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Designing a Payment for Ecosystem Services Scheme for the Sardukhola Watershed in Nepal

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Contents

Abstract

This study was undertaken in the Sardukhola sub-watershed of eastern Nepal to illustrate how local policy instruments can be used to supplement government water supply. We discuss a strategy for using Payments for Ecosystem Services (PES) to meet water demand in Dharan Municipality in Nepal. A rigorous process was followed in designing the PES scheme. Following focus group discussions, a Choice Experiment was carried out to determine the preferences of municipal water users. In addition, upstream households were interviewed to understand their requirements to participate in a watershed management program. Finally, we used a series of formal and informal stakeholder consultations to help validate household survey findings and develop an institutional framework for implementing PES. Our analysis indicates that water quality is the most important attribute preferred by water users and that upstream households require incentives to decrease domestic livestock grazing, change agricultural practices and reduce open defecation. Results suggest that developing a PES scheme would be socially acceptable and financially feasible and may contribute to a flow of USD 118,000 per year from water users for watershed management. In concurrence with local stakeholders, we propose a tri-partite institutional structure to implement PES. We note that a national PES policy would make it easier to initiate such integrated and market-oriented approaches for enhancing drinking water supply.

Keywords

Choice experiment, willingness-to-pay, water quality, water users, upstream, watershed management

Designing a Payment for Ecosystem Services Scheme for the Sardukhola Watershed in Nepal

1. Introduction

Fresh water scarcity remains a major challenge in many parts of the world where large water and sanitation infrastructure is both costly to develop and maintain. This is particularly true in the Himalayas, where remote rural communities are wholly dependent on local water flows (Gurung and Sherpa, 2014). In this region, water availability is affected by upstream diversions for irrigation and hydroelectricity and water quality is impacted by land erosion from road-building, upstream agriculture and forest cover loss (Achet and Fleming, 2006; Merz *et al*., 2003). Often un-supported by modern water and sanitation infrastructure and management, water use is influenced by the actions of upstream communities and by the natural vagaries of monsoons, avalanches and floods (Thapa and Paudel, 2002).

In this context, it is useful to identify local policy instruments that could help with water resource management. Over the last decade or so, Payments for Ecosystem Services (PES), based on the beneficiary-pays principle (Engel *et al.*, 2008), has emerged as an innovative mechanism to motivate communities to better manage their natural resources (Kosoy *et al*., 2007). Essentially, consumers of ecosystem services, such as downstream water users, pay service providers (for example, upstream farmers) to cultivate environmental friendly activities that maintain these services. In theory, PES enhances the welfare of transacting parties by creating a win-win trade and also improves natural resource management (Wunder, 2007). In addition, monetization of services may increase political support for sustaining fragile ecosystems (Gómez-Baggethun *et al*., 2010) and the voluntary transactions may make PES more acceptable than regulatory approaches to resource management.

While the application of PES in developing countries is still in its infancy (Sangkapitux *et al*., 2009; Wunder, 2007), it offers a complementary strategy to cash-strapped governments efforts to provide public services such as clean water. A first step in devising a PES system is to understand whether there is a match between the demand for improved services and the willingness of service providers to change their behavior in order to increase supply. Once this is known, implementing PES requires careful design of payment mechanisms and institutional arrangements that can facilitate voluntary transactions (Sangkapitux *et al*., 2009). It is also important is to ensure that transactions can be monitored and sustained.

We examine the feasibility of implementing a PES scheme to increase water supply in remote rural areas of Nepal. In mountainous Nepal, building and maintaining modern water infrastructure is expensive due to rugged terrain and limited road access. Further, because of its history of civil strife and political in-stability, large infrastructure based water management is un-likely to be to meet the needs of Nepal's rural and semi-urban population in the near future (Domènech *et al*., 2013). Yet, water quantity and quality remain urgent development and health concerns (Pokhrel and Viraraghavan, 2004). Currently, more than 50% of Nepal's populace does not have access to piped tap water within the home (Central Bureau of Statistics, 2012). Around 16,000 people die every year from waterborne diseases and other causes related to water quality. In response to the need for clean water, the Government of Nepal is advocating local management of water resources. As a result some 2,000 sub-watersheds across Nepal are being managed under integrated watershed management programs (National Planning Commission, 2002, 2007).

In the hilly regions of countries such as Nepal, changes in upstream land use activities can contribute to changes in water quality and quantity (Achet and Fleming, 2006). This is because deforestation and forest degradation can influence evapotranspiration, water flows and water pollution (Ellison *et al*., 2012; Fiquepron *et al*., 2013). While the relationship between forests and water quantity is complex, the implications of land use practices on water quality are not disputed. Less erosive land use practices, such as well-maintained terraces on mountain slopes, can result in more water and less turbid water (Gardner and Gerrard, 2003). Reductions in the use of chemical fertilizers and improvements in upstream sanitary conditions also influence water quality (Lenat, 1984). Changes in vegetation, i.e., forests or agro-forestry versus regular agriculture, can increase stream flow, depending on other characteristics of the area such as slope, land type, and aspect (Vincent *et al*., 2015).

While Nepal does not have an over-arching legal framework supporting policy instruments such as payments for ecosystem services, several existing policies can be deployed to share benefits with locals (Bhatta *et al*., 2014). For example, the Hydropower Policy of 2001 stipulates that local governments receive 12% of hydropower revenue (Ministry of Water Resources, 2001), while Buffer Zone Management Regulation searmark 30-50% protected area revenues for surrounding communities (Government of Nepal, 1996). Further, local communities, who regulate forest use in 30% of Nepal's forests, could support water resource conservation in forested areas (Forest, 2014; Niraula *et al*., 2013; Pandit and Bevilacqua, 2011). However, forest communities generally ignore any external costs or benefits to distant ecosystem service users (Pravat and Humphreys, 2013). Nonetheless, building on existing norms and provisions in the Local Self Government Act (1999) and the Forest Act (1993), several PES schemes have begun to emerge (Nepal, 1993, 1999). The Dhulikhel water supply scheme, for instance, supports an agreement between the Municipality's water management committee and upstream forestry user groups (Bhatta and Kotru, 2012). A similar irrigation water scheme has been implemented in Kanchanpur, where downstream irrigators pay the upstream Siddhanath community forest user group (Bhatta *et al*., 2014). These cases reflect the growing possibility of local collaborative approaches for improving community welfare and natural resources management (Ghazoul *et al*., 2009).

In this paper, we assess the potential for linking water users and upstream communities through a PES type mechanism in the Sardukhola sub-watershed in Eastern Nepal. We present results from a choice experiment conducted with water users and discuss the interests of upstream farmers to change livelihood activities. In the next sections, we identify actions that affect the quality of water, preferences of upstream community and water users and tariffs that would allow for better management of thesub-watershed. We also lay outline the design of a local institutional mechanism to implement PES.

2. Study Area

The Sardukhola sub-watershed covers a geographic area of 39.35 km^2 of Sunsari and Dhankuta districts (see Figure 1) in Eastern Nepal (IUCN Nepal, 2011). It is part of the fragile Siwaliks Hills, which were declared a conservation zone in 2014. The watershed is populated by some 12,383 households, with less than 10% of the population being upstream residents (Central Bureau of Statistics, 2013). As shown in Figure 1, the rest of the population lives in downstream areas that are part of Dharan municipality. The Sardu river, its tributaries and aquifers are the main water source for Dharan, a city of approximately 150,000 people.

