform community about the ongoing work. • What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done? **RECORD A VIDEO OF THIS PERFORMANCE!**		
5	Hold a design workshop on painting the tapstands and the central filtration units. People are asked to contribute to the material organised for the community. • Organise paint & brush. • Bring ideas of mandushas. • Collect cash contributions. **RECORD A VIDEO OF THIS PERFORMANCE!**		

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour		Date		Name of interviewer &signature					
Time when left		Arrival time in village		Km travelled				Costs for travel	

Visit No. 5, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members to announce a community meeting on the day of your arrival.		
2	Initiate the community meeting by mobilizing the community.		
3	Inform about the ongoing work. • What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done?		

	RECORD A VIDEO OF THIS PERFORMANCE!		

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour		Date		Name of interviewer &signature					
Time when left		Arrival time in village		Km travelled			Costs for travel		

Visit No. 6, describe current status of infrastructure work:
Borewell:
Container:
Motorpump:
Filtration unit:
Filter media:
Chlorination unit:
Overhead metal construction & overhead tank:
Backwashing chamber:
Pipelines in village:
Household based tapstands:
General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members, WUSC members and PRI members to announce a community meeting on the day of your arrival.		
2	Meet with the WUSC to exchange information about how the infrastructure installation is going according to sheet No. 4. • Discuss the checklist. • Are there any difficulties with the construction?		

	• How is the contact & exchange with the contracting company going? **RECORD A VIDEO OF THIS PERFORMANCE!**		
3	Initiate the community meeting by mobilizing the community.		
4	Let the WUSC inform community about the ongoing work. • What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done?		
5	Q&A session with PHED **RECORD A VIDEO OF THIS PERFORMANCE!**		
6	Initiate a guided tour through the village along the "flow of the water" under supervision of WUSC, guide is the caretaker. • In small groups • A couple of timeslots. **RECORD A VIDEO OF THIS PERFORMANCE!**		

Village Name		Ward No.		Panchayat Name			Block	
Booklet Colour		Date		Name of interviewer &signature				
Time when left		Arrival time in village		Km travelled		Costs for travel		

Visit No. 6, describe current status of infrastructure work:

Borewell:

Container:

Motorpump:

Filtration unit:

Filter media:

Chlorination unit:

Overhead metal construction & overhead tank:

Backwashing chamber:

Pipelines in village:

Household based tapstands:

General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members to announce a community meeting on the day of your arrival.		
2	Initiate the community meeting by mobilizing the community.		
3	Inform about the ongoing work. • What has been done so far? • What were problems in the process? Or what is going on at the moment? • What is going to be done?		

	RECORD A VIDEO OF THIS PERFORMANCE!		

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour		Date		Name of interviewer&signature					
Time when left		Arrival time in village		Km travelled				Costs for travel	

Visit No. 7, describe current status of infrastructure

Borewell:

Container:

Motorpump:

Filtration unit:

Filter media:

Chlorination unit:

Overhead metal construction & overhead tank:

Backwashing chamber:

Pipelines in village:

Household based tapstands:

General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members that you will visit the households. • Inform the households that you will go to visit them and make sure the person responsible for collecting water will be at home.		
2	Find the person in the household who is responsible for collecting water.		

3	Inform about arsenic and microbiological contamination as well as health consequences. • Present health booklet • Tell the participant all of the information provided on the backpage of the booklet		
4	We designed a Prompt to support people in remembering to go to the arsenic-safe taps and not to use arsenic-contaminated handpump for collecting drinking and cooking water. Show her/him the prompt and tag according to sheet Nr. 5		
5.a	Let her/him explain the prompt to you.		
5.b	Let her/him attach the prompt on the wall.		
6.a	Let her/him explain the tag to you.		
6.b	Stick one tag at the chappakal.		
7.a	An implementation intention is a type of contract with oneself. Participants are asked to commit themselves to collect water from the arsenic-safe taps and to specify, when (which situation), where (which safe community scheme taps), how much (number of buckets), and for which purpose (drinking, cooking, or both) they will collect water from. In the end, participants are asked to sign this agreement and keep it. Give him/her sheet Nr. 6 and explain it according to sheet Nr. 5		
7.b	Read the completed implementation intention to the participant and ask her to repeat it. Then ask the participant to sign it by signature or by thumb print. Let her/him sign the paper.		
8	Take pictures of the attached prompt and tags as well as from the filled-out action planning.		
9	Send the pictures to the whatsapp group.		

Sheet No. 5

Two reminders were designed: a prompt to support people to remember collecting drinking water from the arsenic-safe water option (see 1. Prompt) and two tags, one for the arsenic-contaminated handpump (see 2. Tag).

1. Prompt

Description: We designed a prompt to support people in remembering to go to the arsenic-safe water tab and not to use arsenic-contaminated water for drinking and cooking.

1. Please show the prompt to the participant.
2. Let her/him explain the meaning of the prompt to you. Correct her/him if required:
   - "For cooking, boiling, filtering and drinking do use the water from the community based water system at your own tap *(point to the blue circle in the middle)*
   - But remember: this water is only available at certain times in the day!
     - First of all monitor the time. *(point to the clock)* Once in the morning and once in the evening, at fixed hours, you will be able to collect water at the community based water scheme.
     - *Can I help you to set a reminder for the running hours? Let her/him draw the indicators or install an alarm clock on the participants phone.*
     - 2) Always go and collect water at the water tap at these times… *(point to the blue circle in the middle)*
     - 3) …and store it in a covered bucket in your home *(point to the covered water bucket)."*
     - 4) Use this water for drinking and cooking.
3. Ask the participant where she/he usually stores the bucket she/he uses to collect water for drinking. Ask the participant where she/he usually is or what she/he is doing usually at the times when the water scheme is running.

4. Tell the participant that she/he can hang the prompt at the storage place of the containers or at another suitable place (for example when she/he is always doing something in particular in a particular location).
5. If she/he agrees, let her/him attach the Prompt where she/he think it's suitable.
6. Take a picture of the prompt & the spot where they storage the water containers!
7. Next step: show the tag to the participant -> see instructions 2.Tag

2. Tag (arsenic-contaminated handpump)

Description: *We designed a Tag to support people in remembering that they should not use water from arsenic-contaminated handpump for drinking, boiling, filtering and cooking.*

8. Let her/him explain the meaning of the tag to you. Correct her/him if required:
   - "Do not use the water from this handpump for cooking, boiling, filtering and drinking *(point to the two crossed signs on the left)*
   - You may use the water from this handpump for dish washing, showering, washing animals, washing clothes and cleaning purpose *(point to the four signs on the right side)*"
9. Ask the participant, from which arsenic-contaminated handpump she/he usually collects water from.
10. Tell the participant that she/he can attach the tag to the arsenic-contaminated handpump. If she/he agrees, let her/him attach the Tag to the handpump.
11. Next step: show the Implementation Intention -> see instructions 3. Implementation Intention

3. Implementation Intention

12. Please show sheet Nr. 6 to the participant.
13. Explain her/him the aim of the implementation intention:
   - "Imagine situations in which you need arsenic free water.
   - Reflect on what you need to do in these situations.
   - It is necessary, that you have some arsenic free water stored at home. For this, always go and collect arsenic free water, when the scheme is running.
   - Write it down on this paper *(show her/him the action planning)*."
14. Let her/him fill in the action planning. Go through it together and correct if required.

15. Let the participant sign the action planning with his/her signature or the thump-imprint.
16. Let her/him put it at the same place where the buckets are stored.

Sheet No. 6

An IF-THEN plan will help you to remember to always collect water, when the community based water scheme is running. For example:

- Running hours in the morning
- Running hours in the evening
- When you hear the sound of water hitting an empty bucket underneath your private tap

An implementation intention is a type of contract with oneself. Participants are asked to commit themselves to collect water from the arsenic-safe taps and to specify, when (which situation), where (which safe community scheme taps), how much (number of buckets), and for which purpose (drinking, cooking, or both) they will collect water from. In the end, participants are asked to sign this agreement and keep it.

1.   Explain to the participant about implementation intention:

"Sometimes it is helpful to make a specific plan, when, where, how much water, and for which purpose to collect water.

We would like it if you could specify, when, where, how much water, and for which purposes you are going to collect water in the future.

This is a kind of a commitment you make with yourself. It is not intended for anybody else to see. Do you agree?"

2.   If the participant agrees, ask the following questions and fill in the answers into implementation form by drawing the respective icons to the form / let the participant draw:

        a)   When will you collect water from your private tap of the community based water supply system?

        This can be only a time of the day when the scheme is running (e.g. morning, midday, afternoon etc.). Or also, if the participant is doing something always at this particular time.

