Proc. IAHS, 379, 415–420, 2018
https://doi.org/10.5194/piahs-379-415-2018




# Socio-hydrological implications of water management in the dry zone of Sri Lanka

**Isurun Upeksha Gamage**[1] **and Hetti Arachchige Hemachandra Jayasena**[2]

[1]Post Graduate Institute of Science, University of Peradeniya, Peradeniya 20400, Sri Lanka
[2]Department of Geology, University of Peradeniya, Peradeniya 20400, Sri Lanka

**Correspondence:** Isurun Upeksha Gamage (isurun.gamage@yahoo.com)

Received: 31 December 2017 – Revised: 2 April 2018 – Accepted: 4 April 2018 – Published: 5 June 2018

**Abstract.** Water management plays a vital role in the agricultural economy and living conditions of people in Sri Lanka. Though government and non-government organizations have been readily contributing to water management, it is still inefficient, especially in terms of water allocation, consumption and conservation. To identify factors which could be used to implement integrated water resources management (IWRM), a socio-hydrological study was performed in five areas within the dry zone in Sri Lanka. The study covers a comprehensive analysis of how the household income, demography and education level correlating to water usage, purification and disposal methods. The average household income ranges from LKR 2500 to 15 000 per month. The results show that the average daily usage for drinking, cooking, washing, toiletries and bathing are 3, 5, 10, 7, and 85 L per person, respectively. Majority of the families use dug wells and pipe-borne water as the primary source. Correlation coefficients suggest that higher household income or level of education leads to increased water consumption ($R = 0.91, 0.94$). There is no linear relationship between the level of education with the good practices of water purification and disposal. Though these results indicate preliminary assessments based on the dry zone practices, efficient water management could be enhanced by strong socio-hydrological implications through educating people on conservation, usage, disposal practices and health concerns.

## 1 Introduction

Water management plays a vital role in the agricultural economy and living conditions of people in Sri Lanka (Jayasena and Selker, 2004). Though government and non-governmental organizations have been readily contributing to water management, it is still inefficient, especially in terms of water allocation; consumption and conservation as the water management were based on ad-hoc political decisions (Samad et al., 2017). This paper attempts to examine the causal relationship between the consumption pattern and the trend of water management. The cause is worth studying since a variation of water resources distribution and consumption could be identified based on the educational level and economic status among the families, according to the effects generated due to unequal water supply (UNDP, 2012). There are variations in water usage as shown in principle due to socio-economic and educational diversities. The uneven distribution of rainfall is the basis for agricultural definitions for two seasons "Maha and Yala" (Imbulana and Neupane, 2004). In a previous investigation completed in the same area, it was found that the water supply in this basin is not efficient due to lack of perennial water sources and difficulties in construction and maintenance of water supply schemes (Jayasena and Selker, 2004). In addition, this study focuses on how the relationship between the level of education and the role of economic conditions impact on the water consumption, expecting that the results could be used as a moral support for the management and conservation of water in the domestic level. The variations of distribution and consumption of water are the essential factors to be analyzed as it supports future water management plans in the area. The main objective of this study is to trace the relationships among the rural and peri-urban population with their water consumption, which in-turn will support water management and planning practices in the Deduru Oya basin in Sri Lanka.

Water management involves key stages of assessment, planning, and implementation (Hufschmidt, 1993). The concept of integrated water resources management (IWRM) was developed as an empirical model in 1977 during UNDESA session in Mar del Plata (Hassing et al., 2009) which is used as a reference for this study. In IWRM, economic, socio-cultural and political linkages are interacting on land, water supply and specific water usage. For instance, different perspectives of socio-cultural and political linkages exist between water resources development and people who benefit or adversely affect (Hufschmidt, 1993). Water allocation and usage can be regularized through proper planning of water resource management programs using socio-hydrological data.

