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Citizen scientists help with rainfall monitoring in data-scarce Sierra Leone

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Balancing economic growth with environmental sustainability is a major global challenge. This is particularly true for water resources in Sub Saharan Africa (SSA) where many competing pressures affect the sustainable use of the resource. Inland water bodies are used for hydroelectric power, agri-business, water supply, mining, fishing, and transportation [1]. These pose a variety of observable impacts on water resources such as water quality impairments that cause adverse effects on humans, animals, and ecosystems [2]; and problems with water availability and access [3].

There is need for continuous monitoring of those waters to provide data that guide management of potential problems that land use practices may pose. Nonetheless, effective data gathering relies on the requisite human, institutional, and financial capacity, which are usually lacking in SSA [4]. In Sierra Leone, this problem was exacerbated by the destruction of the data gathering infrastructure that existed before the civil war in the 1990s [5]. As such, there is lack of capacity to continuously generate data nationally to help achieve sustainable water resource management.

Citizen Science (CS) is an increasingly popular approach that provides the opportunity to assist in overcoming this data scarcity problem [6]. Citizen scientists are volunteers who collect, processes, and report data as part of the scientific method of inquiry [7]. It has a great potential to minimize the burden of data gathering and experimental design and to promote educational outreach for water resource protection [8]. Actionable science in which experts,

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volunteers, and stakeholders interact to exchange ideas and experiences [9] ensures collection of a more reliable and usable data.

We present a case for a citizen science program as an innovative approach to improve data gathering and promote water security planning in data scarce regions. Our objective is to demonstrate that citizen scientists can collect hydrologic data and help overcome water resource monitoring challenges in Sierra Leone. This work covers three years (2013 -2016) of a citizen science project in 15 communities in the northern and north-western regions of Sierra Leone (Table 1 and Figure 1).

District	Monitoring Location	Site ID
Bombali	Masongbo community	1
Bombali	Addax Env. Office	2
Bombali	Makeni (District Council office)	3
Bombali	Mayawlaw School	4
Koinadugu	Waia community	5
Koinadugu	Kabala (District Council office)	6
Koinadugu	Fadugu Agric. Secondary School	7
Port Loko	Port Loko (District Council office)	8
Tonkolili	Bumbuna-Boyo Primary School	9
Tonkolili	Kakutan community	10
Tonkolili	Kamathor community	11
Tonkolili	Kasokira community	12
Tonkolili	Kathombo Primary School	13
Tonkolili	Magburaka Boys Secondary School	14
Tonkolili	Mathora R.C. Primary School	15

Table 1. Rainfall monitoring sites in the study area

Literate citizens in schools and communities in the study area (along the Rokel Basin) were trained to collect rainfall data every morning using a transparent plastic rain gauge and a simple datasheet. Trained agency personnel worked with the volunteers to build the rainfall monitoring stations and collect rainfall data. Figure 2 shows one of the monitoring stations that was constructed by the volunteers and trained agency personnel.

At 09:00 hours every morning, each volunteer measured the rainfall for the previous day and recorded the amount in the datasheet provided them. Agency staff would visit each volun-

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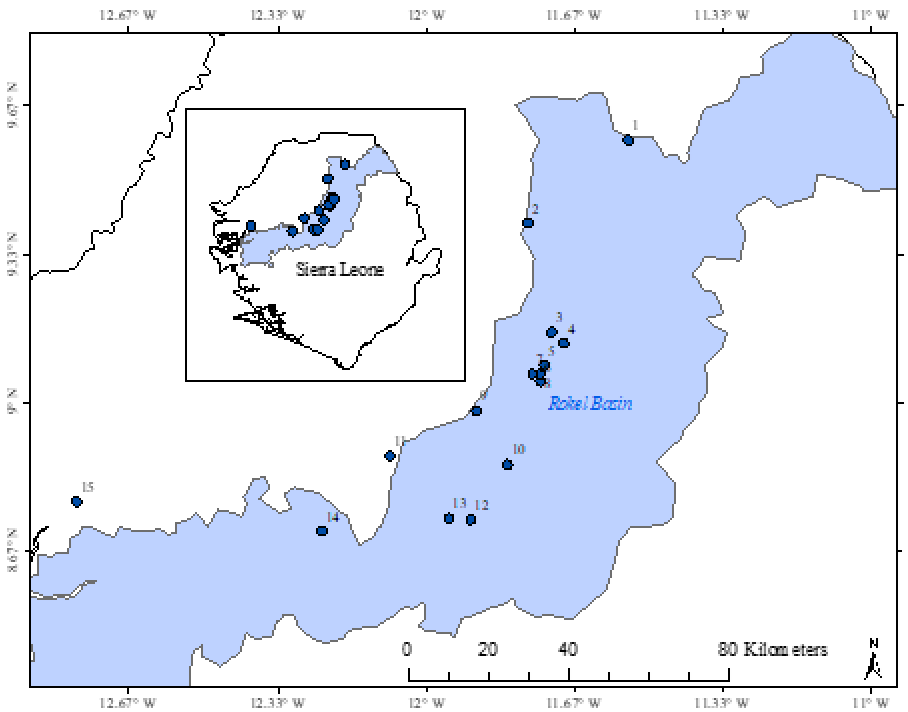