        Draw the hour or the activity in the places indicated on the form.

        If the participant goes to collect water more than once per day, you need to ask her for a time or situation in the day for each time she goes to collect water!

        b)   Where is the tap you will collect your water from?

        Write / draw the location in the space indicated on the form.

        c)   How many buckets will you collect from your tap each time you go to collect water?

        Draw as many buckets on the form as indicated by the participant.

        d)   For what purpose will you collect drinking water from your arsenic-safe tap?

        Indicate whether participant will collect water for drinking or cooking or for both purposes by attaching a glass and/or a cooking stove picture sticker to the form.

Please write down /draw for all the cases an IF-THEN plan, what you are going to do.

IF   my visitor is thirsty   , THEN I collect water at the arsenic free water tab.

IF _____ , THEN

_____.

IF I hear the sound of water hitting my bucket , THEN

_____.

IF I hear the alarm clock going on , THEN

_____ .

I always and only use water from my tap of the community based water scheme for drinking &
cooking purpose.

*Read the completed implementation intention to the participant and ask her to repeat it out loud.
Then ask the participant to sign it by signature or by thumb print.*

Signature/ thumb-imprint:

**Place keep this contract safe, store it in a safe place, where nobody sees it, as
we will come and ask you again about it.**

Village Name		Ward No.		Panchayat Name			Block	
Booklet Colour		Date		Name of interviewer &signature				
Time when left		Arrival time in village		Km travelled			Costs for travel	

Visit No. 7, describe current status of infrastructure work:

Borewell:

Container:

Motorpump:

Filtration unit:

Filter media:

Chlorination unit:

Overhead metal construction & overhead tank:

Backwashing chamber:

Pipelines in village:

Household based tapstands:

General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members that you will visit the households. • Inform the households that you will go to visit them and make sure the person responsible for collecting water will be at home.		
2	Find the person in the household who is responsible for collecting water.		

3	Inform about arsenic and microbiological contamination as well as health consequences. • Present health booklet • Tell the participant all the information provided on the backpage of the booklet		
4	Take a picture explaining the consequences.		

Village Name		Ward No.		Panchayat Name			Block	
Booklet Colour		Date		Name of interviewer &signature				
Time when left		Arrival time in village		Km travelled		Costs for travel		

Visit No. 8, describe current status of infrastructure work:

Borewell:

Container:

Motorpump:

Filtration unit:

Filter media:

Chlorination unit:

Overhead metal construction & overhead tank:

Backwashing chamber:

Pipelines in village:

Household based tapstands:

General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members that you will visit the households. • Inform the households that you will go to visit them and make sure the person responsible for collecting water will be at home.		
2.	Find the person in the household who is responsible for collecting water.		
3.	Inform about arsenic and microbiological contamination as well as health consequences.		

	• Present health booklet • Tell the participant all the information provided on the backpage of the booklet		
4.	If some cues are missing replace theme together: • Tag attached to the handpump • Prompt attached to the storage place of the bucket		
5.	Take pictures informing the participant.		

Village Name		Ward No.		Panchayat Name				Block	
Booklet Colour		Date		Name of interviewer &signature					
Time when left		Arrival time in village		Km travelled				Costs for travel	

Visit No. 8, describe current status of infrastructure work:

Borewell:

Container:

Motorpump:

Filtration unit:

Filter media:

Chlorination unit:

Overhead metal construction & overhead tank:

Backwashing chamber:

Pipelines in village:

Household based tapstands:

General remarks:

Step	Activity	Performed (Yes / No / in parts)	Remarks (-> In what parts?)
1	Two days before visiting the village: • inform Mukiyah, ward members and PRI members that you will visit the households. • Inform the households that you will go to visit them and make sure the person responsible for collecting water will be at home.		
2	Find the person who is responsible for water collecting.		
3	Inform about arsenic and microbiological contamination as well as health consequences.		

	• Present health booklet • Tell the participant all the information provided on the backpage of the booklet		
4.	Take pictures informing the participant.		

Measurement instrument to assess psychological ownership for community based water system in Ambuehl et al., 2021:

If used, please cite as:

Introduction:
Think about the home, animals or furniture that you own or co-own with someone, and the experiences and feelings associated with the statement 'THIS IS MY (OUR) HOUSE!' The next questions deal with the 'sense of ownership' that you feel for the water system in your village.

How true are the following statements for you?
Items:
*) not included in analysis

Item	Answer options	
This is MY water system.	1 2 3 4 5	Not at all true Hardly true Rather true Mostly true Very true
This is our COMMUNITYS water system.	1 2 3 4 5	Not at all true Hardly true Rather true Mostly true Very true
It is hard for me to think about this water system as MINE. *)	1 2 3 4 5	Not at all true Hardly true Rather true Mostly true Very true
My family is one of the owners of the water system.	1 2 3 4 5	Not at all true Hardly true Rather true Mostly true Very true
The water system is owned by all the people who live in this village.	1 2 3 4 5	Not at all true Hardly true Rather true Mostly true Very true

Visual answer scale:

Very true
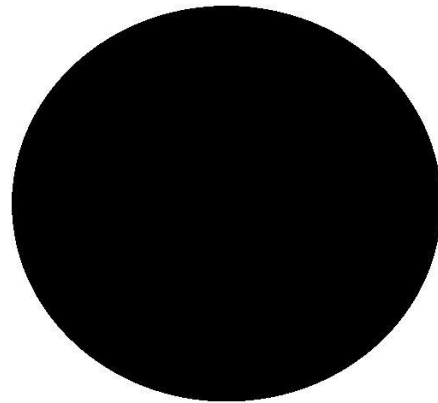
Mostly true
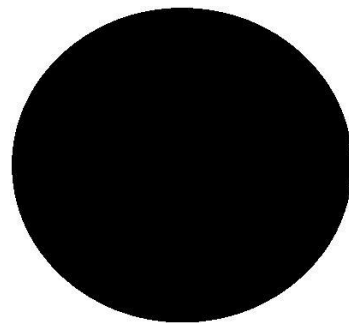
Rather true
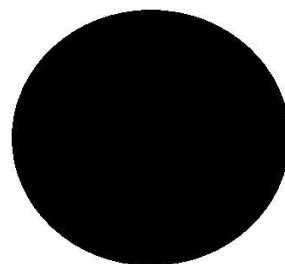
Hardly true
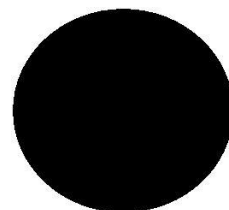
Not at all true
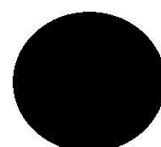
Supplementary materials S3: Intervention fidelity rating protocol

ID		Panchayat		Ward nr.		Block name			
		Activity due to protocol			**Dose due to protocol**	**Points total**	**Points**	**Remarks**	
Preparation		Meeting with or inclusion of important stake holders (health staff, Mukiyah, ward members, PRI, or Asha)			5	1			
		Meet with the WUSC (sheet no. 4)			3	1			
Main part general		Show the video about water scheme			1	1			
		inform about arsenic and microbiology (health booklet)			3	1			
		Information about construction work			4	1			
Ownership		Form a WUSC (sheet no.3)			1	1			
		Write down the WUSC's names			1	1			
		Provide a checklist for the WUSC			1	1			
		Voting on several aspects/decisions			1	1		Monetary: Labour: Water scheme running times:	
		Collective If-then plan			1	1			
		Fencing: labour contribution			1	1			
		Design workshop/paint			1	1			
		Q&A session			1	1			
		Guided tour/procession through water scheme			1	1			
Ending		Inform about upcoming activities / next visit (sheet no. 2)			4	1			
Total points					32	15			
		Remarks:							
		Response of people:							

ID		Panchayat		Ward nr.		Block name			
		Activity due to protocol			**Dose due to protocol**	**Points total**	**Points**	**Remarks**	
Preparation		Meeting with or inclusion of important stake holders (health staff, Mukiyah, ward members, PRI, or Asha)			5	1			
Main part general		Show the pictures about water scheme			1	1			
		inform about arsenic and microbiology (health booklet)			3	1			
		Information about construction work			4	1			
Ending		Inform about upcoming activities / next visit (sheet no. 2)			4	1			
Total points					19	5			
		Remarks:							