## 2 Methodology

The socio-hydrological survey was carried out using a questionnaire designed to cater field level participation of diverse-income families with an aim to collect basic quantitative and qualitative information. The data were collected from five areas, including Weerakodiyana, Rakogama, Aladeniya, Hedeniya and Chilaw Grama Niladhari (GN) divisions (Fig. 1) from the Deduru Oya basin in Sri Lanka and conducted the questionnaire interview by randomly selecting 50 families from each area. Chilaw is a peri-urban town and the sample was mainly from a fishing community whereas Aladeniya has local merchant community. Weerakodiyana and Rakogama are two different rural agricultural areas with the farming community supplied with reservoir based irrigation water. Hedeniya, an agricultural community from the central highlands supplied with natural springs and groundwater developed through foreign agencies. However, due to local field conditions and considering the diversified family backgrounds, only 30 families were selected from the Aladeniya GN division. The study region is within the Deduru Oya basin and the main focus was given to identify its water management system from several social segments as they have dissimilar economic and social backgrounds.

The main aim of using this sample is to understand their economic, educational, ethnic, and gender backgrounds. The data were collected on many aspects covering several periods from 2003 to 2006. One major component of the study focused on daily water requirement and consumption such as drinking, cooking, washing, toiletries, and bathing. The data were collected by trained enumerators selected from the undergraduates and educated high school students. Interviews were carried out as a parallel data collection method to gather information on livelihood, economic barriers, water-related problems and consumption resolution for this paper.

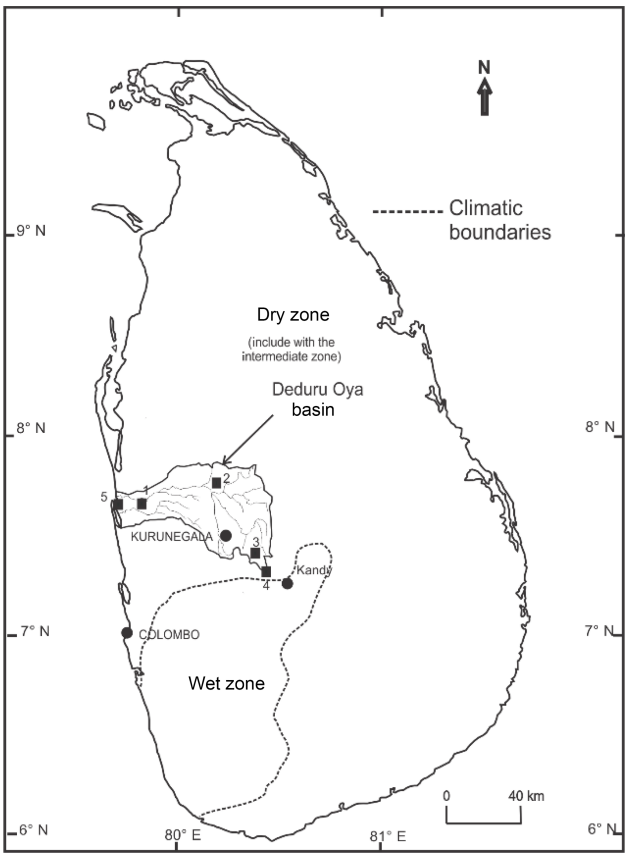


**Figure 1.** Sri Lanka showing climatic zones (modified after Muththuwatta and Liyanage, 2013), and study GN Divisions. 1. Weerakodiyana, 2. Rakogama, 3. Hedeniya, 4. Aladeniya, 5. Chilaw.

## 3 Results and discussion

### 3.1 Water consumption

Per-capita, water consumption has been studied with respect to monthly income and the level of education (Fig. 2) The average water consumption for different income levels has been tested and observed that the water consumption monotonously increases with the income ($R = 0.91$)

This may indicate the freedom of water usage and the easy approach to water availability at the household level that leads to increase in overall consumption. As shown in the village level, public water supply schemes have been incorporated and those who have contributed to the capital and maintenance expenditure got the full share. As given in the previous studies, some communities would prefer to allocate nearly 2–3 % of their monthly emoluments in this respect (Jayasena and Selker, 2004; Jayasena and Dhanapala, 2014). At the same time, food traits or hygiene habits would also change when the buying power is high. As Imbulana and Neupane (2004) reported, about 43–55 % of the families in the Deduru Oya basin have received economic sup-

