Journal of
Water & Climate Change

Journal of Water and Climate Change Vol 13 No 2, 451 doi: 10.2166/wcc.2021.382

Community-based water governance for adaptation to water reduction and scarcity in Badulla district of Sri Lanka

D. D. S. Daluwatte* and S. Sivakumar

Department of Civil Engineering, University of Jaffna, Jaffna, Sri Lanka
*Corresponding author: E-mail: dimuthustc@gmail.com

DDSD, 0000-0002-4206-3494

ABSTRACT

Sustainable Development Goal number 6 declares safe drinking water for all as a human right and it can be used as an indicator to measure development. While urban and municipal residents benefit from safe drinking water through centralized water supply systems, water supply for rural areas and estates were decentralized due to large construction costs, according to the demand-driven approach introducing community governance mechanism for water sources and water supply in rural areas. Community-based water societies emerged as a consequence of this situation. In Badulla district of Sri Lanka, 47% of community-based water societies depend upon natural water springs benefitting 46% of households in a particular area. Recently, two natural water springs dried up affecting 191 households and 10 community-based water societies who depend on natural water springs are regulating their water supply hours due to a long and extended drought situation. This affected 1,953 households in Badulla. Further it represents 8.4% of households who depend upon natural water springs. Owing to the present water scarcity, 37 community-based water societies started catchment protection initiatives with the support of government and non-governmental agencies. One community-based water society in this district has collapsed due to lack of water with the drying up of their natural water spring and another is functioning with an alternative water source. Other community-based water societies are functioning to a varying extent because of water level reduction in natural water springs. While the climate is changing, there are development initiatives that, in particular, are affecting natural water springs.

Key words: community-based water societies, natural water springs, safe drinking water, water governance

HIGHLIGHTS

- Future potential water crisis in Central hills of Sri Lanka.
- Impact for whole country through that incident.
- Importance of community water governance structure.

INTRODUCTION

Access to safe drinking water is a globally recognized prerequisite in the present development scenario. The sixth goal of the Sustainable Development Goals relates to water and sanitation. The centralized water supply mechanism is used to provide safe drinking water to urban and municipal areas, but in rural areas and estates in Sri Lanka, people are suffering due to a lack of safe drinking water and proper sanitation facilities.

According to the Asian Development Bank Report (2015), 44% of Sri Lankans have access to pipe water, while 15% of people do not have safe drinking water within 200 m of their dwelling. According to recent information from the Department of Census of Sri Lanka, only 31.35% of people have safe water from urban water supply systems. 9.3% of rural and estate households get their water through rural water supply schemes (Table 1).

Due to higher construction and maintenance costs, water supply to rural areas and estates was decentralized by many governments around the world, with the introduction of community water governance mechanism through community-based water societies.

The Global Water Partnership (GWP Bulgaria 2002) defined water governance as the range of political, social, economic and administrative systems that are in place to regulate the development and management of water resources and provision of

Table 1 | Different water source utilization of rural households

Water source	Number of households	% Households
Safe well	2,418,279	46.07
Unsafe well	213,371	4.06
Pipe water	1,645,618	31.35
Rural water supply	488,012	9.30
Tube well	176,724	3.37
Bottled water	19,894	0.38
Natural water sources	266,085	5.07
Other	25,893	0.49

Data source: Department of Census, Sri Lanka.

water service at different levels of the society. At the community level, some of the community-based water societies become successful, while others fail, due to various factors.

Further, in Sri Lanka, there are other community-based water projects constructed using supply responsive approaches that have failed. Especially, these projects have been implemented with the full support of different NGOs and government (Shanthasiri & Wijesooriya 2004). Regarding the performance of community-based water projects, social homogeneity of water users (Watson *et al.* 1997), operational rules of the society (Sara & Katz 1998; Isham & Kähkönen 2002), prior organization of users (Narayan & Pritchett 1999), participation of users in other community groups (Isham & Kähkönen 2002), coordination with government (Sara & Katz 1998; Isham & Kähkönen 2002), legal recognition of water user group (Watson *et al.* 1997), skills and knowledge of users (Rondinelli 1991; Sara & Katz 1998; Isham & Kähkönen 2002), and appropriate technology and access to spare parts (Rondinelli 1991) are the main factors.

Apart from the above-mentioned aspects, due to water scarcity, some community-based water societies collapsed, while others are functioning in a critical state, due to depletion of water sources.

Historically, most parts of the Badulla district were covered by natural vegetation and these areas were rich in natural water resources. Since the colonial period, plantation practices have been started that have introduced a new socio-economic context.