Municipal piped water supply to Dharan Municipality, managed by Nepal Water Supply Corporation (NWSC), is in-sufficient to meet the demands of the town. Some 85% of the municipality has piped water connections (IUCN Nepal, 2011). However, municipal water supply meets some 60% of water demand during the rainy (February to May) season and some 25% of demand during rest of the year (IUCN Nepal, 2011). Town residents obtain additional water from tube wells dug in their backyard or from private tankers, who get water from other local rivers and aquifers. The Sardukhola drains into areservoir that is used for water supply. This reservoir fills only in the rainy season, so NWSC also uses ground water sources. Ground water supplies 11% and 77% of municipal water in the in the rainy and dry seasons respectively (Dharan Municipality, 2014).

Both ground and surface water available to Dharan residentsis polluted. Ground water is turbid in the wet season and suffers from bacterial contamination in the dry season (Dongol *et al*., 2005). In this hilly region, agriculture is seen in many steep slopes, contributing to erosion. Municipal water supply is also affected by the use of crop fertilizers and pesticides, forest and soil loss from landslides and wallowing and grazing of livestock in upstream areas. Open defecation and lack of solid waste management are two other factors that affect water supply. Some 45% of households surveyed in an earlier study indicate that they throw their solid waste into the river or into open spaces (IUCN Nepal, 2011). The municipality undertakes basic filtering of water to clear up obvious contaminants and households filter and boil water for drinking propose.

3. PES Linking Upstream Communities and Water Users

The main motivation for this study comes from the efforts made by the government and people of Dharan Municipality to protect this watershed for increasing drinking water supply. The management of the Sardukhola watershed has a three-decade long history. Back in 1976, the Government of Nepal initiated the Sardukhola watershed protection program to conserve sources of drinking water and other resources[1] and relocated local communities from upstream villages to the lowlands. However, due to administrative problems, the relocation program was not effective and settlements prevailed. While the Government and NGOs have persisted in their efforts to improve the watershed, water quality and quantity remain a concern in downstream areas (IUCN Nepal, 2011).

Any PES scheme involves creating new institutions and requires several systematic steps (Wunder, 2005): 1) background analyses of ecosystem services, stakeholders and institutions; 2) assessing market feasibility; 3) demandand supply estimation; and 4) institutional design. Table 1 identifies the different steps, their objectives and the outcomes achieved inour attempt to develop a PES scheme in Sardukhola.

In our study, we started with a careful literature review, followed by meetings with local stakeholders and experts. Dharan residents understand that water supply can be improved by conserving the Sardukhola watershed and have an on-going dialogue with municipal authorities on water source protection. However, these discussions have not sufficiently progressed, possibly because upstream households have largely been ignored and because of limited ideas about a possible institutional architecture.

NWSC, the agency that supplies municipal water to Dharan, does not have any directiveto manage water sources (Government of Nepal, 2007). It cannot generate funds locally or redistribute them to manage water sources. Partly in response to this, the Government created the Dharan Drinking Water Board in 2014, with representatives from public, private and community agencies, and a mandateto handle distribution. The Board is also expected to address some of the challenges of water source management. In this context, the study team was invited to examine household preferences for watershed improvements.

As Table 1 identifies, a second step in PES design is to carefully lay out the linkages between stakeholders who may provide and demand services. To identify the relative preferences for different services and the different activities that would affect services, we under took five Focus Group discussions in upstream area and Dharan municipality. We also consulted with experts to understand the hydrology of the region.

The linkages between upstream land use and water quantity and quality are backed by a larger literature as well as practical examples in Nepal. Water quality in the Nepalese middle hills is affected by sewage and agricultural run-off (Juttner *et al*., 1996). Acute water problems are also a result of a rapidly rising population and poor management (Schreier and Shah, 1996). Changes in forest cover is more noticeably tied to increased precipitation and water availability at larger scales (Ellison *et al*., 2012). However, changes in forests condition can have diverse effects local effects. Big rain events and landslides contribute to erosion and siltation in the fragile Siwalik landscape

[1] The sub-watershed provides multiple services including food, fodder, energy, irrigation water and flood control services IUCN Nepal, 2011. Integrated Watershed Conservation and Management Plan: Sardu Watershed, Dharan, Sunsari, Nepal. IUCN Nepal Country Office, Kathmandu, Nepal.

(Ghimire, 2011). Currently some 32 hectares (1%) of the Sardukhola watershed is affected by landslides, with erosion increasing during the rainy summers (IUCN Nepal, 2011). Grazing, a major driver of deforestation and soil erosion (DFRS, 2014), also contributes to water pollution.

Focus group discussions and expert consultations helped us identify four activities that could change water quality and quantity: open defecation, livestock grazing, chemical fertilizers and landslides affect water supply. Thus, water supply could be improved through: a) construction of toilets to reduce sewage-related contamination; b) reductions in open grazing; c) decrease in chemical fertilizer use; and d) infrastructure to reduce landslides and soil erosion. These considerations led us to design a discrete choice experiment to ascertain water demand and a household survey to examine upstream farmer preferences (Table 1, Step 3). The DCE is discussed in detail in Section 3.

The last step in creating a PES scheme isinstitutional design. For developing an appropriate institutional mechanism, we organized a consultative meeting with local residents after the undertaking the household surveys. Residents of both upstream community and municipality, officials from local bodies (Dharan Municipality, Village Development Committees and District Development Committee), government agencies and non-government organizations participated in these consultations. Participants were informed about survey results and then divided into three groups to discuss a possible institutional set-up,benefit sharing strategies and monitoring mechanisms to implement a PES scheme. The institutional design proposed in this paper is based on these deliberations.

3.1 Understanding demand through a discrete choice experiment

In order to get a clear understanding of whether water users were willing to pay for any changes made in upstream areas and what aspects of water supply they were willing to finance, we implemented a discrete choice experiment (DCE). DCE sare used to elicit individual preferences about a proposed policy or market change in the absence of mechanisms that allow people to clearly reveal their preferences or demand for a good or service (Ben-Akiva and Lerman, 1985; Louviere *et al*., 2000). Under these circumstances, people are asked to respond to multiple alternate scenarios. Each scenario includes differing levels of indicators or attributes of the public good under consideration. Households or individuals are then asked toselect the alternative that maximizes their well-being.

A DCE builds on the assumption that consumers of a set of goods derive utility from the attributes of goods rather than goods *per se* (Lancaster, 1966). Conceptually, household i obtains utility (U_{ij}) by choosing an Alternative j, based on the attributes of the good under consideration. We examine the determinants of this choice by first recognizing that utility can be decomposed into observable (V) and random (ε) components:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (1)$$

Thus, there is a probability P that any given household will choose Alternative j, among all possible Alternatives z, within a choice scenario Ci. This probability function (P), which is influenced by the attributes of different alternatives and by household characteristics, is given by:

$$P\,(j|C_i) = P\,[(V_{ij} + \varepsilon_{ij}) > (V_{iz} + \varepsilon_{iz})] \quad \forall\, j \neq z \qquad (2)$$

The probably function (P) can be empirically estimated, allowing us to establish how much people are willing to pay for certain attributes of a public good.

In the case of the Sardukhola DCE, the public good under examination is drinking water and two important attributes are water quantity and quality. In addition, since erosion of river banks and landslides are frequent problems, the extent of soil erosion is also an important consideration.