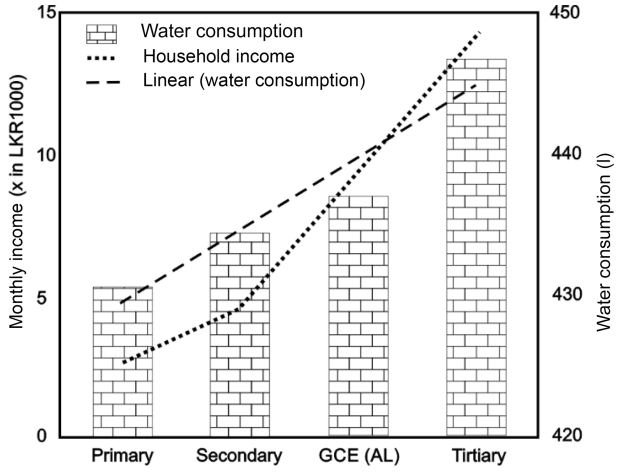


**Figure 2.** Monthly household income and daily water consumption vs. level of education.

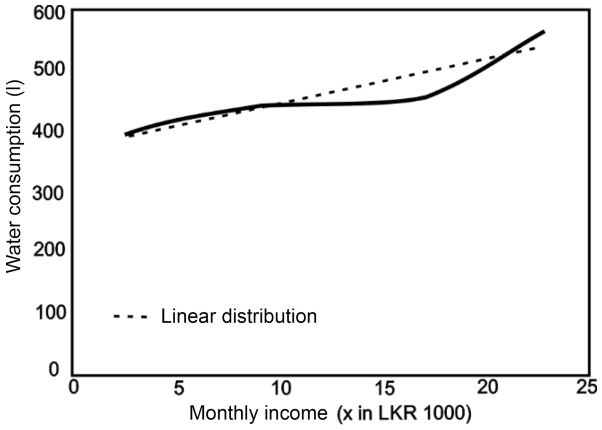


**Figure 3.** Monthly household income vs. daily water consumption.

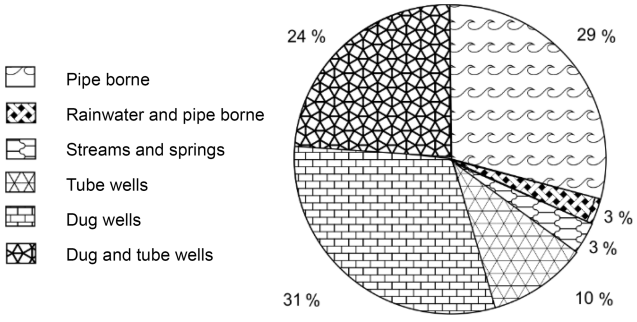


**Figure 4.** Water sources used by the total sample.

ports during this period. The outcome from the areas of study with low economic development contrast with the developed cities. The positive trend of water and income is still obvious. This could also be the reason behind the increased water consumption among the group with the family income above LKR 5000 (approximately USD 50 in 2004). Based on the outcome, one can argue that the traditional approach to water management or case by case isolated approaches are not appropriate as we have socio-economic factors to consider under a holistic approach to the water management problem in hand (Hufschmidt, 1993). A clear relationship between the two parameters reveals that the water consumption is proportional to the monthly income. According to the "psychological law of consumption" by Keynes (1936), water consumption increases with increasing income, but not to the same extent as the increase in income. Consumption will depend on the level of aggregate income. Thus the monthly water consumption ranges from 96 to 136 L per person per day. A correlation coefficient of 0.94 was obtained when water consumption is related to the level of education (Fig. 3).

Although water consumption increases with the level of education, the rate is smaller than the rate of income rise as specified on the secondary plot (Fig. 3). The average income per person in the low education category is approximately LKR 2600 (approximately USD 26 in 2004) per month. This might be due to low educated consumers with low income attempting to save water by different means. Such trends suggest the importance of general education in making changes to the water-related behavior. Thus the influence of education on water management in the dry zone region will have a positive outcome. The water resources planning and management shall be favored by awareness programs and water conservation campaigns for a better management output.

