Determinants of water consumption: A cross-sectional household study in drought-prone rural India

Mrittika Basu[a,b,*], Satoshi Hoshino[a], Shizuka Hashimoto[b], Rajarshi DasGupta[b]

[a] Laboratory of Sustainable Rural Development, Graduate School of Global Environmental Studies, Kyoto University, Kyoto 606 8502, Japan
[b] Laboratory of Landscape Ecology and Planning, Agricultural and Life Sciences, The University of Tokyo, Tokyo 113 8657, Japan

ARTICLE INFO

ABSTRACT

Rural household water consumption has not been well-researched compared to urban water consumption, particularly in developing countries. Using cross-sectional household-level data from 330 villages in a drought-prone rural district of India, determinants influencing domestic water consumption are studied. Per capita water consumption is found to lie much below the national standards as well as within or sometimes below the limit set for basic water requirements for emergency conditions. Household size is found to have largest, but inverse impact on household water consumption. Determinants like collection time and distance, participation in village meetings, local conflicts over water collection etc. are also identified as significant determinants of household water consumption. Also, as the socio-economic conditions vary from low to high, their water consumption also changes demonstrating an inequity in availability and accessibility to water among the households. We present a practical scenario of persisting household water stress situation prevailing in a drought-prone rural area that gets worsened with onset and duration of drought. The identified factors provide the key priorities that need to be addressed in policy making process to ensure basic water requirements of rural households in drought-prone areas.

1. Introduction

Efficient management of water resources, in both rural and urban areas, requires a full understanding of existing patterns of water use [1]. It has several important applications including strengthening the design and planning of services, enabling providers to better target those most in need, increasing scheme reliability, and thus maximizing the benefits derived from the investments. Also, characterization of how water access and use respond to existing levels of rainfall and temperature variability can inform programmes and investments aimed at increasing resilience to longer term climate change and water stress situations. Increasing demands on available water sources due to intensive agricultural, industrialization and population surge has made developing countries more vulnerable to water scarce periods than developed countries. In spite of this, the existing literatures are found to be predominantly focussed to developed nations while less effort has been made for the developing countries [2].

Persistent water stress is one of the significant characteristics of drought prone areas. Fluctuations in rainfall and/or failure of water supply infrastructures increases water stress conditions manifold. Abundant literature is available on the analysis of perceptions, impact

assessment, coping and adaptation, and water conservation attitudes in drought and drought-prone areas [3,4]. However, a lack of studies on household water consumption is observed when meeting household water demand is one of the main goals of various policy interventions and programme guidelines on drought mitigation or domestic water management strategies. In addition, rural household water consumption is under-researched compared to urban residential water demand in spite of a large difference in urban and rural household water consumption pattern [5–8]. Although domestic water consumption accounts for only a small percentage of total water consumption of a household, the benefits associated with an adequate supply, such as the effects on health, savings of time, and greater productivity, are immense. In this context, prediction of household water consumption is essential to perform efficient and effective supply and demand balance assessment at any spatial scale, particularly at household and precinct scales. The present study aims at analyzing the various determinants of household-level water consumption in a drought-prone rural area in India. The study also assesses the impacts of household socio-economic condition on various aspects of domestic water consumption. The results of this study are expected to help policy makers understand the existing challenges on water consumption at a household scale, and

Table 1
List of major dimensions and variables used in the present study.