A final attribute is water tariff that is higher than what Dharan residents are paying. The higher water tariff is required to pay upstream residents to change activities related to land use and sanitary practices.

Running a DCE requires several steps. First, based on Focus Group discussions, preferences for different attributes and feasible changesneed to be identified. The next step is DCE design based on attributes, sample size and an understanding of how households may respond to different scenarios. A third step is a householdsurvey. Finally, the data are analyzed to examine determinants of choices and to estimate the demand for different attributes.

3.1.1 Establishing the choice set

In all choice experiments, focus groups are used to identify the preferences of community members and the range within which choices are most likely to be made. Thus, we carried out five focus group discussions (two upstream and three water users)in order to identify: a) preferences of and challenges faced by different communities related to drinking water; b) ways to measure differences in preferences in water quality and quantity; c) critical activities that influence water resources; and d) community interest in participating in a PES type scheme.

Water user households indicated that upstream activities such as open defecation and chemical fertilizer use affect water quality. Soil erosion from fragile topography and poor management of upstream areas is also thought to contribute to water scarcity and its poor quality. The focus groups with water users discussed the possibility of paying for improvements in water services. A range of water tariffs (see Table 2) was identifiedthrough these discussions.

Upstream participants were informed about the multiple problems perceived by water users. Upstream households identified three actions that they would consider undertaking to reduce their impact on water quality. Households would consider moving towards 'no open defecation', which would require toilets in each household; reduce the use of chemical fertilizers and regularize of grazing. The need for toilet construction was also identified by the previously developed Sardukhola watershed conservation and management plan based on bacterial contamination and coliform count in water (IUCN Nepal, 2011). Upstream households were informed that they would be compensated if they undertook some of these actions.

In addition to focus group discussions, local experts, including officials from District Forest Office, District Soil Conservation Office, local non-government organizations, Nepal Water Supply Corporation and Dharan Municipality, were consulted to finalize the list of water related attributes and levels. Thus, we devised units of levels of attributes based on local perception and discussions with these local experts. Table 2 presents the attributes and their levels included in the choice experiment.

For the DCE, we developed 20 choice scenarios for water users of Dharan Municipality. Each choice set or scenario presented a picture of the watershed with different levels of the four attributes in Table 2. We grouped these 20 choice sets into five blocks; thus, developing five versions of a household questionnaire. Eachmunicipal respondents were presented four different choice sets during the household survey.

3.1.2 Data and price estimation

Ahousehold survey was undertaken in 2013 in Dharan Municipality to implement the DCE. First, we randomly selected five wards (4, 6, 12, 16 and 18) from the 19 in the Municipality and 40 households in each ward. The first household was selected randomly and every 10th household was interviewed (ensuring their location on either side of the street). Given that there were five versions of the DCE questionnaire, every sixth household received the same questionnaire.

In upstream areas, all nine wards within three village development committees were sampled, with the number of households selected being in proportion to the population of the wards. The upstream survey obtained information on what intervention and incentives would be needed to change households' behavior for improving water quality. The first household was selected randomly, then every 3rd or 4th or 5th household was interviewed based on the ward population. A total of 203 upstream households and 201 municipal households were surveyed. The head of the household, of either gender, was interviewed.

DCE respondents were presented with colorful choice sets, with pictures and bars, describing each alternative scenario (see Figure 2) in order to facilitate responses (Rai and Scarborough, 2013).

During the household survey, municipal respondents were informed that the increased water tariff would support upstream activities, which would be monitored by a local institution. Respondents were informed that a ten-year watershed management plan would be developed and implemented with the finances raised from the water tariff.

To examine municipal water demand, we estimated random parameter logit (RPL) models with the data from the DCE. We estimated indirect utility from the choices municipal households made as follows:

$$V_{ij} = ASC + \beta x_{ij} + \eta x_i + \gamma s_i \quad (3)$$

where, V_{ij} is the utility obtained by the i^{th} household from the j^{th} alternative, x_i is a vector of attributes included in the experiment, β is a vector of coefficients that informs us how different attributes influence choices and η is a vector of individual deviations of random attributes. A vector of socio-economic variables (s_i) are introduced to control for household heterogeniety and the coefficient (γ) reflects these effects. An alternative specific constant (ASC) explains systematic variation between the status-quo and proposed alternatives that cannot be captured by the attributes. These constants are coded as 1 for policy alternatives and 0 for the status-quo.

Selected socioeconomic variables were interacted with the ASCs to identify the sources of heterogeneity in choice tasks (Table 3). The selection of these socioeconomic variables is based on their linkage with welfare changes and natural resource management (Rai and Scarborough, 2013; Sangkapitux *et al*., 2009). Since each respondent receivesfour different choice sets, these observations cannot be treated as random. We used a panel specification to address this problem (Bliemer and Rose, 2008).

We estimated equation (3) in order to quantify the implicit price of different attributes. In equation (3), allattributes are treated as non-random except for the cost variable. The distribution of the cost attribute is assumed to have a triangular distribution in order to ensure finite moments (Daly *et al*., 2012; Rai *et al*., 2015). We estimate the implicit price of the attribute k, representing water quality, water quantity and land erosion control using the following expression:

$$IP_k = -\beta_k / (\beta_c + \sigma_c \times \varphi_c) \quad (4)$$

where, β_k and β_c are coefficients of attribute k and cost respectively, σ_c is the estimated standard error of cost attribute, φ_c is a draw from the triangular distribution (Hensher *et al.*, 2005).

Since households were informed about a set of proposed changes for the watershed, we estimate their willingness to pay to implement the proposed management plan. The change in household welfare from implementing the planned watershed management program can be estimated using following formula (Hanemann, 1984):

$$WTP_{hh} = \frac{1}{\beta c} [ln (\Sigma_{jER} exp (V_0)) - ln \Sigma_{jER} exp (V_1))] \quad (5)$$

where WTP_{hh} is the household willingness to pay (WTP) for the change in utility moving from the current situation to a new scenario. V0 is utility in the current situation and V1 is utility in new situation. Aggregating across all beneficiary households, the total financing that would be available locally if the watershed management plan is implemented is estimated as follows:

$$Total\ WTP = WTP_{hh} \times population \times p \quad (6)$$

where p is the proportion of respondents with a positive WTP.

4. Results

Our results focus on differences between upstream and municipal households based on the household survey, the value municipal households place on water quality and quantity and preliminary ideas for an institutional architecture for implementing PES.

4.1 Differences between upstream and municipal households

Survey data (Table 3) suggests that there are some significant differences between upstream and municipal areas in land use activities, while demographically, they are similar. The average household size in both areas is 5, the household head has about 4 years of education in upstream areas, and is slightly more educated in the Dharan Municipality.

Upstream areas are dominated by farmers, while less than 13% of the sample from municipal areas was farmers (Table 3). Some 56% of upstream farmers indicate that agriculture is their main source of income, while only 3% of municipal farmers point to agriculture as the main income source.

Upstream households, on average, own some 3.6 tropical livestock units per family, while livestock is rarely owned in municipality. Some 56% of these households graze their livestock in the forests and18% take their animals regularly to upstream water bodies. In upstream areas, 57% of the households have a toilet with flush connected to a septic tank, 29% have pit/ring toilet and 13% do not have toilet. All municipal houses generally have a toilet connected to either a septic tank or the municipal sewer system.