The average of the total water consumed 110 L per person per day is generally tolerable and taking regular baths is the biggest water usage among the households. As we consider the average daily usage for drinking, cooking, sanitation (water usage for toiletry), washing (particularly clothes) and bathing are 3, 5, 7, 10, and 85 L respectively. With respect to proper management, we cannot expect efficiency by putting up the water price. Sri Lanka has both piped and non-piped water sources so that the influence of price change is insignificant due to the complimentary usage of private well water which is free (Nauges and Van Den Berg, 2009). As findings of Kandy Municipality water conservation suggest that domestic water is neither price-nor income-elastic (Gunatilake et al., 2001). For water management, there should be an estimation of how much water to allocate for different sectors.

Majority households use groundwater though the occurrence is limited to regolith and the fractured network in the basin (Jayasena et al., 1986). As such 31 % of the households use only dug wells, 10 % use tube wells and another 24 % depending on both dug and the tube wells as the primary source of water (Fig. 4). Usually, the Rakogama and Weerakodiyana areas have the maximum usage through domestic dug wells and tube wells. Unfortunately, there is a minimal usage of rainwater, as rainwater harvesting for domestic purposes has not yet been effectively practiced by the villagers (Ariyananda, 1999). From the traditional constructions of tank cascade systems and man-made reservoirs

mainly for the purpose of irrigation agriculture, people still consume water; however, there are no significant improvements to the traditional constructions of minor tanks due to the conflict between traditional irrigation systems and mechanized modernization methods. The irrigation system of most dry zone villages is crude in comparison to that existed under the ancient civilization (Panabokke, 2009). On the other hand, short-term political and economic plans and haphazard technical inputs are not yet geared enough for such efficient water management as observed in the history (Gangadhara and Jayasena, 2005). It is imperative to apply suitable socio-technical methods to be used in the modern periods where the outcome of the projects satisfies the needs of society. The water resources in a basin are basically fixed and tend to be relatively scarcer than land resources and they are determined by climatic conditions (Falkenmark, 1995).

The water consumption is mainly dependent on the traditional sources as discussed above. Therefore, the rainwater harvesting systems for a domestic use shall be implemented as a fine project in the dry zone of Sri Lanka. If people can use rainwater in conjunction with the pipe-borne water, the water wasted through infiltrating and soaking into the ground, evaporating into the atmosphere and discharge into the drainage systems can be controlled as such that effective economic management can be placed under IWRM guidelines. According to Jønch-Clausen (2004), the importance of improved water efficiency as part of national water strategies, and thus considered as a part of the IWRM plans. Water resources management shall yield adequate benefits if there is integration between institutions and proper data and scientific analysis of basin hydrology (Hufschmidt, 1993).

Another significant factor as observed in this study is the influence on water consumption due to the unregulated water supply. Availability and access to more water may psychologically tempt consumers to use more water so that the overall usage would be high as quoted by de Miranda Coelho et al. (2016). For instance, having money, big houses and gardens, and a big family promote water waste according to Corral-Verdugo et al. (2003). Overall groundwater usage in the basin is 65 % through dug and tube wells. Only 29 % have access to national pipe-borne water supply (Fig. 4). Accordingly, consumers using pipe-borne water or other natural water resources consume more water compared to dug well or tube well users. The reason for this difference could be two-fold. Partly it could be due to low amounts of water produced in the wells and tube wells in the dry zone. On the other hand, one can argue with the natural tendency of humans not to extend their energy to fetch water from areas having difficult access. Psychologically people trying to minimize or share their energy usage, so that they developed various machines to suit their requirements. Corral-Verdugo et al. (2003) study state "using water-saving devices, facing norms demanding a decreased consumption, and living in a place where water is scarce lead to water conservation". Therefore, scarcity of water influences people for lower usage.