The practice of deforestation started in this area during the last three decades, and different power groups are engaged in it. The same practices in water catchment areas have seriously affected natural water sources available in these districts, increasing water scarcity.

According to Global Forest Watch, for the period of 2000–2010, 2,696 ha of vegetation cover was lost and for 2011–2018, 2,796 ha of vegetation cover was lost in Badulla district.

Apart from governance and management aspects, quality of water supply service is a major factor contributing to the performance of community-based water societies. Several collapsing and inactive community-based water societies have been reported within the last ten years due to the lack of quality in water supply service.

There are three categories of community-based water society in Badulla district based on functional status (Figure 1) as follows:

(1) In the first category, the water source had already dried up, and the community-based water societies have collapsed due to lack of water as a result of the dried-up water source.
(2) In the second category, the community-based water societies are functioning, but not performing well. (Criteria for assessing performance included: meetings in last six months, fund capacity, maintenance status, recovery rate.) (In addition, water yield reduction and reasons for inactivity were examined.)
(3) Finally, the third category had both a society and scheme functioning, but at different degrees of operation.

The objective of this study is to research climate change impacts upon Badulla district and study how they affect natural water springs and community-based water societies based on natural water springs in Badulla district of Sri Lanka.

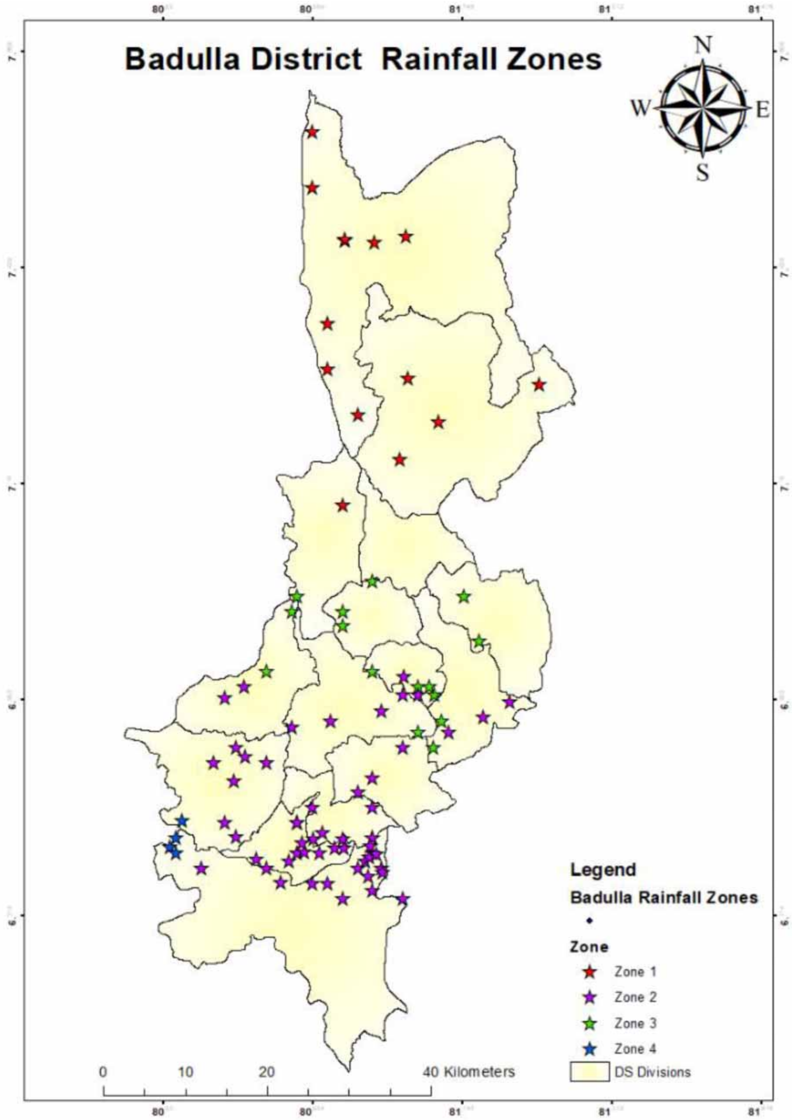

Figure 1 | Community-based water society status in Badulla district.