ID		Panchayat		Ward nr.			Block name		
		Activity due to protocol			**Dose due to protocol**	**Points total**	**Points**	**Remarks**	
Preparation		Meeting with or inclusion of important stake holders (health staff, Mukiyah, ward members, PRI, or Asha)			5	1			
Main part general		Show the pictures about water scheme			1	1			
		inform about arsenic and microbiology (health booklet)			3	1			
		Information about construction work			4	1			
Habit		Explanation of tags and prompts (sheet no. 5)			1	1			
		Attach tags and prompts			1	1			
		Fill in action planning			1	1			
		Sign action plan			1	1			
		Check tags and prompts			1	1			
Ending		Inform about upcoming activities / next visit (sheet no. 2)			4	1			
Total points					28	10			
		Remarks:							

ID		Panchayat		Ward nr.		Block name	

		Activity due to protocol	Dose due to protocol	Points total	Points	Remarks
Preparation		Meeting with or inclusion of important stake holders (health staff, Mukiyah, ward members, PRI, or Asha)	5	1		
		Meet with the WUSC (sheet no. 4)	3	1		
Main part general		Show the video about water scheme	1	1		
		inform about arsenic and microbiology (health booklet)	3	1		
		Information about construction work	4	1		
Ownership		Form a WUSC (sheet no.3)	1	1		
		Write down the WUSC's names	1	1		
		Provide a checklist for the WUSC	1	1		
		Voting on several aspects/decisions	1	1		Monetary: Labour: Water scheme running times:
		Collective If-then plan	1	1		
		Fencing: labour contribution	1	1		
		Design workshop/paint	1	1		
		Q&A session	1	1		
		Guided tour/procession through water scheme	1	1		
Habit		Explanation of tags and prompts (sheet no. 5)	1	1		
		Attach tags and prompts	1	1		
		Fill in action planning	1	1		
		Sign action plan	1	1		
		Check tags and prompts	1	1		
Ending		Inform about upcoming activities / next visit (sheet no. 2)	4	1		
Total points			37	20		
		Remarks:				
		Response of people:				

Examples of sanitary inspectionforms

Examples of sanitary inspection forms are given here as follows:

Nonpiped supplies: open dug well (Fig. A2.1); dug well with windlass and partial cover (Fig. A2.2); covered dug well with hand-pump (Fig. A2.3); rain-water collection and storage (Fig. A2.4); tubewell with hand-pump (Fig. A2.5); tanker trucks, filling stations, and household tanks (Fig. A2.6).

Piped supplies: deep borehole with mechanical pump (Fig. A2.7); protected spring source (Fig. A2.8); surface sources and abstraction (Fig. A2.9); piped distribution (Fig. A2.10); water-treatment plant (Fig. A2.11).

With the exception of Fig. A2.11, these all consist of two pages and include illustrations depicting the various types of water supplies in appropriate settings; potential hazards are listed and numbered. The use of these forms enables a hazard score to be assigned to the particular water supply based on the total number of hazards found; however, differential weighting may be necessary to allow for local conditions (see p. 47).

Latrines and other point sources of potential faecal contamination should be located sufficiently far from groundwater sources used for drinking purposes to ensure that the risk of pathogen survival is very low. Once the "travel time" of microbial pathogens through the ground has been established, it is possible to determine a minimum safe distance (MSD) of potentially polluting activities from water sources.

The travel time of microbes depends on local hydrogeological conditions, in particular the hydraulic conductivity or permeability of the soil and rock in the unsaturated and saturated zones. Thus it is difficult to set MSDs that are universally applicable. Travel time will also be affected by the volume and concentration of contamination introduced into an area. It has been shown that in rural areas of low population density, the majority of viruses and bacteria will die after 10 days in groundwater. Thus, in these areas, where small-scale water supplies and sanitation are introduced, this travel time may be used as a basis for establishing MSDs. In urban areas where municipal wastewater is discharged and in those where there is intensive use of on-site sanitation, a figure of 50 days is more appropriate.

It is often difficult to obtain sound hydrogeological information. However, some idea of the local hydrogeological conditions can be gained by carefully recording the changes in soil and rock type during test drilling and by conducting infiltration tests in the area where latrine construction is proposed. The infiltra-

tion capacity of the soil in the area should be assessed when the water table is at its highest.

An infiltration test can be carried out as follows:

- Bore a hole(s) of diameter 10 cm and depth slightly greater than the maximum depth of the latrine pits (usually about 3 m).
- Fill the hole(s) with water and leave overnight to allow the soil to become saturated. When the soil is very dry, it may be necessary to refill the hole several times to ensure that the surrounding soil becomes saturated.
- Refill the hole(s) to a depth of 30 cm, and measure the fall in water level over 30- and 90-minute periods. The infiltration rate can then be estimated from the fall in water level during these periods. For greater accuracy, the volume of water infiltrating should be calculated and a value of the infiltration rate obtained in m^3/m^2 per hour or m/h.

It should be noted that the above test gives the infiltration capacity of the soil, i.e. the steady-state capacity to absorb water. Under very dry conditions, the actual infiltration rate may vary considerably. The test will usually be carried out with "clean" water, but the liquid from pit latrines will be "dirty" and the true infiltration capacity may therefore be lower. However, it is always better to be careful when locating latrines, and using clean water is likely to give a MSD which will be more than adequate for "dirty" water.

The procedure described above is a basic test which only gives an idea of how quickly liquid from a pit latrine will infiltrate and move through the ground. For greater precision, the hydraulic conductivity of the soil should be established by means of more sophisticated formulae based on Darcy's law, for which reference should be made to standard texts on groundwater and hydrogeology. Information should be obtained on the geology of the area where infiltration capacity is being evaluated, particularly on whether any fissures or joints underlie the area proposed for latrine development, since these may dramatically increase the hydraulic conductivity and thus the MSD.

The rate of movement of groundwater varies greatly depending on the permeability, ranging from fractions of metres per day in clays, to 1–10 m per day in sands, 50 m plus per day in very permeable gravels, and even greater rates in rock fissures, e.g. in limestone. Thus, while the MSD for impermeable clays may be as low as a few metres, for sands this may increase to 100 m; in permeable gravel beds or areas where there are shallow aquifers in fissures, it may reach as much as several kilometres.

As a rough guide, a value of 10 m can be considered as the absolute MSD allowable in areas of deep impermeable clay which does not form cracks during dry periods. However, unless detailed investigations of the area have been carried out under all conditions, it is preferable to increase this distance to at least 30 m. If the groundwater in the area is found in very permeable aquifers, such as gravels and rock fissures, on-site sanitation may not be appropriate. If no other option is available, sealed pits with impermeable concrete linings should be used.

Fig. A2.1 Example of sanitary inspection form for open dug well

Note: MSD = minimum safe distance as determined locally; see section 6.2.2.
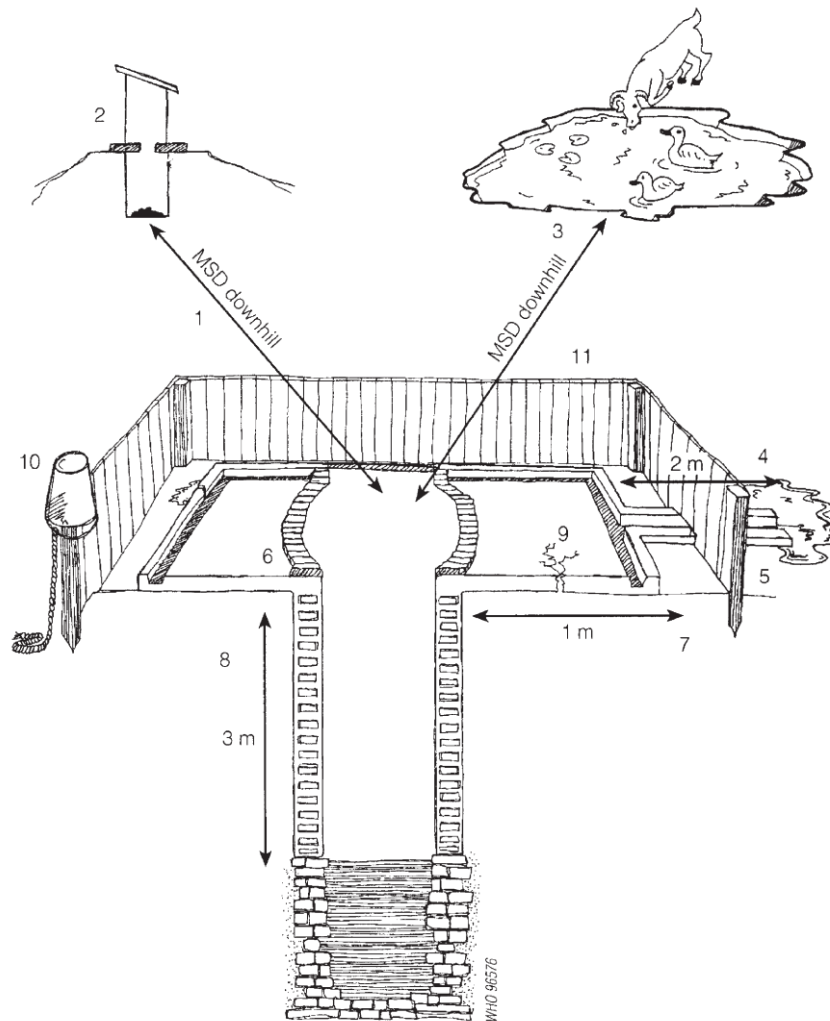
I   Type of facility   OPEN DUG WELL

  1. General information: Health centre ....

                                        Village ....