The household survey shows that most Dharan municipal households (88%) have private taps within their homes. In upstream areas, 84% households have private taps and about 13% use public taps. In the dry season, a majority (68%) of the municipal households uses tube wells to fulfill household water demand, a smaller proportion (9%) buys from private vendors and the rest adjust their consumption. In upstream areas, during the dry season, some 17% buy water from the market and the rest adjust their household activities (see Figure 3). Most households boil and filter before drinking water.

Overall, a remarkable number of respondents (93%) view water as a service provided by forests. Some 69% of upstream and municipal respondents were aware that water sources need special management activities and 88% were confident that upstream activities influence the availability of water quality and quantity. Almost all upstream households expressed interest in agro-forestry and farm based income generation activities, including livestock keeping and organic farming. For these activities they expect materials.

4.2 Dharan municipality water demand

This section and the next examine municipal household preferences for water and what households are willing to pay to satisfy these preferences. We assess implicit prices of different attributes from anestimated RPL model based on 500 iterationsin Table 4. The model estimates the price of drinking water as random parameter. As expected, respondents preferincreased supply in drinking water during the dry season, improved drinking water quality, a decrease in the area affected by landslides and lower drinking water fee. The coefficients of the levels of drinking water quality, which are coded as dummy variables, indicate that respondents prefer to have drinking water if they can drink directly from a tap compared to filtering before drinking. But, boiling before drink is not significant.

The results indicate that men are more likely to select alternatives (improved watershed conditions) compared to their female counterparts. This may be because watershed management activities are generally undertaken by men (Croke *et al.*, 2012). Older respondents select alternatives less frequently compared to younger respondents, reinforcing similar results from other research inthe Koshi Basin (Rai *et al.*, 2015). As expected, household incomeis positively associated with selecting alternatives over staying with the status quo. Likewise, respondents using more drinking water select alternatives more frequently compared to respondents using less drinking water.

The implicit prices of each attributes included in choice sets and their upper and lower boundsare estimated in Table 5. Currently, households in Dharan pay NPR 15 per kiloliter of drinking water and generally filter and boil water for drinking purpose. Households are willing to pay an additional 18 paisa[2] per kiloliter if there is a 10% (58 liters per household) increase in drinking water supply in the dry season[3]. This means, if drinking water meets 35% of dry season demand, given that current availability is 25% of demand, then households are willing to pay NPR 15.18 per

[2] Paisa is a sub-unit of Nepalese rupee (NPR). 1 NPR= 100 paisa. 1 USD~NPR 108.

[3] Households are collecting 432 liter and 144 liter water per day in average during wet and dry season respectively (IUCN 2011).

kiloliter. Similarly, the average WTP for the protection of one hectare of land from landslides is anadditional eleven paisa per kiloliter. Dharan municipal households are willing to pay an additional NPR 2.19 and NPR. 2.75 per kiloliter for improvements in water quality to drinkable after filtering and drinkable without any treatment respectively. This indicates that water quality is the most important issue to municipal household. Based on average monthly water consumption 10 kiloliter per family in Dharan, this amount for improved water quality is reasonable because the average monthly cost of filtration is NPR 6 in Kathmandu in 2005 (Pattanayak *et al*., 2005).

In 2011, IUCN Nepal worked with local stakeholders to create a master plan for the Sardukhola watershed to enable improved water quality and quantity (IUCN Nepal, 2011). By using equation 5, we estimate municipal households' willingness to pay to operationalize two planned scenarios that build on suggestions in the master planand from our focus group discussions. The first scenario (Scenario I) is a plan to double water supply available to municipal households during the dry season, protect eight hectares of land close to the reservoir from erosion and make tap water drinkable after filtering. The second scenario (Scenario II) would require improving drinking water quality to make water drinkable after filtering. It does not include any measures to protect against landslides or increase the quantity of water. Both scenarios would require upstream activities to improve water supply such as regularization of grazing, ban on open defecation, reducing the use of chemical fertilizer and pesticides in farming and solid waste management.

Our DCE findings suggest that municipal households are, on average, willing to make an annual payment of NPR 387 (USD 3.58) for Scenario I and NPR 270 (USD 2.50) for Scenario I[4]. We note that the annual payment for Scenario I and II are 18% and 13% higher than the current average annual water fee of NPR 2,106 (USD 19.5) per household. Aggregating over 27,750 municipal households in Dharan, the total WTP for Scenario I and Scenario II is NPR 11 million (USD 0.1 million) and NPR 8million (USD 0.08 million) respectively.

4.3 Upstream responses

A PES scheme to improve water supply to Dharan Township is only possible if upstream households are willing to make changes in the activities in lieu of any payments received. Upstream farmers have an array of priorities to spend any potential funds received to improve watershed management. Focus group participants of upstream area unanimously stated that they were willing to construct toilets, regularize grazing and reduce the use of chemical fertilizer and pesticides in farmland close to water sources, if funding is available to support these changes.

While upstream farmers are willing to take certain actions to reduce impacts on water supply, they also have additional priorities for local development. If funds are unconditional, nearly half the farmers surveyed said they would prefer to utilize these resources for tourism development, including hotel management. Farmers were also inclined to use resources to support vegetable farming (37%), livestock raising (9%), expanding existing livelihood activities (6%) and cultivating non-timber forest products (3%). This result is not surprising as Bhedetar, a keyupstream village, is a tourist hub with growing demand for hotels and fresh vegetables. Thus, without proper institutional arrangements and effective monitoring, transferring funds to upstream farmers would not necessarily result in watershed improvements.

Two important issues on the supply side is whether the activities proposed (toilet construction, reduction in open grazing, changes in the use of pesticides and fertilizers and control of run-off into water streams) would be adequate to change the quantity or quality of drinking water and whether upstream farmers will stick to any promises they make. Our literature review and discussions with experts indicate that the proposed upstream changes would contribute to better ecosystem conditions and services. While immediate changes may not occur, these shifts in will influence land use and water quality in the medium term. In addition, some additional measures to control landslides, improve agricultural terracing practices, develop water treatment tanks and construct small ponds for irrigation may need to be developed (IUCN Nepal, 2011). The issue of how to implement such additional measures and monitor farmer behavior is discussed below.

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[4] Proposed scenario is to increase by 144 liter water per day per household during the dry season.

4.4 Institutional architecture

Implementing a PES mechanism requires a credible institutional set-up and state support (Fauzi and Anna, 2013). In the context of Sardukhola, the state has a decisive role since the Nepal Water Supply Corporation controls water distribution. However, the Corporation has no legal obligation to protect or manage drinking water sources (Government of Nepal, 2007) even though water supply could be improved through watershed management. This calls for creating new institutional arrangements, which could increase transaction costs and reduce the funds available for upstream communities. These issues were discussed with upstream and water user communities during the Stakeholder Consultation meetings.

During the discussions with local participants about different PES type schemes prevalent in Nepal and their own local constraints, an institutional architecture emerged. Three local institutions: (i) Dharan Drinking Water Board, (ii) Sardu Watershed Protection Committee and (iii) Sardu Upstream Committee (Figure 3) could work together to implement a PES based fund.

The proposed Water Board in Sardukhola could act as a service buyer and make agreements with the Sardu Upstream Committee, which would be the supplier of watershed services. The proposed Sardu Watershed Protection Committee, with representatives from upstream community and water users as well as line agencies, would become responsible for watershed management, funds management and distribution to the Upstream Committee and monitoring.