LITERATURE REVIEW

Ulpotha is the type of water spring used by community-based water societies to fulfil their water needs. During the wet season, there is a steady water flow, while the water flow becomes a trickle or dries up in the dry season (Liyanage 2009). There are a few springs utilized by local authorities for rural water supply schemes (Liyanage 2009). There are a large number of springs concentrated in Badulla district (Liyanage 2009). The quality and the duration of water flow from a spring are entirely dependent on the amount and distribution of rainfall that recharge the groundwater, soil drainage and water holding capacity of soil (Liyanage 2009). Springs underlying the crystalline limestone rock are capable of producing a moderate yield of 25,000–50,000 gallons per day (Liyanage 2009).

The research conducted by Weerathunga in 2017, in Liyangahawela area, revealed that the main cause of drying up of the springs was related to human activities in the upper catchment, such as cultivation of tea, planting pine trees, cultivating vegetables and construction of buildings (Gunatilake 2008). The flow of water from springs is affected by fluctuations of the groundwater table between the dry and wet season (Liyanage 2009).

In climate change rain forecast calculation, the highest rainfall decline is indicated in Nuwara Eliya as 52 mm decade-1 and in Badulla district it is 19 mm decade-1 (De Costa 2008). According to the HadCM3 model of rainfall forecasting, there is an increase in rainfall for five months in the south-west monsoon creating landslides, and reduction of rainfall in the remaining seven months for the central hills in Sri Lanka. (De Silva 2008) After the year 2008, there have been no predictions in the literature regarding analysis and forecast in rainfall and temperature.

METHOD

To discover climate change impacts on Badulla district, TerraClimate satellite data were collected and rainfall trends of different climatic zones were analysed using monthly average rainfall data. Rainfall data available for 1958–2019 in the TerraClimate source were used for that analysis. Accordingly, TerraClimate rainfall data were calibrated with the rainfall data available from the Department of Meteorology of Sri Lanka for 17 available rain gauge points in Badulla district.

According to rainfall data calibration in Table 2, tcom value of all the selected rain gauge stations was more than 0.05. With that, the validity of TerraClimate data was ensured.

TerraClimate rainfall data of Badulla district for 92 rain gauge points (Figure 2) were collected for the period of 1958–2019. For that particular period, monthly average rainfall values were calculated for the relevant 92 rain gauge points. Results revealed four rainfall zones having different annual rainfall patterns on rainfall data for the period of 1958–2019 (Figures 3–6).

Then, the rainfall pattern variation was analysed for the first 30 years as 1958–1988 and the second 30 years as 1989–2019. The analysis indicated variations in the second 30-year rainfall pattern compared to the first 30-year pattern, increasing monthly average rainfall for January and November and reducing monthly average rainfall for March and April (Figures 7–10).

Further, annual rainfall variation was analysed using calculated annual average rainfall values through linear trend pattern analysis for different rainfall zones and revealed different levels of annual average rainfall reduction for each zone for the period of 1958–2019 (Figures 11–14).

To analyse the status of community-based water societies and impacts for natural water springs due to rainfall pattern variation, 136 samples of natural water spring-based community-based water societies were selected and sample size was calculated using the following equation (Daniel 1999):

$$n = \frac{z^2 p(1-P)}{\in^2} \qquad n' = \frac{n}{1 + \dfrac{z^2 \times p(1-P)}{\in^2 N}}$$

where n' is sample size, N is total population, $\in$ is margin of error, P is population proportion and z is Z score.

Table 2 | Calibration of TerraClimate rainfall data

Rain gauge station	r^2	t_{com}
Diyathalawa	0.553753	13.10686
Badulla	0.582193	17.32529
Aluthnuwara	0.276103	3.839695
Bandara Eliya Estate	0.523217	7.577415
Bandarawela Irrigation	0.511109	6.61934
Keenakelle Estate	0.606171	13.06674
Ledgerwatta Estate	0.548654	14.28581
Wewessa Estate	0.572578	11.68467
Lower Spring Valley	0.546143	14.25038
Gourakelle	0.607419	11.05339
Ginniheriya	0.187139	1.423003
Horaborawewa	0.097844	1.205746
Rantambe	0.718821	14.53711
Haputale Factory	0.45266	6.618144
Canawerella Group	0.394149	5.164097
Bogahamaditta	0.537981	8.376185
Ella Kinigama	0.294871	1.216432