  2. Code no.—Address ....

  3. Water authority/community representative signature ....

  4. Date of visit ....

  5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II   Specific diagnostic information for assessment   Risk

  1. Is there a latrine within 10 m of the well?   Y/N

  2. Is the nearest latrine on higher ground than the well?   Y/N

  3. Is there any other source of pollution (e.g. animal excreta, rubbish)   Y/N
       within 10 m of the well?

  4. Is the drainage poor, causing stagnant water within 2 m of the well?   Y/N

  5. Is there a faulty drainage channel? Is it broken, permitting ponding?   Y/N

  6. Is the wall (parapet) around the well inadequate, allowing   Y/N
       surface water to enter the well?

  7. Is the concrete floor less than 1 m wide around the well?   Y/N

  8. Are the walls of the well inadequately sealed at any point for   Y/N
       3 m below ground?

  9. Are there any cracks in the concrete floor around the well which   Y/N
       could permit water to enter the well?

10. Are the rope and bucket left in such a position that they may   Y/N
       become contaminated?

11. Does the installation require fencing?   Y/N

                                        Total score of risks .... /11

Contamination risk score: 9–11 = very high; 6–8 = high; 3–5 = intermediate;
                         0–2 = low

III   Results and recommendations

The following important points of risk were noted: .... (list nos 1–11)
and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.2 *Example of sanitary inspection form for dug well with windlass and partial cover*

Note: MSD = minimum safe distance determined locally; see section 6.2.2.
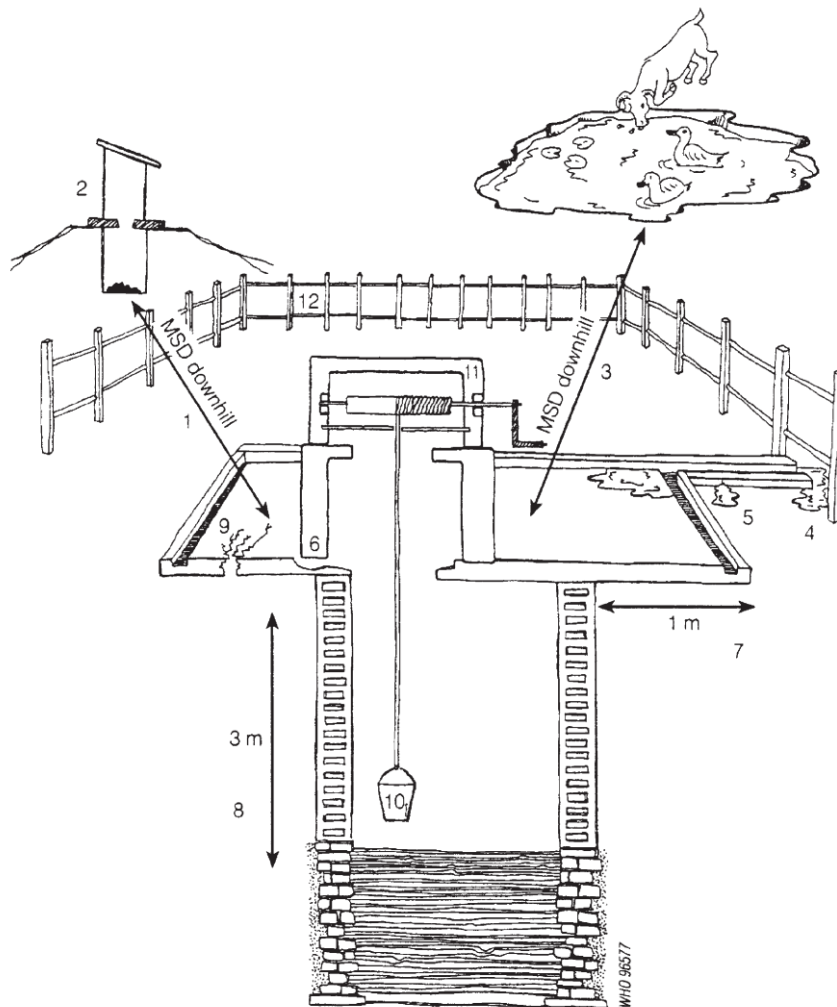
I   Type of facility   DUG WELL WITH WINDLASS AND PARTIAL COVER

1. General information: Health centre ....
                          Village ....

2. Code no.—Address ....

3. Water authority/community representative signature ....

4. Date of visit ....

5. Water sample taken?....... Sample no. .... Thermotolerant coliform grade ....

II	Specific diagnostic information for assessment	Risk
1.	Is there a latrine within 10 m of the well?	Y/N
2.	Is the nearest latrine on higher ground than the well?	Y/N
3.	Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the well?	Y/N
4.	Is the drainage poor, causing stagnant water within 2 m of the well?	Y/N
5.	Is there a faulty drainage channel? Is it broken, permitting ponding?	Y/N
6.	Is the wall (parapet) around the well inadequate, allowing surface water to enter the well?	Y/N
7.	Is the concrete floor less than 1 m wide around the well?	Y/N
8.	Are the walls of the well inadequately sealed at any point for 3 m below ground?	Y/N
9.	Are there any cracks in the concrete floor around the well which could permit water to enter the well?	Y/N
10.	Are the rope and bucket left in such a position that they may become contaminated?	Y/N
11.	Does the well require a cover?	Y/N
12.	Does the installation require fencing?	Y/N

Total score of risks ..../12

Contamination risk score: 9–12 = very high; 6–8 = high; 3–5 = intermediate;
                          0–2 = low

III   Results and recommendations

The following important points of risk were noted: .... (list nos 1–12) and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.3 Example of sanitary inspection form for covered dug well with hand-pump

Note: MSD = minimum safe distance determined locally; see section 6.2.2.
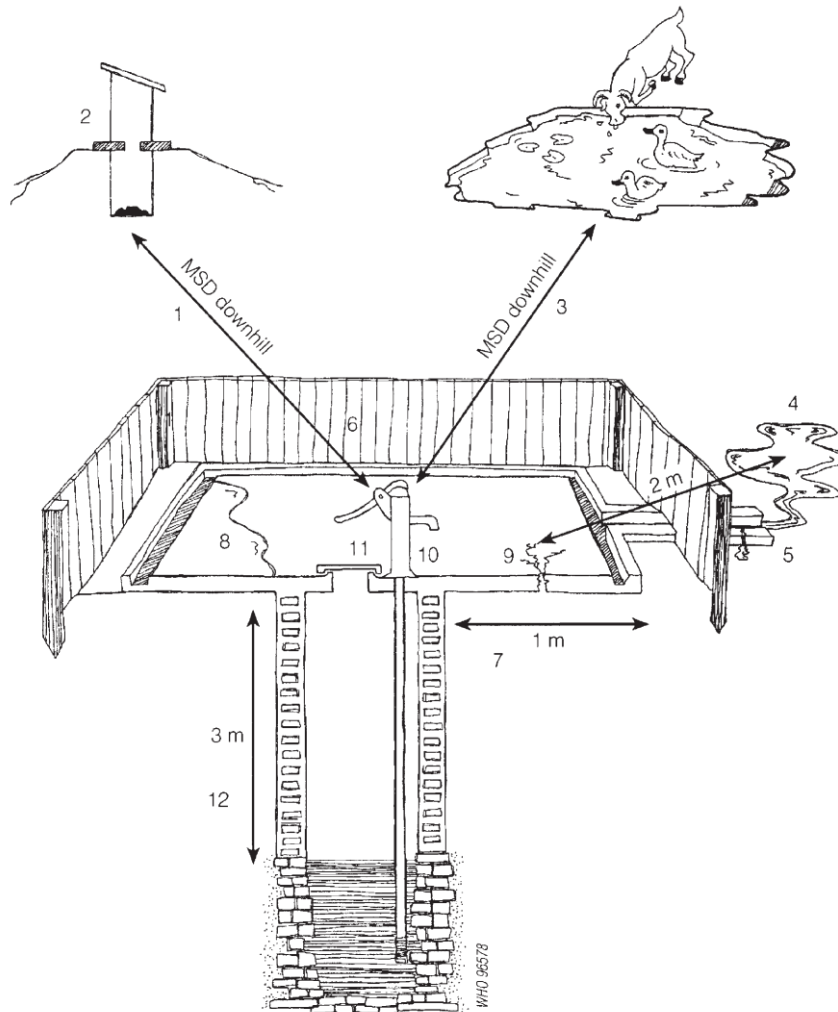
I   Type of facility   COVERED DUG WELL WITH HAND-PUMP