Families living in the selected communities use basic methods such as boiling or filtering in order to eliminate suspended particles. Sometimes the villagers do not want to boil or filter as they believe boiling could alter the taste. On the other hand, most dug wells have "kumbuk" (Terminalia Arjuna) trees next to or in the surrounding environment and it was considered as a purifier of water. This has been inherited from their ancestors and common knowledge passing through ayurvedic or Sinhala medicine (Uragoda, 2000). Surprisingly, there is no clear evidence that higher level of education leads to a higher tendency towards water purification. However, it seems that those who have completed a higher level of education are determined at least to boil water which is significantly prominent compared to other education levels. With further data analysis concurrent with similar studies, a formal design to the water management among the families in the dry areas could be achieved.

## 4 Summary

This paper discusses the data collected from 5 different dry-zone GN divisions in Sri Lanka through questionnaire survey to relate them and identify domestic water demand, water management and how socio-technical parameters viz: economy, inherited knowledge and education act on water management. Water price and income were the most influential parameters of the study. In this paper, attempt to relate collected data with other variables such as occupation level and purification type.

The most popular method of purification was boiling irrespective of the level of education and economic background of the family. Even though there is a direct correlation between economic background and water consumption, it is unhealthy to practice water conservation and management by increasing the price of water since the majority of the families are on the government aid. As a significant factor, the level of awareness and improvement of the IWRM practices in the area for a well-managed water policy need to implement in order to get rid of water consumption imbalances. Thus it is essential to follow the guidelines of IWRM and applying them with the inputs from the socio-technical background of the local regions.

**Data availability.** The data set that provides information gathered from 50 families each from Weerakodiyana, Rakogama, Hedeniya, and Chilaw, and another 30 families from Aladeniya in the Deduru Oya basin are available at https://www.academia.edu/36404612/Data_Set_2nd_April_2018. These data were collected in the 2003–2006 period with support from the Tharuna Aruna Skilled Development program conducted through Soil Tech (Pvt.) Ltd. These data are comprised of basic socioeconomic, water usage, water purification, and disposal at the household level. This is a subset of the original larger data set which will be available in due course after completion of the detailed analysis.

**The Supplement related to this article is available online at https://doi.org/10.5194/piahs-379-415-2018-supplement.**

**Competing interests.** The authors declare that they have no conflict of interest.

**Special issue statement.** This article is part of the special issue "Innovative water resources management – understanding and balancing interactions between humankind and nature". It is a result of the 8th International Water Resources Management Conference of ICWRS, Beijing, China, 13–15 June 2018.

**Acknowledgements.** The data collection were supported by enumerators employed through the TharunaAruna Skilled Program of the Government of Sri Lanka and the Soil Tech (Pvt) Ltd, Colombo Sri Lanka. Without their meticulous inputs, the project could not result in such high-quality socio-technical data. The support extended to the senior author during his sabbatical in Canada by the Orbit Engineering is acknowledged. Fellows and friends who supported us in the preparation of this manuscript are acknowledged with many thanks.

Edited by: Zongxue Xu
Reviewed by: two anonymous referees

## References

Ariyananda, T.: Rainwater harvesting for domestic use in Sri Lanka, in: Proceedings of the Integrated Development for Water Supply and Sanitation, 25th WEDC Conference, Addis Ababa, Ethiopia, 369–372, 1999.

Corral-Verdugo, V., Bechtel, R. B., and Fraijo-Sing, B.: Environmental beliefs and water conservation: An empirical study, J. Environ. Psychol., 23, 247–257, 2003.

de Miranda Coelho, J. A. P., Gouveia, V. V., de Souza, G. H. S., Milfont, T. L., and Barros, B. N. R.: Emotions toward water consumption: Conservation and Wastage, Revista Latinoamericanade Psicología, 48, 117–126, 2016.

Falkenmark, M.: Land and water integration and river basin management, Proceedings of an FAO informal workshop, Publications Division, Food and Agriculture Organization of the United Nations, Rome, Italy, 31–32, 1995.