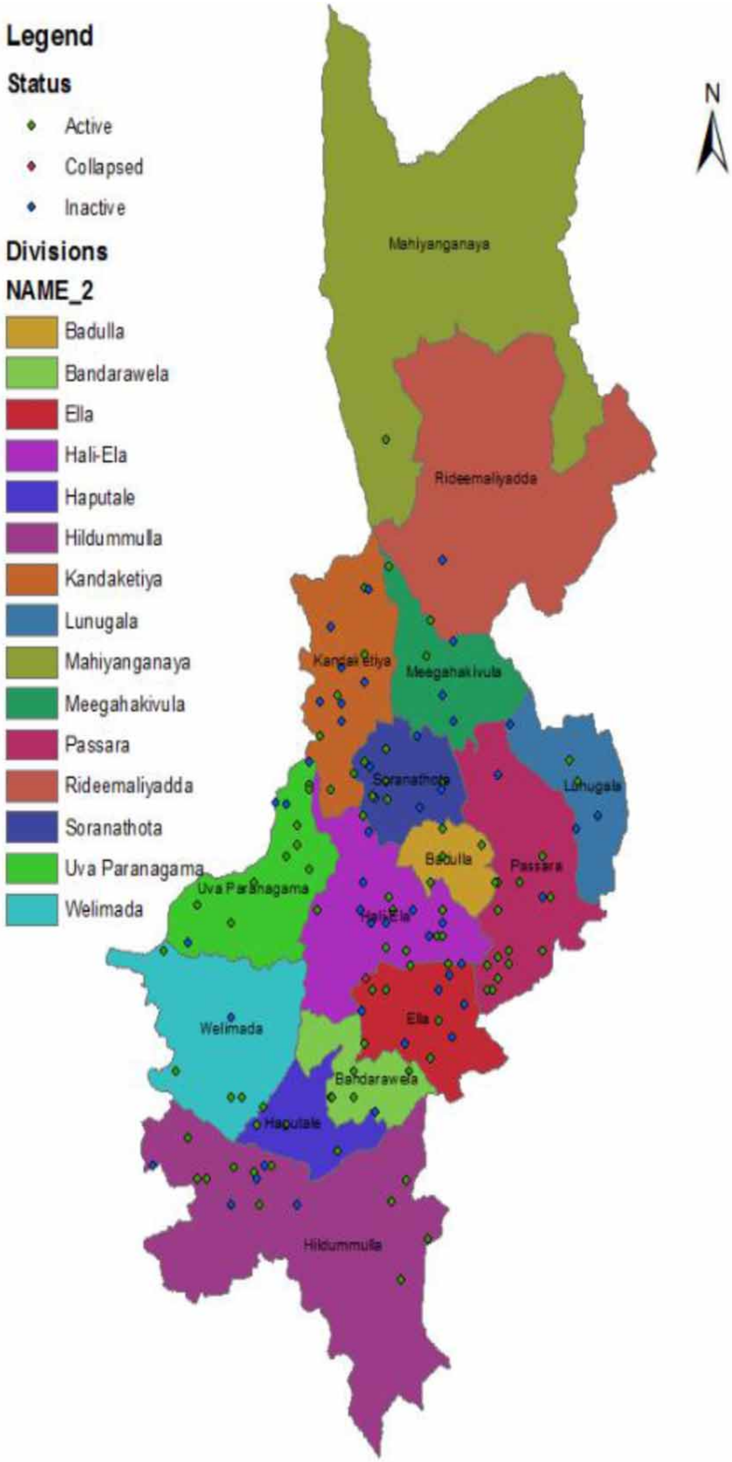

Figure 2 | Identified rain gauge points for rainfall zone identification.

Among the 447 community-based water societies, there are 210 in Badulla district which are based on natural water springs. Proportionately distributed random sampling technique was used for sample selection from each division in the study area. For each division, sample community-based water societies were selected using the random table method. Due to the data availability, the effective sample was adjusted accordingly (Table 3).

Figure 3 | Annual rainfall pattern in Zone 1.

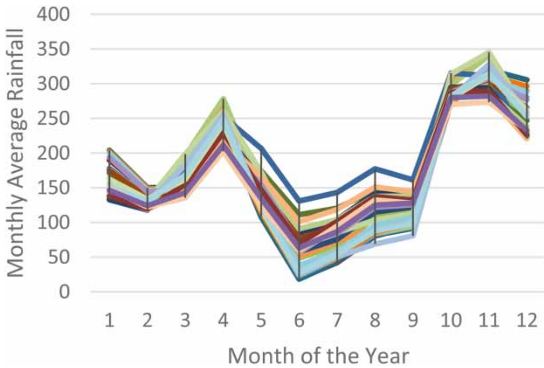

Figure 4 | Annual rainfall pattern in Zone 2.