Major Dimensions	Variables	Explanation of Variables and unit of measurement
Demographic Characteristics	Household size	Number of adults (12 years and above) living in the house for last one year
	Household head age and gender	Age (in years) and gender (male/female) of the household head
	Age dependency ratio	Ratio of household members under 15 and over 65 years to the population between 16 and 64 years
	Male: Female ratio	Ratio of male to female household members
	Household head education	Percentage of households with different level of education (Table 2)
	Literate members of household	Household members with formal schooling i.e. primary education and above
Physical Characteristics	Primary construction of the house	Percentage of households living in 'Kachha' house made of mud or straw with thatched roof or 'Pukka' house made of bricks and cement with concrete roof
	Primary light source	Percentage of households with and without electricity
	Primary cooking fuel source	Percentage of households using traditional like fuelwood and cow dung, intermediate like coal, charcoal and kerosene, and modern fuel sources like LPG
Economic Characteristics	Households below poverty line	Percentage of households with monthly income less than $ 0.49 /capita/day
	Primary source of household income	Percentage of households earning from different income sources (Table 2)
	Household income per day	Household income range in Indian Rupees (INR)
	Household assets	Household ownership of various assets like refrigerator, car, bicycle etc.
	Access to sufficient food	Average number of months households have access to sufficient food for all members
	Households with migrated members	Percentage of households in which at least 1 member has migrated for earning
Social Characteristics	Participation in *Gram Sansad* meetings	The frequency of participation of household in village meetings: Never, Rarely – once in 6 months, Sometimes – not regular, Often –once a while, Always – never miss a meeting
	Priorities or demands addressed in local decision making process	The frequency of demands getting addressed in local decision making process: Never, Rarely – once in 6 months, Sometimes – not regular, Often – once a while, Always – always addressed
Productive Characteristics	Agricultural land holding size	Percentage of households with different average land holding size in hectares
	Livestock holding	Percentage of household with and without ownership of livestock
Water Availability	Primary source of domestic water	Percentage of households fetching water from different sources like hand pump, public tap, dug well etc.
	Availability of water from primary source	Average number of months water available from primary source
	Water collected by household	Volume of water (in liters) collected by households for consumption
Water Quality	Household water treatment	Percentage of households treating water before consumption
Water Accessibility	Access to personal water source	Household's access to water sources within the house premises
	Time spent on collection of water	Average time (minutes) to fetch water including return trip and standing in queue
	Water collection distance	Average distance (in km) to the primary water source
	Number of trips to collect water per day	Average number of return trips to the water source to fetch water
Sanitation	Household access to toilet facility	Percentage of households having toilet facilities at house and/or its premises
Conflicts over water	Intra-community conflicts	The frequency of household involvement in intra-community conflicts over water accessibility, use, availability and collection.
	Inter-community conflicts	The frequency of household involvement in inter-community conflicts over water accessibility, use, availability and collection.

design strategies to overcome the issues in a rural setup in drought-prone areas.

2. Theoretical framework

Design of the present study is developed after a thorough literature review and previous studies on water security in the study area [9,10]. Rural water demand management has been mainly focused on meeting the agricultural water demand, whereas domestic water demand is largely ignored by the policy makers. The success of domestic water demand management strategies depends on identifying the determinants and their interaction that influence water consumption at a household scale. Households are considered as the key unit to analyze domestic water demand as well as the relationship between determinants and household water consumption [11]. Household water consumption, in the current pretext, refers to the volume of water withdrawn and conveyed for use.

Drawing from the various frameworks on monitoring of domestic water supply [13,35,36], water availability, accessibility, quality and, water for sanitation are identified to be the major determinants of domestic water supply. Table 1 shows the major dimensions and variables used in the present study. Traditionally, availability has been at the central focus. In the present study, the source of the water, volume of water collected from the source per day and monthly availability of water (Table 1) has been included to assess water availability. Monthly availability of water also signifies the reliability on the primary source. The lack of reliability and/or continuity in improved water sources can force households to search for potentially less improved water sources [9,12]. Water accessibility is difficult to quantify as it gets affected by

various factors like quality of water, continuity of the improved source, distance to the source or the age and gender of the water carrier [13]. The availability and location of natural water sources and the siting of water supply points in communities determine the ease of accessibility, which may influence quantities consumed. Hence, variables like time spent on water collection and distance to water source has been considered to quantify water accessibility in the present study (Table 1). A study by Cairncross and Cliff [14] reported that a drop in collection time from 5 h to 10 min increases water consumption from 4.1 to 11.1 lpcd. It has been also found that beyond 30 min, the amount of water collected decreases dramatically with increasing collection time [15]. Similarly, Sandiford et al. [16] observed that a decrease in the distance to the water source from 1000 to 10 m, increases per capita water consumption of 20% in rural areas in developing countries. The number of return trips conducted by the household is considered as a proxy indicator of water accessibility as well as variation in volume of water consumed by households. The higher the number of return trips to water source higher is the hypothesized consumption of a household. Analyzing water quality in the rural area is out of the scope of the present study. As groundwater is the principle water source and there are no reported cases of chemical contamination in the study area, it is hypothesized that the drinking water quality is acceptable for consumption. In the present study, household's intention to treat water shows its awareness towards health safety as well as perceived quality of water by the particular household. Water for sanitation is one of the most important determinants to domestic water supply. Previous studies [9,10] demonstrate the predominance of open defecation and lack of toilet facilities in the study area. Quantification of water required for sanitation becomes difficult. Presence of sanitation facility is selected,