Gangadhara, K. R. and Jayasena, H. A. H.: Was rainwater harvesting in the dry zone of Sri Lanka a technically adapted methodology by the ancients?, XII-International Rainwater Catchment Systems Association (IRCSA) Congress, 15–18 November 2005, New Delhi, India, 1–15, 2005.

Gunatilake, H. M., Gopalakrishnan, C., and Chandrasena, I.: The economics of household demand for water: the case of Kandy Municipality, Sri Lanka, Int. J. Water Resour. D., 17, 277–288, 2001.

Hassing, J., Ipsen, N., Clausen, T. J., Larsen, H., and Lindgaard-Jørgensen, P.: Water in a changing world: Integrated Water Resources Management in Action: Side publication series, Dialogue paper, United Nations Education Scientific and Cultural Organization, Paris, France, 22 pp., 2009.

Hufschmidt, M.: Water Resource Management, in: Hydrology and Water Management in the Humid Tropics: Hydrological Research Issues and Strategies for Water Management (International Hydrology Series), edited by: Bonell, M., Hufschmidt, M., and Gladwell, J., Cambridge University Press, Cambridge, 471–495, https://doi.org/10.1017/CBO9780511564468.026, 1993.

Imbulana, K. A. U. S. and Neupane, B.: Integrated water resources management: the relevance of indicators for measuring river basin status and performance, in: Proceedings of Monitoring Tailor-Made IV, International Workshop on Information for Sustainable Water Management, Netherlands, 91–102, September 2004.

Jayasena, H. A. H.: Socio Hydrological data, Data Set, the Academia, available at: https://www.academia.edu/36432381/Data_Set_2nd_April_2018.xlsx (last access: 19 April 2018), uploaded 2 April 2018.

Jayasena, H. A. H. and Selker, J. S.: Thousand Years of Hydraulic Civilization Some Socio-technical Aspects of Water Management, Understanding the Role of Politics in Water Management, in: Proceedings of the Conference: Water and Politics, Understanding the role of Politics in Water Management, World Water Council, Marseilles, France, 225–236, 2004.

Jayasena, H. A. H. and Dhanapala, T. R. W. S.: Analysis of Domestic Waste Water Usage in a Tropical Mountainous Basin in Sri Lanka, in: Proceedings of the World Mountain Forum, Moving mountains towards global sustainability, Cusco, Peru, 23–24 May 2014.

Jayasena, H. A. H., Singh, B. K., and Dissanayake, C. B.: Groundwater occurrences in the hard rock terrain of Sri Lanka – A Case Study, AQUA, 4, 214–219, 1986.

Jønch-Clausen, T.: Integrated water resources management (IWRM) and water efficiency plans by 2005: Why, what and how, Global Water Partnership, Elanders Infologistics Väst AB, Sweden, 5–4, 2004.

Keynes, J. M.: The general theory of employment, interest, and money, 2007 Edn., Macmillan and Co, London, 472 pp., 1936.

Muththuwatta, L. P. and Liyanage, P. K. N. C.: Climate Change Models Shift Boundaries of Agro-Ecological Zones in Sri Lanka IPC climate net, available at: http://climatenet.blogspot.com/2013/09/climate-change-models-shift-boundaries.html, last access: March 2018. 2013

Nauges, C. and Van Den Berg, C.: Demand for piped and non-piped water supply services: Evidence from Southwest Sri Lanka, Environ. Resour. Econ., 42, 535–549, 2009.

Panabokke, C. R.: Small village tank system of Sri Lanka: Their evolution, setting, distribution and essential functions, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka, 84 pp, 2009.

Samad, M., Aheeyar, M., Royo-Olid, J., and Arulingam, I.: The political and institutional context of the water sector in Sri Lanka: An overview, EU, Luxembourg, Europe, 92 pp., 2017.

Uragoda, C. G.: Traditions of Sri Lanka: A Selection with a Scientific Background, Michigan, Vishva Lekha Publishers, 327 pp., 2000.

UNDP: Sri Lanka Human Development Report 2012: Bridging Regional Disparities for Human Development, UNDP, Sri Lanka, 178 pp., 2012.