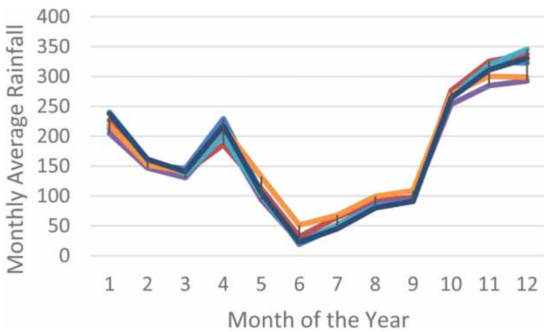

Figure 5 | Annual rainfall pattern in Zone 3.

In the study sample, key informant interviews were conducted with the officer in charge and field officers of the National Community Water Supply Department to collect data about community-based water societies related to present functional status, water source, number of beneficiaries, functional capacity, their observations related to water capacity of water sources, etc.

Focus group discussions were conducted with community-based water society leaders and beneficiaries, to collect information related to community-based organization functionality in the field, status of water source and water availability, critical status of their water source and their actions for water source conservation.

The functionality of the community-based water societies was based upon analysis of water supply, financial capacity, legal entity, maintenance and water source.

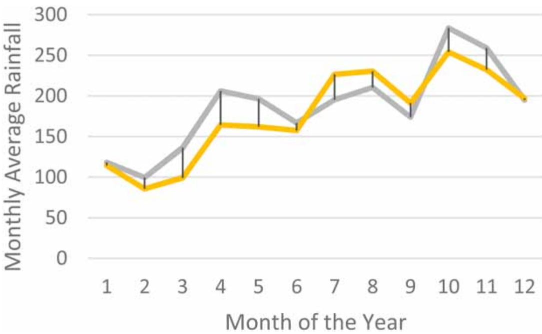

Figure 6 | Annual rainfall pattern in Zone 4.

Figure 7 | First 30 years to second 30 years' annual rainfall pattern variation in Zone 1 (1958–2019).

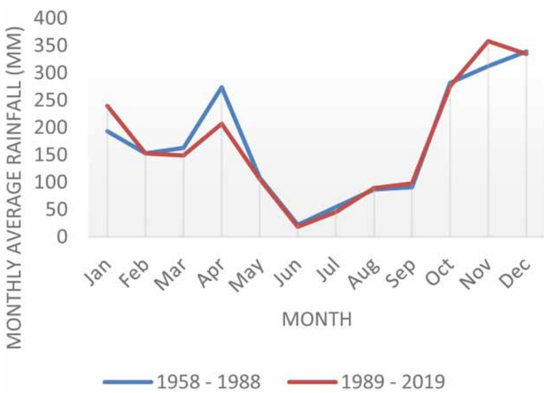

Figure 8 | First 30 years to second 30 years' annual rainfall pattern variation in Zone 2 (1958–2019).

FINDINGS AND DISCUSSION

Factors discussed here strongly affected the functionality and sustainability of community-based water societies. Further, these factors are interrelated and dependent upon one another.

According to the rainfall monthly average rainfall analysis for 1958–2019, four rainfall patterns were identified in four different climatic zones (Figures 3–6).

Rainfall variation trends were identified using annual average rainfall analysis. While reporting maximum rainfall reduction rate from Zone 4, minimum rainfall reduction rate is reported from Zone 1. (Table 4).

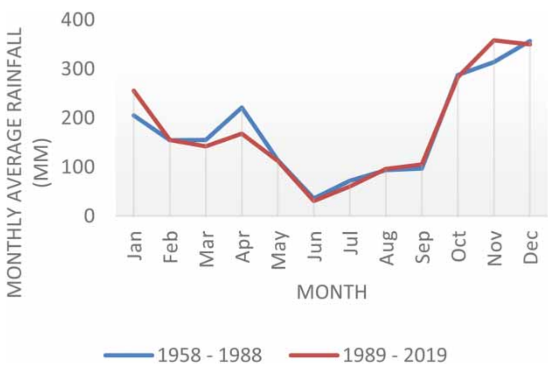

Figure 9 | First 30 years to second 30 years' annual rainfall pattern variation in Zone 3 (1958–2019).

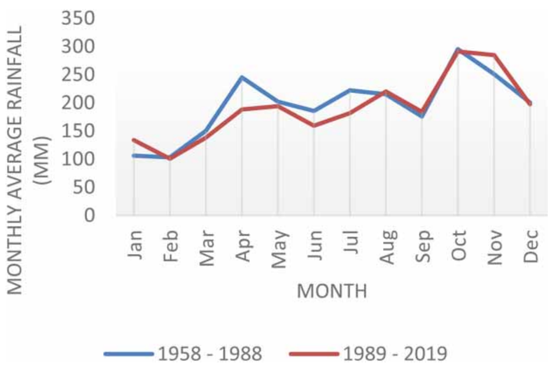

Figure 10 | First 30 years to second 30 years' annual rainfall pattern variation in Zone 4 (1958–2019).