1. General information: Health centre ....
                          Village ....

2. Code no.—Address ....

3. Water authority/community representative signature ....

4. Date of visit ....

5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II	Specific diagnostic information for assessment	Risk
1.	Is there a latrine within 10 m of the well and hand-pump?	Y/N
2.	Is the nearest latrine on higher ground than the hand-pump?	Y/N
3.	Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the hand-pump?	Y/N
4.	Is the drainage poor, causing stagnant water within 2 m of the cement floor of the hand-pump?	Y/N
5.	Is there a faulty drainage channel? Is it broken, permitting ponding?	Y/N
6.	Is the wall or fencing around the hand-pump inadequate, allowing animals in?	Y/N
7.	Is the concrete floor less than 1 m wide all around the hand-pump?	Y/N
8.	Is there any ponding on the concrete floor around the hand-pump?	Y/N
9.	Are there any cracks in the concrete floor around the hand-pump which could permit water to enter the hand-pump?	Y/N
10.	Is the hand-pump loose at the point of attachment to the base so that water could enter the casing?	Y/N
11.	Is the cover of the well unsanitary?	Y/N
12.	Are the walls of the well inadequately sealed at any point for 3 m below ground level?	Y/N

Total score of risks .... /12

Contamination risk score: 9–12 = very high; 6–8 = high; 3–5 = intermediate;
0–2 = low

III   Results and recommendations

The following important points of risk were noted: .... (list nos 1–12)
and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.4 Example of sanitary inspection form for rainwater collection and storage
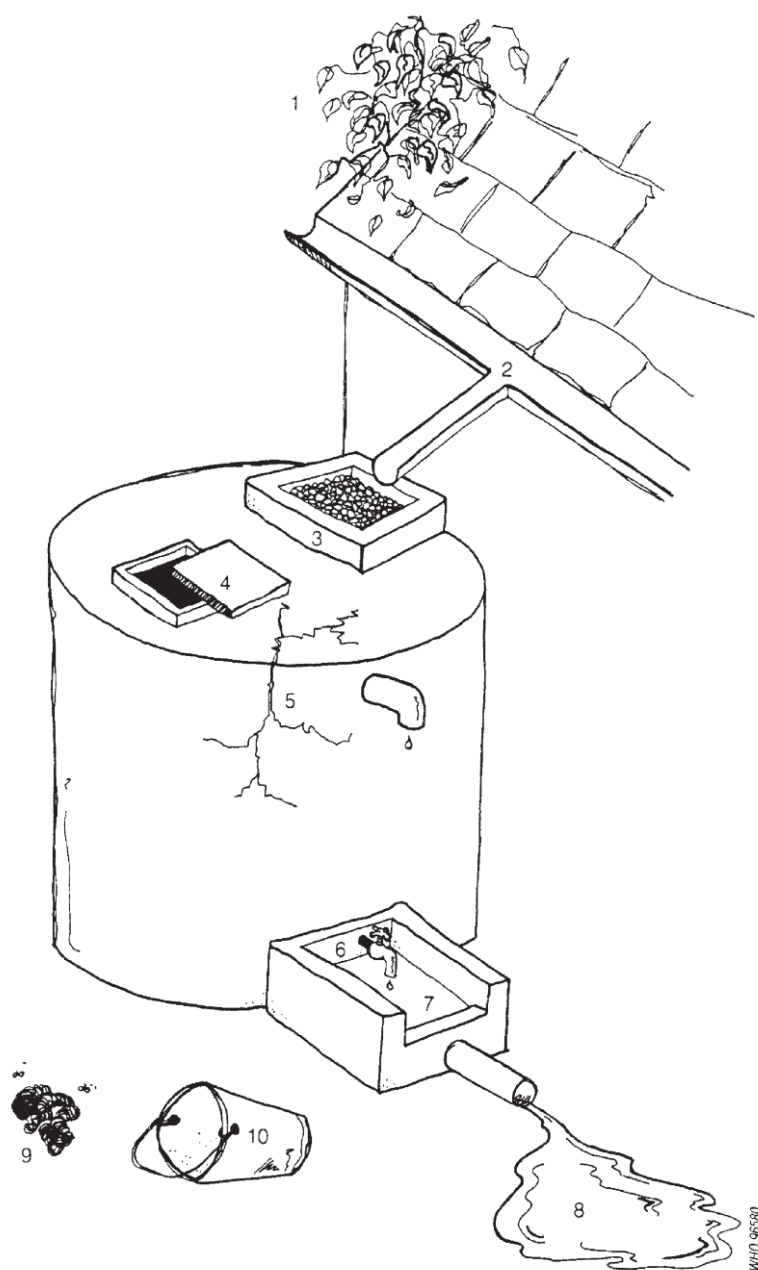
I   Type of facility   RAINWATER COLLECTION AND STORAGE

1. General information: Health centre ....
                         Village ....

2. Code no.—Address ....

3. Water authority/community representative signature ....

4. Date of visit ....

5. Water sample taken?....... Sample no. .... Thermotolerant coliform grade ....

II   Specific diagnostic information for assessment   Risk

1. Is there any visible contamination of the roof catchment area   Y/N
    (plants, dirt, or excreta)?

2. Are the guttering channels that collect water dirty?   Y/N

3. Is there any deficiency in the filter box at the tank inlet   Y/N
    (e.g. lacks fine gravel)?

4. Is there any other point of entry to the tank that is not properly covered? Y/N

5. Is there any defect in the walls or top of the tank (e.g. cracks) that Y/N
    could let water in?

6. Is the tap leaking or otherwise defective?   Y/N

7. Is the concrete floor under the tap defective or dirty?   Y/N

8. Is the water collection area inadequately drained?   Y/N

9. Is there any source of pollution around the tank or water collection   Y/N
    area (e.g. excreta)?

10. Is a bucket in use and left in a place where it may become contaminated? Y/N

                                        Total score of risks .... /10

Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate;
                          0–2 = low

III   Results and recommendations

The following important points of risk were noted: .... (list nos 1–10)
and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.5 Example of sanitary inspection form for tubewell with hand-pump

Note: MSD = minimum safe distance determined locally; see section 6.2.2.

WHO 96581

I   Type of facility   TUBEWELL WITH HAND-PUMP

1. General information: Health centre ....
                           Village ....

2. Code no.—Address ....

3. Water authority/community representative signature ....

4. Date of visit ....

5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II   Specific diagnostic information for assessment   Risk

1. Is there a latrine within 10 m of the hand-pump?   Y/N

2. Is the nearest latrine on higher ground than the hand-pump?   Y/N

3. Is there any other source of pollution (e.g. animal excreta, rubbish,   Y/N
    surface water) within 10 m of the hand-pump?

4. Is the drainage poor, causing stagnant water within 2 m of the
    hand-pump?   Y/N

5. Is the hand-pump drainage channel faulty? Is it broken, permitting
    ponding? Does it need cleaning?   Y/N

6. Is the fencing around the hand-pump inadequate, allowing animals in?   Y/N

7. Is the concrete floor less than 1 m wide all around the hand-pump?   Y/N

8. Is there any ponding on the concrete floor around the hand-pump?   Y/N

9. Are there any cracks in the concrete floor around the hand-pump which   Y/N
    could permit water to enter the well?

10. Is the hand-pump loose at the point of attachment to the base so that   Y/N
    water could enter the casing?

                                       Total score of risks ..../10

Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate;
                          0–2 = low

III   Results and recommendations

The following important points of risk were noted: .... (list nos 1–10)
and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.6 Example of sanitary inspection form for filling stations, tanker trucks, and household tanks