Can this institutional arrangement create an incentive compatible system? Clearly, the Water Board has the ability to increase and collect tariff from water users as long as the water quality, in particular, improves based on upstream changes. It would be feasible for the Watershed Protection Committee to monitor at least some of these behaviors because the number of upstream farmers is relatively small and actions such as open defecation and grazing are visible. Reductions in the use of fertilizers and pesticides, on the other hand, may be a bit more difficult to implement. The Board would need to monitor and regularly publicly report on water quality in the reservoir. In addition, farmers could be encouraged or financed to develop structures to control run-off from fields so that agricultural pollutants do not enter streams and rivers.

Discussions with local authorities in Dharan indicate that the proposed tri-institutional set up will not run into bureaucratic hurdles since the Local Self-governance Act mandates local governments to support such activities. This proposed institutional mechanism also has a model to build on since it resembles a similar arrangement in Dhulikhel Municipality, where local water management committees, involving up-steam farmers and city residents, support water supply management (Bhatta *et al*., 2014). PES development is also being tested in other areas in Nepal.

5. Discussion

The DCE-based WTP estimates indicate that implementing a PES scheme is socially possible in the Sardukhola sub-watershed. Given household willingness to pay for different attributes of water, it is clear that watershed management activities should focus on improvements in water quality. This is reasonable because clean tap water is used for drinking and cooking and most households pump ground water for other household uses. Household desire for better drinking water quality is to be expected since water borne diseases are a major problem in Nepal (Bhatta *et al*., 2007; Shrestha *et al*., 1998).

Changes in upstream household activities, particularly related to sanitation and livestock management, would result in improvements in water quality. However, there are significant costs associated with these changes. Twenty percent (187) upstream households in our sample do not have toilets. The estimated construction cost of one pit and proper toilet is NPR 25,000 and NPR 40,000 respectively. Aggregating over an estimated 121upstream households who do not have toilets, the total costs of constructing toilets for households without toilets in upstream areas amounts to NPR 3.02 million (USD 28,010) and NPR 4.48 million (USD 44,815) for pit toilets and proper toilets, respectively. Furthermore, the estimated average annual cost of raising livestock in stalls in Nepal NPR 8,000 per household (Shrestha and Evans, 1984). Given the average livestock units per household that are forest grazed in upstream areas, this implies that the annual livestock raising cost for 299 upstream households who currently use forests for grazing is NPR 2.39 million (USD 22,150).

The total annual WTP of Dharan municipality for water quality improvements is NPR 8 million (Scenario II). This amount is greater than the resources required for pit or proper toilet construction for 13% of the upstream households, who do not have a toilet. Then, from the second year, the funds can be used for grazing regularization and other expenses. Further, any surplus amount can be used for establishing and operating the PES program, for awareness raising, environmental management activities such as run-off prevention, waste management, forest improvement and land slide protection, and coordinating with the local district and village development committees to mainstream watershed management into development processes. Water quality monitoring could be undertaken at to ensure that water users are receiving the benefits they are paying for.

Fiscal arrangements and transaction costs need serious attention in PES implementation (Fauzi and Anna, 2013). The participation of central as well as local government along with private and community based organizations is also crucial becausesuccessful implementation depends on trades between multiple parties (Vatn, 2010). While the transaction costs are yet unclear, the Sardukhola PES institutional design and expressed preferences for clean water suggest that a trade-based scheme is possible.

6. Conclusions

This paper discusses a local policy instrument to improve water supply in remote parts of the developing world. Developing a PES type mechanism in Sardukhola sub-watershed in Nepal seems both socially acceptable and financially feasible. Choice experiments allow us to identify land use changes that can improve water quality and assess what households are willing to pay for water quality improvements. In this case, the average household in Dharan is willing to pay NPR 270 (USD 2.50) or 13% more than the current average annual tariff of 2,106 (USD 19.5) to obtain water that is drinkable after filtering. A master plan for the watershed developed in 2011 indicates that this water quality is achievable by undertaking household waste management, grazing regularization and enhancing organic farming (IUCN Nepal, 2011).

The limited mandate of existing water supply agencies can act as a barrier for developing innovative mechanisms to improve water supply. Through discussions with stakeholders, we suggest that some of these barriers can be removed by combining the responsibilities of three local level institutions. The institutions would take on the role of: (i) ecosystem service consumers, (ii) ecosystem service producers, and (ii) a monitoring agency represented by both consumers and producers. Any transaction costs could be further reduced through cross-agency coordination. For instance, the local government and District Health Office in Nepal implement sanitation programs in many villages. Linking these programs with the proposed PES scheme would reduce costs.

In the case of the Sardukhola PES scheme, the next step involves obtaining government clearance for the proposed institutional arrangement. Currently, draft guidelines for the Sardukhola watershed PES scheme await government approval, with ICIMOD and other partners supporting the approval process. However, both the approval process and initiation of PES schemes is hindered by the lack of a proper legal framework for PES. A carefully crafted national level policy would ensure a quick and less costly process for instituting PES mechanisms. It would also open the door for local and regional governments to initiate PES schemes.Thus, it is timely to develop a national level PES policy framework in Nepal.

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References

Achet, S.H., Fleming, B., 2006. A watershed management framework for mountain areas: Lessons from 25 years of watershed conservation in Nepal. *Journal of environmental planning and management* 49, 675-694.

Ben-Akiva, M.E., Lerman, S.R., 1985. Discrete choice analysis: theory and application to travel demand. MIT press.

Bhatta, D., Bangtrakulnonth, A., Tishyadhigama, P., Saroj, S., Bandekar, J., Hendriksen, R.S., Kapadnis, B., 2007. Serotyping, PCR, phage-typing and antibiotic sensitivity testing of Salmonella serovars isolated from urban drinking water supply systems of Nepal. Letters in applied microbiology 44, 588-594.

Bhatta, L.D., Kotru, R., 2012. Learning perspectives and analytical framework for framing PES in Nepal, in: Acharya, K., Tripathi, D., Joshi, N., Gurung, U. (Eds.), Leveraging and landscapes: conservation beyond boundaries. Nepal Foresters Association Kathmandu, Nepal, pp. 132-157.

Bhatta, L.D., van Oort, B.E.H., Rucevska, I., Baral, H., 2014. Payment for ecosystem services: possible instrument for managing ecosystem services in Nepal. International Journal of Biodiversity Science, Ecosystem Services & Management 10, 289-299.

Bliemer, M.C.J., Rose, J.M., 2008. Construction of experimental designs for mixed logit models allowing for correlation across choice observations, Institute of Transport and Logisitics Studies, in: Sydney, T.U.o. (Ed.), Working Paper Sydney

Central Bureau of Statistics, 2012. National Population and Housing Census 2011 (National Report), in: Secretariat, N.P.C. (Ed.), Kathmandu, Nepal

Central Bureau of Statistics, 2013. National Populationa and Housing Census 2011: Caste/Ethnicity, in: Statistics, C.B.o. (Ed.), Kathmandu, Nepal.

Croke, B., Cornish, P., Choudhry, K., Kharmakar, D., Chakraborty, A., Islam, A., Khan, M., 2012. Water harvesting and better cropping systems for the benefit of small farmers in watersheds of the East India Plateau. Water Practice and Technology 7.

Daly, A., Hess, S., Train, K., 2012. Assuring finite moments for willingness to pay in random coefficient models. Transportation 39, 19-31.