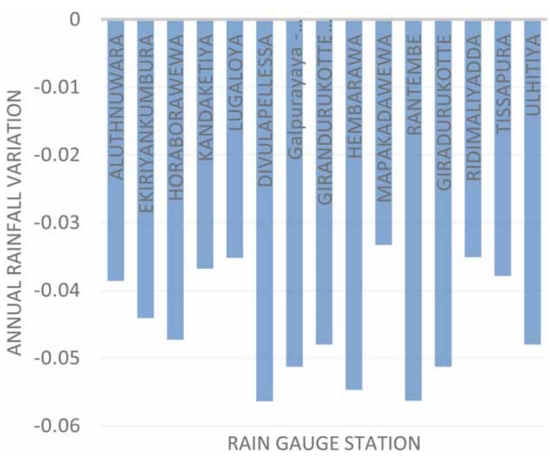

Figure 11 | Annual rainfall variation in Zone 1 (1958–2019).

Further, 1958–1988 and 1989–2019 rainfall patterns and pattern variations were analysed in different zones. In different rainfall patterns, as a whole, average rainfall for the months of January and November increased while monthly average rainfall for the months of March and April is decreasing with a clear indicator of extending drought. For Zone 4, the monthly average rainfall for the months of May, June and July also reduced, indicating and ensuring maximum rainfall reduction for Zone 4.

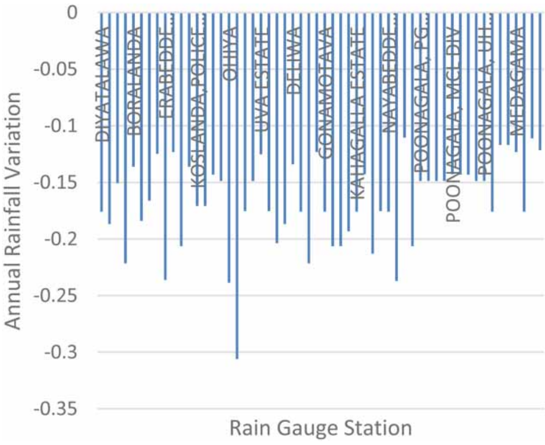

Figure 12 | Annual rainfall variation in Zone 2 (1958–2019).

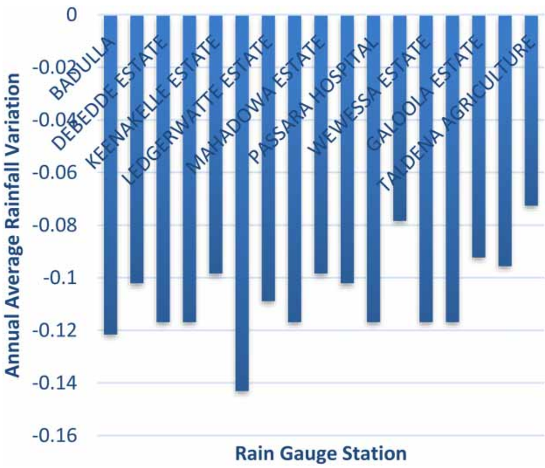

Figure 13 | Annual rainfall variation in Zone 3 (1958–2019).

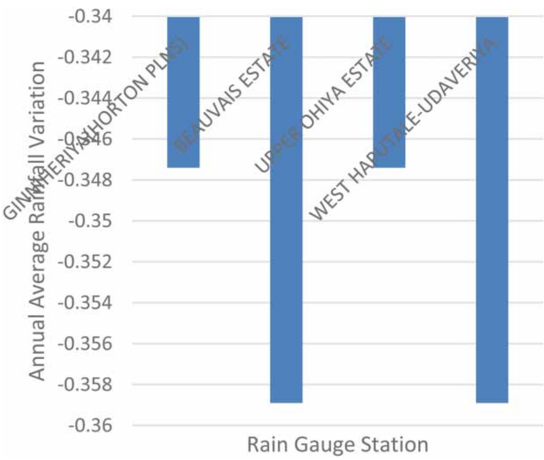

Figure 14 | Annual rainfall variation in Zone 4 (1958–2019).