Figure 1 Map of Sierra Leone and the locations of the CS monitoring sites along the Rokel Basin (blue polygon)

teer at the end of the month to collect their datasheets, carry out quality control routines, and help them troubleshoot any issues they may have encountered during the month. The volunteers would contact agency personnel for troubleshooting whenever they ran into issues during field measurements. The agency personnel also served as mentors who helped the volunteers learn how to apply information from the rainfall data such as better planning for livelihood activities (e.g., the farming season) and the impact of seasonality on surrounding ecosystems (e.g. surface runoff and water quality).

At the end of each monitoring cycle, a "Rainfall Monitors Day" was organized at a location where volunteers met and shared experiences on rainfall data gathering. Community leaders and other invited stakeholders also participated in the program. The meeting included workshops where water resource experts explained the meaning and importance of the data collected by the volunteers. Prices were also awarded for excellence in rainfall monitoring.

The results of the three-year long (2013 – 2016) rainfall measurement by the volunteers in the 15 communities are presented in Figure 3. The monthly rainfall amounts (mm) are the

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Figure 2. Rainfall monitoring site in the Kasokira community

computational results of the daily rainfall measurements recorded by the volunteers.

The rainfall trends at all the rain gauge sites reflect the general pattern of rainfall in Sierra Leone: few to no rain during the dry season (November-May) and heavy rainfall in the rainy season, especially in July to September [10]. Figure 3 is an illustration that citizen scientists can collect and submit credible rainfall data when they are trained by and interact with agency personnel.

This work demonstrates that CS can be useful in overcoming the economic and logistical burdens of water resource monitoring. The CS approach to water monitoring has been useful in Sierra Leone, where limited resources constraint data availability and such data scarcity impede best practice in water resource management.

A key benefit of CS is that the involvement of citizens allows them to interact with nature through which they experience the value of the connections between humans and the natural capital. Consequently, a CS program could increase awareness and involvement of local communities in the stewardship of natural resources in a more sustainable manner. The societal benefits are understanding core scientific processes that are relevant within the context, developing new scientific investigation methods to overcome data limitations in data-scarce regions, savings in costs related to logistics and equipment purchase, and improvements in

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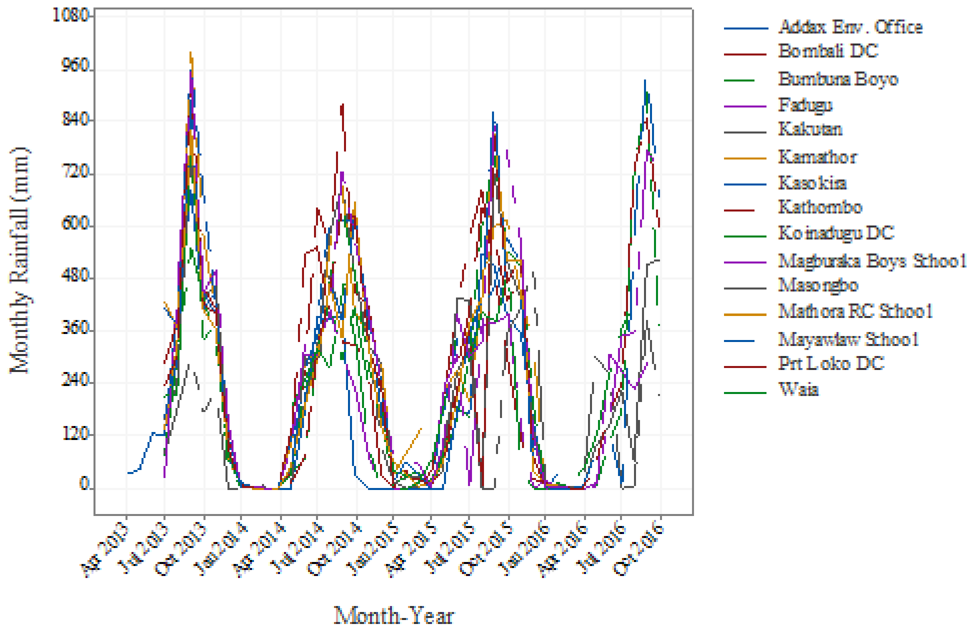

Figure 3. A graph showing rainfall data collected by citizen scientists in 15 communities in Sierra Leone

human and institutional capacity.

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