DFRS, 2014. Churia Forests of Nepal in: (DFRS), F.R.A.o.N.P.D.o.F.R.a.S. (Ed.), Kathmandu, Nepal

Dharan Municipality, 2014. Final Detailed Design Report : Integrated Urban Development Project (IUDP), Dharan, Nepal. Dharan Municipality, Dharan

Domènech, L., March, H., Saurí, D., 2013. Contesting large-scale water supply projects at both ends of the pipe in Kathmandu and Melamchi Valleys, Nepal. Geoforum 47, 22-31.

Dongol, B.S., Merz, J., Schaffner, M., Nakarmi, G., Shah, P.B., Shrestha, S.K., Dangol, P.M., Dhakal, M.P., 2005. Shallow groundwater in a middle mountain catchment of Nepal: quantity and quality issues. Environmental Geology 49, 219-229.

Ellison, D., N Futter, M., Bishop, K., 2012. On the forest cover–water yield debate: from demand-to supply-side thinking. Global Change Biology 18, 806-820.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological economics 65, 663-674.

Fauzi, A., Anna, Z., 2013. The complexity of the institution of payment for environmental services: A case study of two Indonesian PES schemes. Ecosystem Services 6, 54-63.

Fiquepron, J., Garcia, S., Stenger, A., 2013. Land use impact on water quality: valuing forest services in terms of the water supply sector. *Journal of environmental management* 126, 113-121.

Forest, D.o., 2014. Community Forestry Database (unpublished), in: Forest, D.o. (Ed.), Kathmandu, Nepal.

Gardner, R.A.M., Gerrard, A.J., 2003. Runoff and soil erosion on cultivated rainfed terraces in the Middle Hills of Nepal. Applied Geography 23, 23-45.

Ghazoul, J., Garcia, C., Kushalappa, C., 2009. Landscape labelling: a concept for next-generation payment for ecosystem service schemes. Forest Ecology and Management 258, 1889-1895.

Ghimire, M., 2011. Landslide occurrence and its relation with terrain factors in the Siwalik Hills, Nepal: case study of susceptibility assessment in three basins. Natural Hazards 56, 299-320.

Gómez-Baggethun, E., de Groot, R., Lomas, P.L., Montes, C., 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecological economics 69, 1209-1218.

Government of Nepal, 1996. Buffer Zone Managmenet Rules, 2052 (1996), in: Nepal, G.o. (Ed.), Kathmandu, Nepal

Government of Nepal, 2007. Third Amendment of the Nepal Water Supply Corporation Act, 2007, Kathmandu, Nepal.

Gurung, P., Sherpa, T.Y.C., 2014. Freshwater Scarcity and Sustainable Water Management in the Hindu Kush-Himalayan (HKH) Region. Hydro Nepal: *Journal of Water, Energy and Environment* 15, 42-47.

Hanemann, M., 1984. Welfare evaluations in contingent valuation experiments with discrete responses. *American Journal of Agricultural Economics* 66, 332-341.

Hensher, D., Rose, J., Greene, W., 2005. Applied choice analysis: a primer. Cambridge University Press, Cambridge.

IUCN Nepal, 2011. Integrated Watershed Conservation and Management Plan: Sardu Watershed, Dharan, Sunsari, Nepal. IUCN Nepal Country Office, Kathmandu, Nepal.

Juttner, I., Rothfritz, H., Ormerod, S., 1996. Diatoms as indicators of river quality in the Nepalese Middle Hills with consideration of the effects of habitat-specific sampling. Freshwater Biology 36, 475-486.

Kosoy, N., Martinez-Tuna, M., Muradian, R., Martinez-Alier, J., 2007. Payments for environmental services in watersheds: Insights from a comparative study of three cases in Central America. *Ecological Economics* 61, 446-455.

Lancaster, K.J., 1966. A new approach to consumer theory. *The journal of political economy*, 132-157.

Lenat, D.R., 1984. Agriculture and stream water quality: a biological evaluation of erosion control practices. Environmental management 8, 333-343.

Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. Stated choice methods: analysis and applications. Cambridge University Press.

Merz, J., Nakarmi, G., Shrestha, S., Dahal, B., Dangol, P., Dhakal, M., Dongol, B., Sharma, S., Shah, P., Weingartner, R., 2003. Water: A Scarce Resource in Rural Watersheds of Nepal's Middle Mountains. Mountain Research and Development 23, 41-49.

Ministry of Water Resources, 2001 The Hydropower Development Policy, 2001 in: Resources, M.o.W. (Ed.), Kathmandu, Nepal

National Planning Commission, 2002. Tenth Plan (2002-2007), in: Commission, N.P. (Ed.), Kathmandu, Nepal

National Planning Commission, 2007. Three Year Interim Plan (2007/08–2009/10), in: Commission, N.P. (Ed.), Kathmandu, Nepal

Nepal, G.o., 1993. Forest Act 2049 (1993), in: Conservation, M.o.F.a.S. (Ed.). Law Books Management Board Kathmandu, Nepal

Nepal, G.o., 1999. Local Self-Governance Act 2055 (1999), in: Justice, M.o.L.a. (Ed.). Law Books Managemnet Board Kathmandu, Nepal

Niraula, R.R., Gilani, H., Pokharel, B.K., Qamer, F.M., 2013. Measuring impacts of community forestry program through repeat photography and satellite remote sensing in the Dolakha district of Nepal. Journal of environmental management 126, 20-29.

Pandit, R., Bevilacqua, E., 2011. Forest users and environmental impacts of community forestry in the hills of Nepal. Forest Policy and Economics 13, 345-352.

Pattanayak, S., Yang, J.-C., Whittington, D., Kumar, K.B., 2005. Coping with unreliable public water supplies: Averting expenditures by households in Kathmandu, Nepal. Water Resour. Res 41, W02012.

Pokhrel, D., Viraraghavan, T., 2004. Diarrhoeal diseases in Nepal vis-à-vis water supply and sanitation status. J Water Health 2, 71-81.

Pravat, P.S., Humphreys, D., 2013. Using a multilevel approach to analyse the case of forest conflicts in the Terai, Nepal. Forest policy and economics 33, 47-55.

Rai, R.K., Scarborough, H., 2013. Economic value of mitigation of plant invaders in a subsistence economy: incorporating labour as a mode of payment. Environment and Development Economics 18, 225-244.

Rai, R.K., Shyamsundar, P., Nepal, M., Bhatta, L.D., 2015. Differences in demand for watershed services: Understanding preferences through a choice experiment in the Koshi Basin of Nepal. Ecological Economics 119, 274-283.

Sangkapitux, C., Neef, A., Polkongkaew, W., Pramoon, N., Nonkiti, S., Nanthasen, K., 2009. Willingness of upstream and downstream resource managers to engage in compensation schemes for environmental services. International Journal of the Commons 3.

Schreier, H., Shah, P., 1996. Water dynamics and population pressure in the Nepalese Himalayas. GeoJournal 40, 45-51.

Shrestha, R., Evans, D., 1984. The private profitability of livestock in a Nepalese hill farming community. Agricultural Administration 16, 145-158.

Shrestha, S., Hennig, A., Parija, S., 1998. Prevalence of rhinosporidiosis of the eye and its adnexa in Nepal. *American Journal Of Tropical Medicine And Hygiene* 59, 231-234.