Table 3 | Sample selection from different divisions

Division	Total number of community-based water societies	Water spring using community-based water societies	% Representation of total water spring usage	Sample size
Badulla	11	8	4%	5
Hali Ela	66	35	17%	23
Bandarawela	26	10	5%	6
Ella	36	23	11%	15
Haldumulla	28	23	11%	15
Meegahakiula	8	7	3%	5
Kandaketiya	22	19	9%	12
Reedemaliyadda	31	3	1%	2
Lunugala	18	10	5%	6
Welimada	52	8	4%	5
Uva-Paranagama	54	17	8%	11
Haputale	6	6	3%	4
Mahiyanganaya	32	1	0%	1
Passara	34	22	10%	14
Soranatota	23	18	9%	12
Total	447	210		136

Table 4 | Annual rainfall variation rate in different zones

Zone	Annual rainfall reduction rate
1	−0.0333 to −0.0564
2	−0.1105 to −0.3062
3	−0.0726 to −0.3473
4	−0.3474 to −0.3589

From June to September, Zones 1, 2 and 3 are normally affected by drought conditions, but results revealed that drought is extending for another two months starting from March. In focus group discussions, the same response was received from communities too as their personal experience, confirming the revealed results further.

Analysis of community-based water societies revealed that there are two societies, in Zone 2 and Zone 3, that have collapsed, because the natural water springs used as their water sources have dried up. In the same zones, the yields of the six natural water springs have reduced and community-based water societies become inactive for that reason.

Some natural water springs, utilized as water sources in community-based water projects had dried up, while other natural water sources indicated water yield reduction. Further, there were some other community-based water projects that limited their water supply to particular hours because of water scarcity during the whole year or certain periods of the year (Table 5).

In the study sample, Palleporuwa natural water spring was dried up in Ella division and due to that Piyarandowa community-based water society, which depended on that spring, has collapsed because of lack of water.

There are 50,279 households fulfilling their basic water needs from community-based water societies, and among them, 23,089 are based on natural water springs representing 46% of the total number of beneficiaries dependent upon community-based water projects.

In HaliEla division, among 23 samples, one community-based water society is functioning by limiting their water supply hours due to extended drought over the past few years.

In Bandarawela division, among six sampled community-based water societies, four are functioning by limiting their water supply hours due to extended drought per year for a few years.

Table 5 | Status of natural water springs in different zones

Zone	Division	Total number of community-based water societies	Water spring based community-based water societies	% Representation of sample	Sample size	Total in the zone	Reducing water and limit supply due to extended drought	Spring dried
1	Rideemaliyadda	31	3	1%	2	3		
	Mahiyanganaya	32	1	0%	1			
2	Bandarawela	26	10	5%	6	65	4	
	Ella	36	23	11%	15			1
	Haidummulla	28	23	11%	15			
	Lunugala	18	10	5%	6		2	
	Weilmada	52	8	4%	5			
	Haputale	6	6	3%	4			
	Passara	34	22	10%	14			
3	Badulla	11	8	4%	5	57		
	HaliEla	66	35	17%	23		1	
	Meegahakiula	8	7	3%	5		1	
	Kandaketiya	22	19	9%	12		4	1
	Soranatota	23	18	9%	12			
4	Uva-Parangrama	54	17	8%	11	11		

In Meegahakiwla division, among five sampled community-based water societies, one is functioning by limiting their water supply hours due to extended drought per year for a few years.

In Kandaketiya division, Godunna community-based water society was dependent upon Amunukara natural water spring and this has been dried up for over two years; however, they found a small stream located near the dried spring. Further, among the selected samples of 12 community-based water societies, four are functioning by limiting their water supply hours due to extended drought.

In Lunugala division, among the six selected community-based water societies, two are functioning with limited water supply hours due to extended drought over the past few years.

As a whole, the results showed that two natural water springs were dried up among the sampled 210 natural water springs based on community governance and another ten community-based water societies have had to limit their water supply, affecting 1,953 households.

Among community-based water societies, where the water source dried up, one collapsed and the other one is functioning using an alternative water source.

As community actions for water source conservation, 37 community-based water societies started initiatives for catchment protection, such as planting trees, vegetation cover conservation and so on.

CONCLUSIONS

According to the Asian Development Bank Report (2015), 44% of Sri Lankans have access to pipe water, while 15% of people do not have safe drinking water within 200 m of their dwelling. According to recent information from the Department of Census, only 31.35% of people have safe water from urban water supply systems. 9.3% rural and estate households have water via rural water supply schemes.

In a situation where well water is unavailable for day-to-day consumption, 981 natural water springs in Sri Lanka are contributing to supply safe water for people in rural areas and estates. Community water supply is becoming an important solution for safe and clean water for domestic consumption.