WHO 96582

WHO 96582a
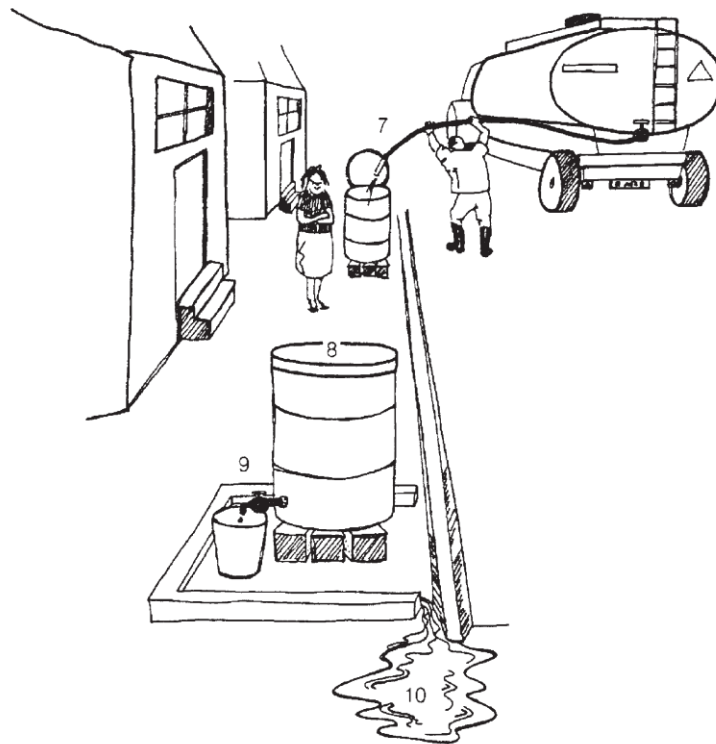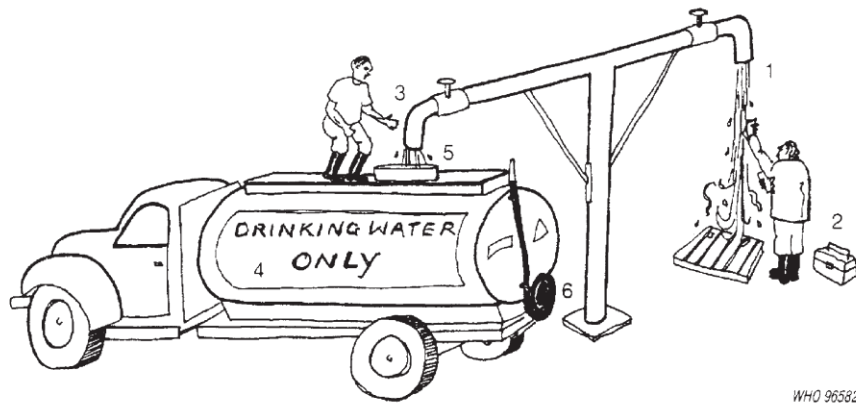
I   Type of facility   FILLING STATIONS, TANKER TRUCKS, AND
                          HOUSEHOLD TANKS

1. General information: Health centre ....
                          Village ....

2. Code no.—Address ....

3. Water authority/community representative signature ....

4. Date of visit ....

5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II   Specific diagnostic information for assessment   Risk

Tanker filling stations

1. Is the chlorine level at the filling station less than 0.5 mg/litre?   Y/N

2. Is the filling station excluded from the routine quality-control   Y/N
    programme of the water authority?

3. Is the discharge pipe unsanitary?   Y/N

Tanker trucks

4. Is the tanker ever used for transporting other liquids besides   Y/N
    drinking-water?

5. Is the filler hole unsanitary, or is the lid missing?   Y/N

6. Is the delivery hose nozzle dirty or stored unsafely?   Y/N

Domestic storage tanks

7. Can contaminants (e.g. soil on the inside of the lid) enter the tank   Y/N
    during filling?

8. Does the tank lack a cover?   Y/N

9. Does the tank need a tap for withdrawal of water?   Y/N

10. Is there stagnant water around the storage tank?   Y/N

                                        Total score of risks .... /10

Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate;
                          0–2 = low

III   Results and recommendations

The following important points of risk were noted: .... (list nos 1–10)
and the authority advised on remedial action.

Signature of sanitarian ....

163

Fig. A2.7 **Example of sanitary inspection form for deep borehole with mechanical pump**

Note: MSD = minimum safe distance determined locally; see section 6.2.2.
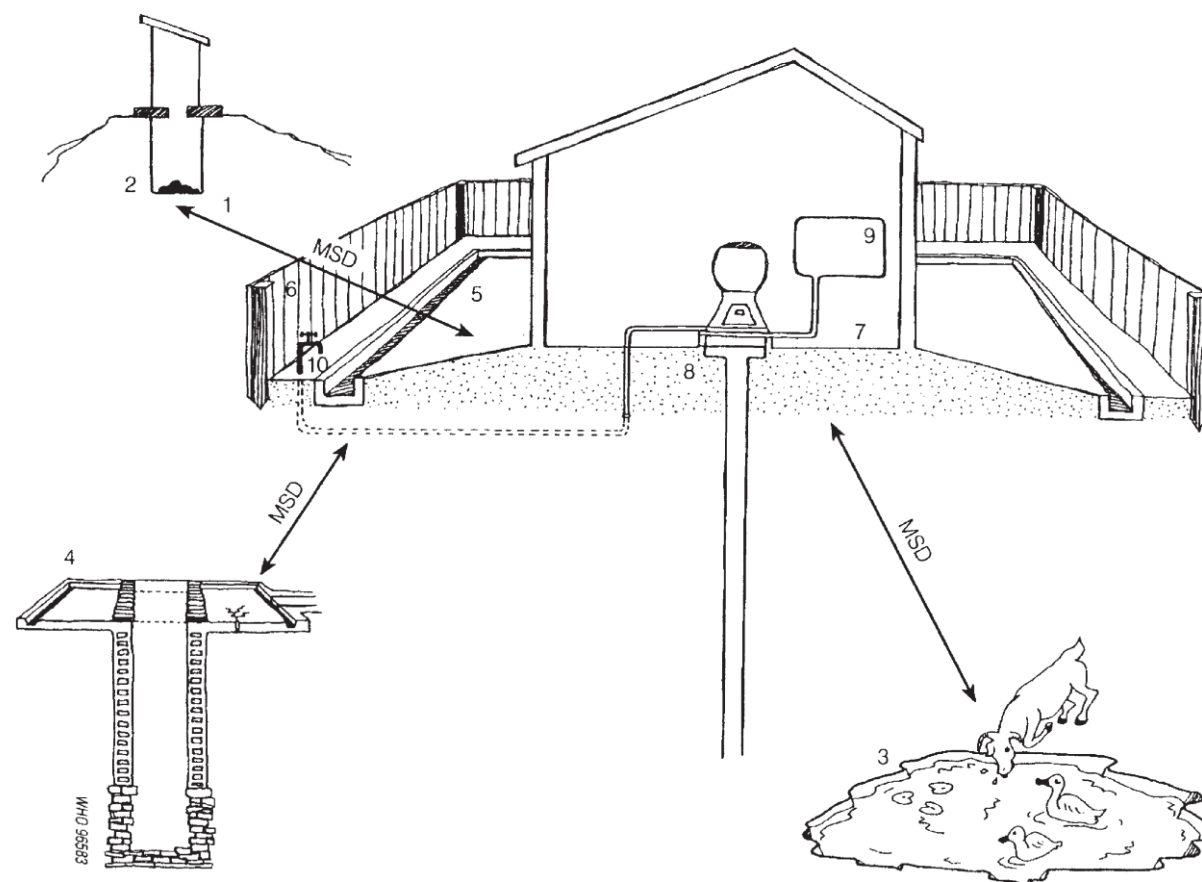
I Type of facility   DEEP BOREHOLE WITH MECHANICAL PUMP

  1. General information: Health centre ....
                           Village ....

  2. Code no.—Address ....

  3. Water authority/community representative signature ....

  4. Date of visit ....

  5. Is water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II Specific diagnostic information for assessment   Risk

  1. Is there a latrine or sewer within 15–20 m of the pumphouse?   Y/N

  2. Is the nearest latrine a pit latrine that percolates to soil, i.e. unsewered?   Y/N

  3. Is there any other source of pollution (e.g. animal excreta, rubbish, surface   Y/N
      water) within 10 m of the borehole?

  4. Is there an uncapped well within 15–20 m of the borehole?   Y/N

  5. Is the drainage area around the pumphouse faulty?   Y/N
      Is it broken, permitting ponding and/or leakage to ground?

  6. Is the fencing around the installation damaged in any way which   Y/N
      would permit any unauthorized entry or allow animals access?