Thapa, G.B., Paudel, G.S., 2002. Farmland degradation in the mountains of Nepal: a study of watersheds 'with' and 'without' external intervention. Land Degradation & Development 13, 479-493.

Vatn, A., 2010. An institutional analysis of payments for environmental services. *Ecological Economics* 69, 1245-1252.

Vincent, J.R., Ahmad, I., Adnan, N., Burwell III, W.B., Pattanayak, S.K., Tan-Soo, J.-S., Thomas, K., 2015. Valuing water purification by forests: an analysis of Malaysian panel data. Environmental and Resource Economics, 1-22.

Wunder, S., 2005. Payments for environmental services: some nuts and bolts. CIFOR Jakarta, Indonesia.

Wunder, S., 2007. The efficiency of payments for environmental services in tropical conservation. Conservation biology 21, 48-58.

Tables

Table 1: Steps to develop a PES scheme

Step	Objective	Methods	Outcomes
Background Analyses	To identify i) Services users, producers and existing institutions. ii) The nature of upstream and downstream activities.	i) Literature and document review. ii) Expert consultations.	i) Preliminary investigation of stakeholders, watershed management issues and existing management practices. ii) Identification of factors that affect services.
Assessing Market Feasibility	To understand i) Local priorities over ecosystem services. ii) Ecosystem conditions and linkages between upstream and downstream activities.	i) Mapping of local areas and activities. ii) Focus group discussions with upstream and downstream communities. iii) Expert consultations.	i) List of attributes prioritized by downstream users. ii) Identification of mechanisms through which upstream activities affect downstream water. iii) Status of current and potential desired upstream activities.
Analyzing Demand and Supply	To assess the value placed on ecosystem services and opportunity costs of changes required.	i) Choice experiment design ii) Household survey and analyses.	Estimation WTP of downstream users
Institutional Design	To develop a local institution for facilitating and monitoring PES.	i) Workshop and discussions with local stakeholders. ii) Dialogue with local government agencies and community leaders. iii) Development of a local fund	i) Sharing of results from CE survey and stakeholder discussions. ii) Design of local level institution to implement PES.

Table 2: Selected attributes and their levels for downstream (Dharan municipality)

Attributes	Description	Levels
Drinking water Quality	Quality of drinking water supplied to downstream households. This is measured by the type of treatment required before drinking. Currently, water requires filtering first and then boiling to make it drinkable.	1. Drinkable after filtering and boiling 2. Drinkable after filtering (using normal home water filter) 3. Drink directly from tap
Drinking Water Quantity	Quantity of water available for household use during the dry season (February- May). This is measured by the percentage of water supplied during the dry season. Currently, on average, each household gets approximately 25% of its 'required' dry season quantity.	1. 50% of requirement 2. 75% of requirement 3. 100% of requirement
Soil Erosion and Landslides	Mass wasting of river banks and soil erosion in midstream and upstream areas. This is measured by the area of land vulnerable to landslides and soil erosion. Currently, about one percent of the watershed area (32 ha) is covered by landslides.	1. 24 ha 2. 16 ha 3. 8 ha
Water fee	This is price per kilo liter (1,000 liter) of water supplied by the Nepal Water Supply Corporation. The current price is NPR. 15.00 per kilo liter.	1. NPR. 16 2. NPR. 17 3. NPR. 18

Table 3: Socio-economic characteristics of sample (standard deviation in parentheses)

Variables	Upstream	Dharan municipality
Female	64%	62%
Age (Years)	39.16 (14.18)	42.98 (14.66)
Education (Years)	3.59 (1.93)	4.52 (2.13)
Family size	5.40 (2.10)	5.52 (2.19)
Agriculture as the main source of income	56%	3%
Drinking water demand (liter/day)	219 (465)	589 (247)
Irrigated land (ha)	0.07 (0.19)	0.14 (0.66)
Unirrigated land (ha)	0.19 (0.23)	0.02 (0.08)

Table 4: Results of RPL model (Downstream /Dharan municipality)

Variables	Coefficients (standard error)
Attributes	
Drinking water quantity	1.90e-2 (7.77e-3)**
Erosion	-0.115(1.28e-2)***
Drink after boiling	1.09 (1.06)
Drink after filtering	2.26 (1.05)**
Drink directly from tap	2.83(1.08)***
Drinking water fee	-1.08(0.102)***
Characteristics	
Household income	0.779 (0.274)***
Male	0.881 (0.515)*
Drinking water use	1.59e-3(7.03e-4)**
Age	-5.80e-2 (1.51e-2)***
ASC	-2.05e-2(0.104)
Standard deviations of random parameters	
Drinking water fee (T)	0.542 (5.13e-2)***

Table 5: Implicit prices and their confidence intervals

Attributes	Implicit prices (NPR)
Drinking water quantity increase by 10% (per kilo liter)	0.18 (0.14-0.22)
Erosion (Reduction of erosion per ha)	0.11 (0.09-0.13)
Drinking water quality-drink after filtering (per kilo liter)	2.19 (1.70-2.68)
Drinking water quality-drink directly from tap (per kilo liter)	2.75 (2.15-3.35)