As this research revealed, two natural water springs in Badulla district are dried up. Twelve community-based water societies have limited their water supply within the past three years. There was a strong positive relationship between rainfall and spring discharge (Fiorillo & Doglioni 2010). Accordingly, the rainfall fluctuation and reduction, as De Costa (2008) revealed, may lead to reduced water level and drying up of natural water springs.

Further considering development actions, clearing the land and catchment cover change has occurred since the colonial period and the nature of catchment also might be affecting reduction of water in natural water springs. Further research on rainfall, spring discharge with rainfall fluctuation and spring discharge with land cover are needed to determine the circumstances behind natural water springs in Badulla district.

This study revealed annual rainfall pattern variation as a result of climate change. This clear indicator is given not only for community-based water societies, but for many other sectors like agriculture, aquaculture, development actions and industries to gradually adopt to the expected changes with alternative actions for sustainability. Especially, this area is significant, because water ways flowing around Sri Lanka start from the central hills and the climatic pattern of this district is important not only for Badulla district, but also for the whole of southern, south-eastern and eastern parts of Sri Lanka.

Recommendations

While climate change is taking place, in Badulla district there are massive development initiatives such as plantation and the Uma Oya hydropower complex construction. Further research is needed to determine the reasons behind natural water spring drying up, and mitigation actions and adaptation should be planned accordingly.

Rainfall analysis is important and experiments to establish the relationship between rainfall, land cover and natural water springs are needed to develop a strategic plan to initiate a water governance mechanism in Sri Lanka in view of climate change.

ACKNOWLEDGEMENTS

I hereby acknowledge Dr S. Sivakumar, who encouraged and guided me in this work. I also acknowledge everyone in the WaSo Project who enabled this wonderful opportunity.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

REFERENCES

Asian Development Bank 2015 *Asian Development Bank Annual Report 2015*. Asian Development Bank, Mandaluyong City, Philippines. Available from: https://www.adb.org/documents/adb-annual-report-2015

Daniel, W.W. 1999 *Biostatistics: A Foundation for Analysis in the Health Sciences*. 7th edition. John Wiley & Sons, New York.

De Costa, J. 2008 Climate change in Sri Lanka: myths or reality? Evidence from long-term meteorological data. *Journal of the National Science Foundation of Sri Lanka* **36**, 63–88.

De Silva, C. S. 2008 Impact of climate change for water resource in central hills of Sri Lanka and possible adaptation measures. In: *Annual Academic Sessions, Conference*, pp. 100–103.

Fiorillo, F. & Doglioni, A. 2010 The relationship between karst spring discharge and rainfall by cross-corelation analysis. *Hydrology Journal* **18**, 1881–1895.

Gunatilake, A. 2007 Groundwater conditions in Sri Lanka: a geomorphic perspective. *Journal of National Science Foundation* **36** (1), 113–114.

GWP Bulgaria 2002 *Water Management (Governance) in Bulgaria*. Global Water Partnership Bulgaria, Sofia, Bulgaria.

Isham & Kähkönen 2002 How do participation and social capital affect community-based water projects? Evidence from Central Java, Indonesia. In: *The Role of Social Capital in Development* (C. Grootaert, ed.). Cambridge University Press, Cambridge, UK.

Liyanage, M. 2009 Natural water springs in Sri Lanka: an overview. *Economic Review* 37–40.

Narayan, D. & Pritchett, L. 1999 Cents and sociability: Income and social capital in rural Tanzania. *Economic Development and Cultural Change* **47** (4), 871–897.

Rondinelli, Dennis A. 1991 Decentralizing Water Supply Services in Developing Countries: Factors Affecting the Success of Community Management. *Public Administration and Development* **11** (4), 415–430.

Sara, J. & Katz, T. 1998 *Making Rural Water Supply Sustainable: Report on the Impact of Project Rules*. United Nations Development Programme/World Bank Water Program, Washington, DC.

Shanthasiri, H. K. S. & Wijesooriya, R. 2004 Case Study on Community Involvement in Rural Water Supply in Sri Lanka. In: *Conference Contribution*, Lao.

Watson, G., Jagannathan, V., Gelting, R. & Beteta, H. 1997 Water and Sanitation Associations: Review and Best Practices. In: *User Organizations for Sustainable Water Services* (N.V. Jagannathan, A. Subramanian & R. Meinzen-Dick, eds.). World Bank Technical Paper, World Bank, Washington, DC.

First received 7 October 2020; accepted in revised form 2 November 2021. Available online 7 December 2021