  7. Is the floor of the pumphouse permeable to water?   Y/N

  8. Is the well seal unsanitary?   Y/N

  9. Is the chlorination functioning properly?   Y/N

 10. Is chlorine present at the sampling tap?   Y/N

                                        Total score of risks .... /10

Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate;
                          0–2 = low

III Results and recommendations

The following important points of risk were noted: .... (list nos 1–10)
and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.8 Example of sanitary inspection form for protected spring source
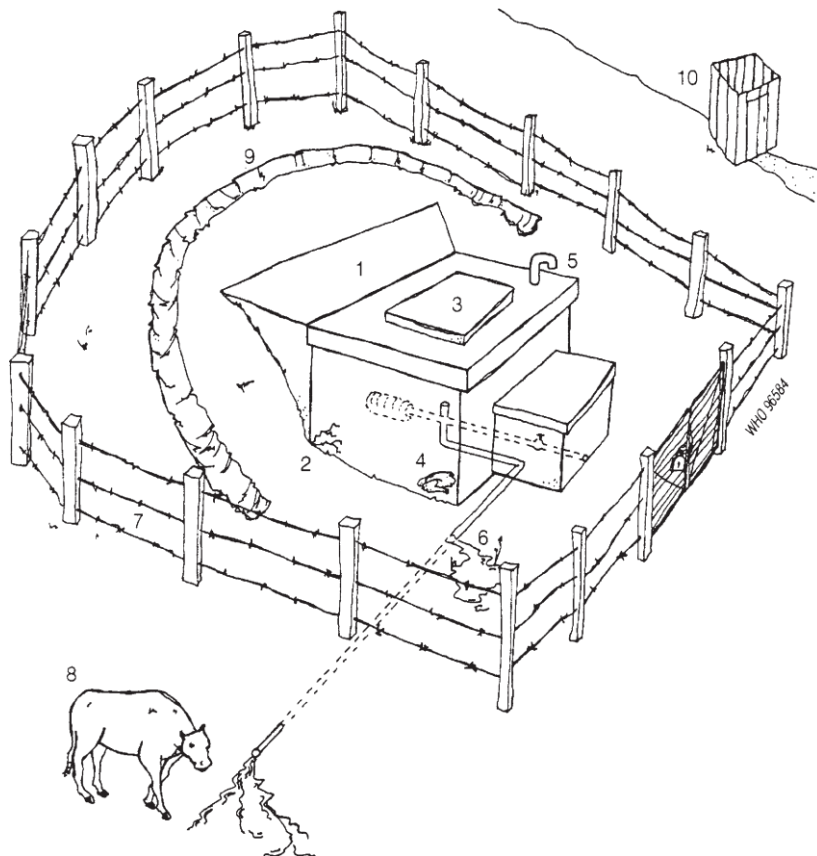
I   Type of facility   PROTECTED SPRING SOURCE

1.   General information: Health centre ....
                          Village ....

2.   Code no.—Address ....

3.   Water authority/community representative signature ....

4.   Date of visit ....

5.   Water sample taken?....... Sample no. .... Thermotolerant coliform grade ....

II	Specific diagnostic information for assessment	Risk
1.	Is the spring source unprotected by masonry or concrete wall or spring box and therefore open to surface contamination?	Y/N
2.	Is the masonry protecting the spring source faulty?	Y/N
3.	If there is a spring box, is there an unsanitary inspection cover in the masonry?	Y/N
4.	Does the spring box contain contaminating silt or animals?	Y/N
5.	If there is an air vent in the masonry, is it unsanitary?	Y/N
6.	If there is an overflow pipe, is it unsanitary?	Y/N
7.	Is the area around the spring unfenced?	Y/N
8.	Can animals have access to within 10 m of the spring source?	Y/N
9.	Does the spring lack a surface water diversion ditch above it, or (if present) is it nonfunctional?	Y/N
10.	Are there any latrines uphill of the spring?	Y/N

Total score of risks .... /10

Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate; 0–2 = low

III   Results and recommendations

The following important points of risk were noted: .... (list nos 1–10) and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.9 Example of sanitary inspection form for surface source and abstraction
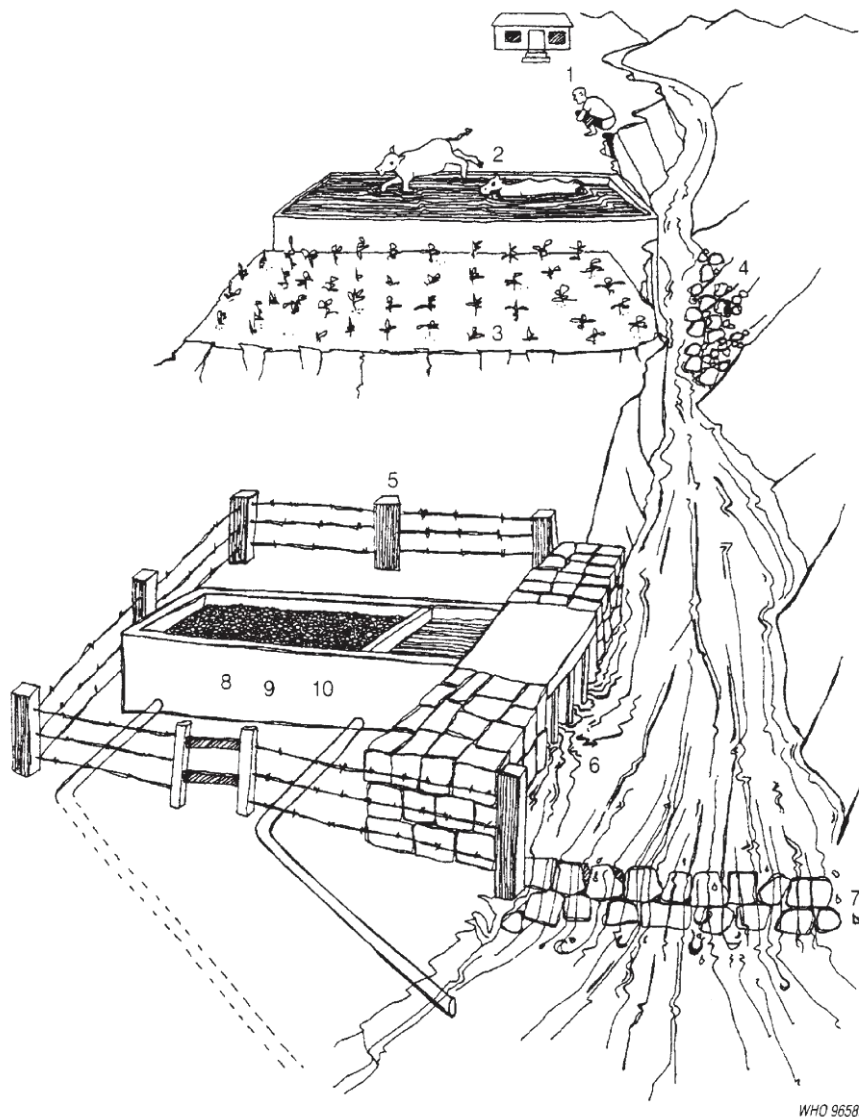
WHO 96585

I Type of facility SURFACE SOURCE AND ABSTRACTION

1. General information: Health centre ....
                        Village ....

2. Code no.—Address ....

3. Water authority/community representative signature ....

4. Date of visit ....

5. Water sample taken? .... Sample no. .... Thermotolerant coliform grade ....

II	Specific diagnostic information for assessment	Risk
1.	Is there any human habitation upstream, polluting the source?	Y/N
2.	Are there any farm animals upstream, polluting the source?	Y/N
3.	Is there any crop production or industrial pollution upstream?	Y/N
4.	Is there a risk of landslide or mudflow (causing deforestation) in the catchment area?	Y/N
5.	Is the intake installation unfenced?	Y/N
6.	Is the intake unscreened?	Y/N
7.	Does the abstraction point lack a minimum-head device (weir or dam to ensure minimum head of water)?	Y/N
8.	Does the system require a sand or gravel filter?	Y/N
9.	If there is a filter, is it functioning badly?	Y/N
10.	Is the flow uncontrolled?	Y/N

Total score of risks ..../10

Contamination risk score: 9–10 = very high; 6–8 = high; 3–5 = intermediate;
0–2 = low