Figures

Figure 1: Study Area

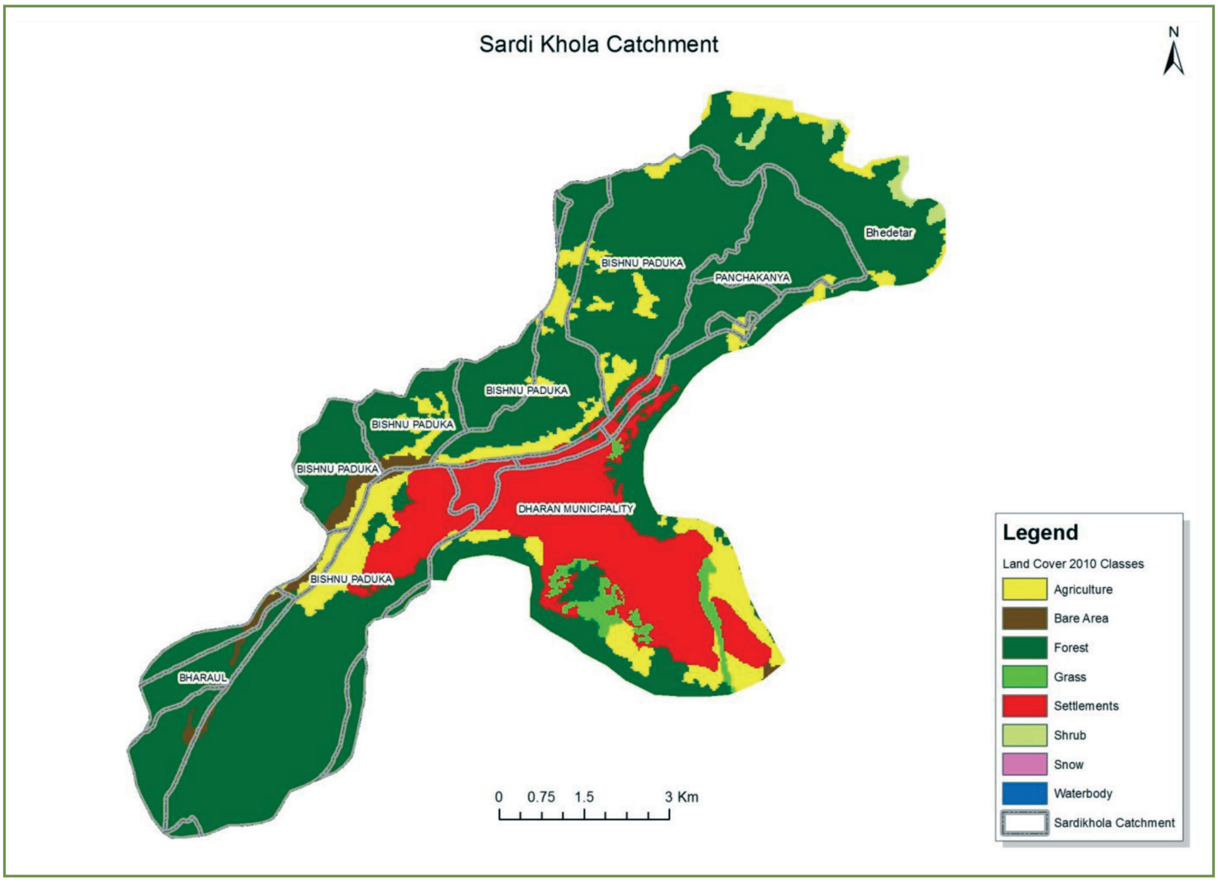


Figure 2: An example of choice set for downstream community

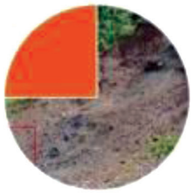
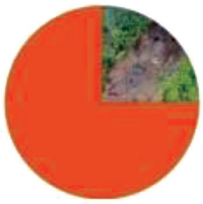
Attributes	Alternative 1	Alternative 2	Current situation
Drinking water in dry season 	As per need 	Three fourth of need 	One fourth of need 
Drinking water quality 	Drink tap water 	Drink after filter 	Filter and boil 
Area affected by landslide 	24 ha 	8 ha 	32 ha 
Drinking water fee 	NRs.16 	NRs.18 	NRs.15 
Your Choice: Please tick (√) one box			

Figure 3: Households' current strategy to fulfill dry season water demand

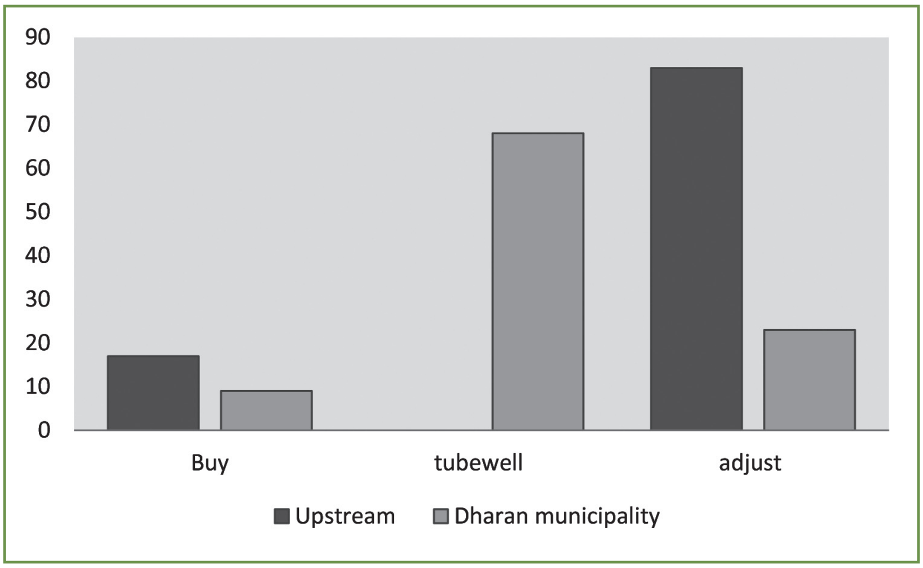
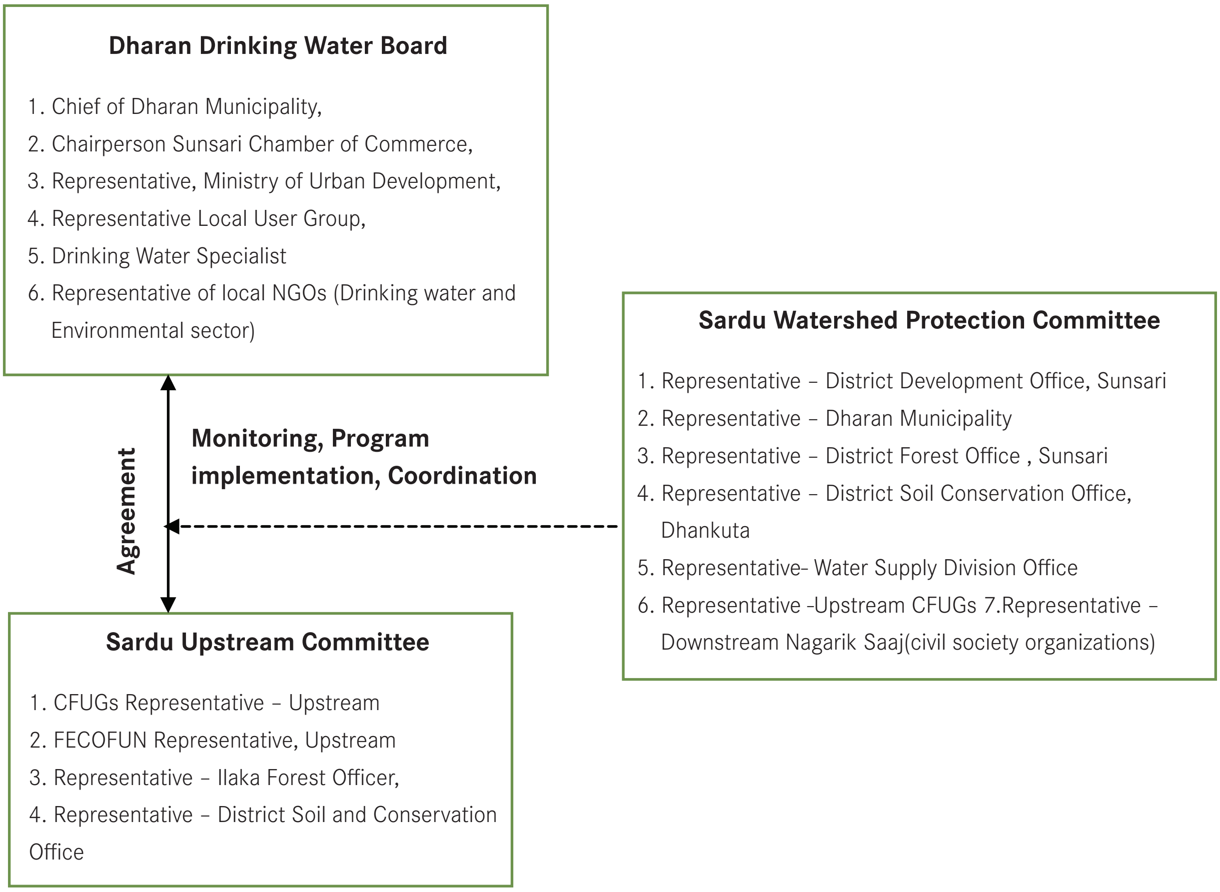


Figure 4: Proposed institutional set-up for PES scheme in Sardukhola sub-watershed



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