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Water storage systems and preference heterogeneity in water-scarce environments: A choice experiment in Nepal's Koshi River Basin

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A B S T R A C T

Many rural communities in Nepal experience considerable water stress during the dry season. Water storage systems (WSSs) have been proposed to supplement rain-fed irrigation and augment domestic water services in these communities. We evaluate household preferences for WSSs using a choice experiment and latent class modeling techniques. Results indicate the presence of three classes. The majority of households ($\approx$92%) belong to two equally-sized classes, a relatively privileged group (i.e. wealthier, better educated, etc.) with strong preferences for supplemental irrigation and a less privileged group that is mainly interested in improved domestic water services. The remaining class' preferences are dominated by the cost attribute and are consistent with households facing severe cash constraints. Estimated welfare effects reveal that WSSs disproportionately benefit the privileged, although this disparity is mitigated with the provision of domestic water. These findings highlight the potential welfare gains from WSS investments, but stress the need for multi-purpose water resource development and the potential for elite capture.

1. Introduction

Nepal possesses abundant rainwater, lakes, rivers, glaciers, and groundwater. The country's annual renewable freshwater resources are estimated at 198.2×10^{11} m^3, with per capita resources at 6502 m^3; the latter being substantially greater than the 1700 m^3 threshold commonly used to identity countries prone to chronic water stress [18,50]. These figures, however, mask the spatial and temporal disparity of water availability. Of particular importance is Nepal's monsoon climate, which gives rise to periods of intense rainfall and prolonged dryness. Many rural mountain communities lack access to secure surface or groundwater supplies, relying on seasonally-varying natural springs for domestic water needs and rainfall for irrigation. For these communities, the dry season is marked by a diminished supply of clean drinking water and severely restricted crop production—potentially leading to increased incidence of water-borne disease from use of inferior-quality water (e.g. typhoid, schistosomiasis, and dysentery), lower income, and malnutrition [36,48].

An estimated 1.6 billion people, primarily in Sub-Saharan Africa and South Asia, are susceptible to water scarcity despite living in water-abundant regions [36]. This scarcity arises from a lack of infrastructure and institutional capacity, as well as inequitable distribution of existing resources [36]. Water storage systems (WSSs) are often proposed as a mechanism for addressing water scarcity. These systems collect rainfall, spring and stream

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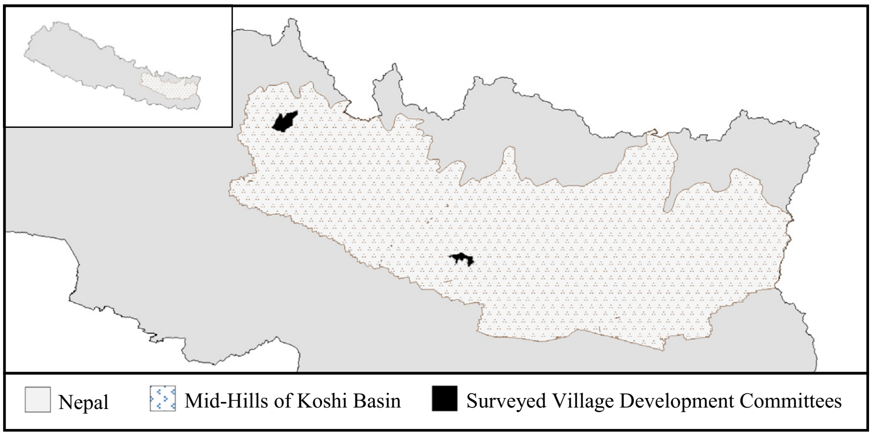

Fig. 1. Middle-hills of the Koshi Basin and surveyed Village Development Committees.

Table 1
Choice experiment attributes and levels.

Attribute	Description	Levels
High Yield (HYield)	Years per decade when land irrigated by the WSS has low water stress and high productivity.	5 Years/Decade 7 Years/Decade 9 Years/Decade
Low Yield (LYield)	Years per decade when land irrigated by the WSS has high water stress and low productivity.	0 Years/Decade 1 Year/Decade
Drinking Water (DWater)	Gagri (25 l) of drinking water available to the household from the WSS per week during the dry season.	0 Gagri/Week 1 Gagri/Week 2 Gagri/Week 3 Gagri/Week
Repair Frequency (Repair)	Years per decade when the WSS requires major repair.	0 Years/Decade 1 Year/Decade 2 Years/Decade 5 Years/Decade
Labor Contribution (Labor)	Days of labor the household must contribute to construction of the WSS.	1 Day 4 Days 8 Days 12 Days
Annual Fee (Fee)	Annual fee paid by the household used for operating and maintaining the WSS.	200 NPR/Year 800 NPR/Year 1400 NPR/Year 2000 NPR/Year 2600 NPR/Year

flow, or water vapor for use by households with limited access to irrigation and domestic water services. Although WSS benefits vary with system scale and scope, there is ample evidence to suggest that they can improve agricultural productivity and rural livelihoods [20,35,42]. In recent decades, Nepal's Department of Irrigation (DOI) and several nongovernmental organizations have supported the construction of small-scale WSSs in rural settlements. These systems are broadly classified by their method of storage: tanks, ponds, and multiuse systems. Tanks are enclosed containers designed to store domestic-use water. They are constructed from ferroconcrete or cement and range in capacity from 1 to 10 m^3 [34]. Reservoirs are concrete- or plastic-lined ponds, ranging between 20 and 250 m^3, primarily used to store water for livestock and supplemental irrigation [43]. Multiuse systems integrate the two storage methods, using tank overflow to fill an uncovered reservoir. These systems are designed to meet the diverse, and occasionally conflicting, needs of water users [45].

In this analysis, we use a choice experiment (CE) to identify preferences for WSSs in the middle-hill region of Nepal's Koshi River Basin (Fig. 1). This region is home to 2.4 million people.[1] It is a mountainous area, ranging in elevation from 800 to 3000 m, which exhibits considerable diversity in climate conditions [15]. Annual precipitation varies between 800 and 3500 mm, with approximately 80% falling during the monsoon season [15]. The vast majority of the population live in rural communities where livelihoods revolve around rain-fed agriculture; although, as in many parts of rural Nepal, the region is characterised by high levels of out-migration and an increasing reliance on remittances [15,26]. Recent census data indicate that 78% of households have access to an improved water

[1] Author's calculation based on the 2011 National Population and Housing Census, available at http://cbs.gov.np/.