III Results and recommendations

The following important points of risk were noted: .... (list nos 1–10) and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.10 Example of sanitary inspection form for piped distribution
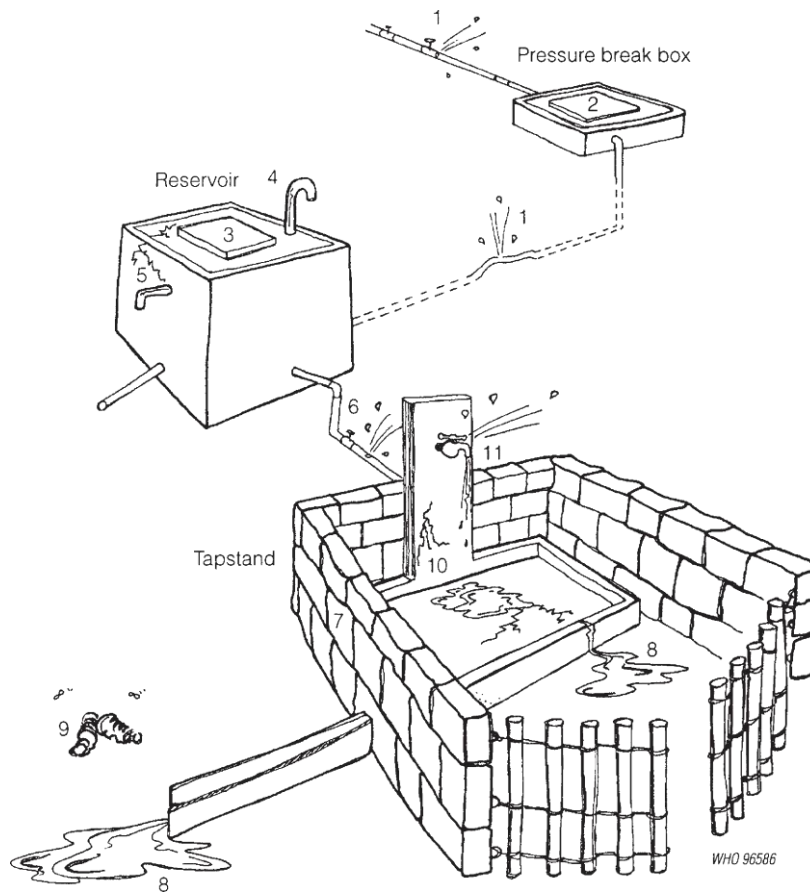
I   Type of facility   PIPED DISTRIBUTION

1. General information: Health centre ....
      : Village ....

2. Code no.—Address ....

3. Water authority/community representative signature ....

4. Date of visit ....

5. Water sample taken?....... Sample no. .... Thermotolerant coliform grade ....

II	Specific diagnostic information for assessment	Risk
1.	Is there any point of leakage between source and reservoir?	Y/N
2.	If there are any pressure break boxes, are their covers unsanitary?	Y/N

If there is a *reservoir*:

|		
3.	Is the inspection cover unsanitary?	Y/N
4.	Are any air vents unsanitary?	Y/N
5.	Is the reservoir cracked or leaking?	Y/N
6.	Are there any leaks in the distribution system?	Y/N
7.	Is the area around the tapstand unfenced (dry stone wall and/or fencing incomplete)?	Y/N
8.	Does water accumulate near the tapstand (requires improved drainage canal)?	Y/N
9.	Are there human excreta within 10 m of the tapstand?	Y/N
10.	Is the plinth cracked or eroded?	Y/N
11.	Does the tap leak?	Y/N

Contamination risk score: 10–11 = very high; 6–9 = high; 3–5 = intermediate;
                          0–2 = low

III   Results and recommendations

The following important points of risk were noted: .... (list nos 1–11)
and the authority advised on remedial action.

Signature of sanitarian ....

Fig. A2.11 Example of sanitary inspection form for water-treatment plant

I   General information   WATER-TREATMENT PLANT

1. Date of survey............./............/............

2. Survey of   ....
                     Source   Intake   Treatment plant   Distribution

3. Carried out by   ....
        Name of person   Agency

4. Name of supply   ....
                        State   District   Treatment plant

5. Address...

6. Person in charge ....

7. Year started operation...

8. Area served .... Population served ....

9. Treatment-plant capacity   Designed ....   Actual ....

10. Security of plant   Fence: Y/N   Security guard: Y/N

II   Source

1.   Type of water source: ....   Stream   River   Well   Others
                                Reservoir   ....

III   Intake

1. Is the intake adequate with respect to: Location?   Y/N
                                                Structure?   Y/N

                                                Maintenance?   Y/N
                                                Pollution sources in the vicinity?   Y/N

IV   Treatment processes employed

1. Fine screen   ....

2. Grit chamber   ....

3. Oil and grease trap   ....

4. Presedimentation   ....

5. Predisinfection/oxidation   ....
                                Chlorine   Ozone

6. Activated carbon treatment ....

7. Aeration ....

8. Coagulation and flocculation ....
     Lime   Alum   Others

9. Sedimentation ....
     Rectangular   Circular   Others

10. Filtration ....
     Slow   Rapid   Granular carbon

11. Disinfection ....
     Chlorine   Ozone   Others

12. Other processes (specify): ....
     ....

V   Sedimentation

1. No. of sedimentation tank: ....

2. Frequency of desludging: ....

3. Type of desludging facility: ....

4. Method of sludge disposal: ....

5. General appearance of clarified water: ....

6. Turbidity (NTU) at inlet: .... (NTU) at outlet: ....

VI Filtration

1. No. of filters: ....

2. Filtration rate: ....

3. Filter run: ....

4. Depth of gravel: ....

5. Depth of sand: ....

VII Backwashing

1. Criteria used for initiating backwashing:

    Air scour: ....
                Rate   Duration

    Water scour: ....

Rate   Duration

2. Distribution of air and water supply in the sand bed:

    ....
    Even   Uneven

3. Capacity of clean water for backwash: ....

4. Any mud balls or cracks in the filter bed?

    Before backwash ....

    After backwash   ....

5. Where does the wash water go? ....

VIII Fluoridation

1. Chemical used: ....

2. Dosage of chemical: ....

IX Chlorination

1. Any interruption in chlorination? ....

2. Frequency of interruption: ....

3. Cause of interruption: ....

4. Type of chemical used: ....

5. Dosage of chemical: ....

6. Safety equipment and measures: ....

7. Reserve stock of disinfectant: .... Quantity.................

8. Storage conditions: ....

X Clear-water tank(s)

1. No. of tanks: ....

2. Capacity of each tank: ....

3. Concentration of free residual chlorine: ....

4. pH: ....

5. Chemical used for pH adjustment and its dosage: ....

6. Any leak in the tank? ....

7. Is the tank properly covered and locked? ....

8. Any scum or foreign substances in the tank? ....

9. Are air vents and overflow pipes protected by screens? ....

XI Process control

		Yes	No	Frequently
1.	Jar test:	....	....	....
2.	pH:	....	....	....
3.	Free residual chlorine:	....	....	....
4.	Colour:	....	....	....
5.	Turbidity:	....	....	....
6.	*E.coli*/thermotolerant coli:	....	....	....
7.	Fluoride:	....	....	....
8.	Others:	....	....	....

SANITARY INSPECTION

XII Record keeping

1. Chemical consumption:...
2. Process-control tests:...
3. Bacteriological examination: ....
4. Residual chlorine: ....
5. Others: ....

XIII Maintenance

		Cleaning	Calibrating/oiling/greasing
1.	Screen:	....	....
2.	Pumping facility:	....	....
3.	Chlorine-dosing facility:	....	....
4.	Alum-dosing facility:	....	....
5.	Fluoride-dosing facility:	....	....
6.	Instrument (gauge, recording devices, etc.):	....	....
7.	General housekeeping:	....	....
8.	Storage of chemicals:	....	....
		Adequate	Inadequate

XIV Personnel

1. No. of present staff: ....
   Permanent   Casual

2. Academic level of the plant superintendent or the most senior operator of the treatment plant:

   ....

3. Length of service in present water-treatment plant: ....

4. Total experience in water treatment: ....

XV Complaints received

1. From operators: ....

   .... `

   ....

   ....

   ....

2. From management: ....

   ....

   ....

   ....

XVI Problems (if any) with:

		Yes	No	Description of problems
1.	Fine screen:	....	....	....
2.	Grit chamber:	....	....	....
3.	Oil and grease trap:	....	....	....
4.	Presedimentation:	....	....	....
5.	Activated carbon:	....	....	....
6.	Aeration:	....	....	....
7.	Coagulation and flocculation:	....	....	....
8.	Sedimentation:	....	....	....
9.	Filtration:	....	....	....
10.	Fluoridation:	....	....	....

11. Disinfection: ....

12. Other process: ....

13. Process control: ....

14. Record keeping: ....

15. Maintenance: ....

XVII   Flow diagram of water works (*insert diagram*)

XVIII   Remedial measures recommended

1. Measures to be taken immediately:

....

....

....

....

....

....

2. Measures to be taken later on:

....

....

....

....

....

XIX   Have problems identified in the previous sanitary survey been corrected?

....

....

....

....

....

....

Signature of inspector: ....