Citizen Science for Monitoring Rainfall in Vietnam

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Abstract. Citizen Science (CS) has been arising as a promising approach to address hydro-meteorological data gaps spatially and temporally and providing information about catchment characteristics for water resource management for the last ten years. In Vietnam, many national efforts aimed to renovate and extend the operating water monitoring networks. However, the lack of reliable hydro-meteorological data remains an issue that may be better handled by using a CS approach. This study examines the CS approach to monitor rainfall in the Bui River Basin in Vietnam using low-cost rain gauges constructed from soda bottles, concrete, and rulers. The rainfall data of 19 citizen scientists from January 2022 to August 2023 were used for the analysis. The CS data were compared with data from one official reference station. The correlation coefficient (R) was applied to evaluate the significance of the agreement between the monthly CS data at the station with the longest measurement period and reference data. Results yield a significant correlation between CS and reference station with an R = 0,90. The results show that citizen science has the potential of being a complementary approach for existing Vietnamese monitoring systems, particularly for data-scarce areas.

1 Introduction

Rainfall represents a pivotal element of the global water cycle [1]. Consequently, a comprehensive understanding of the spatial and temporal distribution of rainfall is crucial for effective exploitation and management of water resources [2]. Nevertheless, monitoring rainfall over space and time is fraught with difficulties and uncertainties [1]. The total area of all the rain gauges belonging to the worldwide rain gauge monitoring network is less than 50% of the area of a standard soccer field [3], while the spatial variability of rainfall is heterogeneous. Furthermore, the maintenance costs associated with rain gauges are considerable. In response to these expenses, several countries have reduced the number of

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rain gauges, particularly in developing countries [4]. It is therefore necessary to identify an alternative means of addressing these issues.

Recently, low-cost sensors and equipment have been installed in numerous locations to enhance the density of rain gauge networks [5]. Furthermore, the involvement of citizens in collecting data through citizen science has emerged as a promising approach to address the data gap [1]. The use of information and communication technology, such as smartphones and social media, has facilitated the emergence of citizen science, which enables citizens to collect and provide data proactively. Although community-based rainfall monitoring has been a popular approach in the United States, the United Kingdom, and Nepal for the last two decades[1], [5], [6], this approach remains a new topic in Vietnam, where the rain gauge network is insufficient.

The research aims at developing community-based rainfall monitoring by using low-cost rain gauges and evaluating the reliability of citizen science rainfall data by comparing them to data collected from an automatic rain gauge station. The approach was applied to the Bui River Basin in northern Vietnam.

2 Study area and method

2.1 Study area

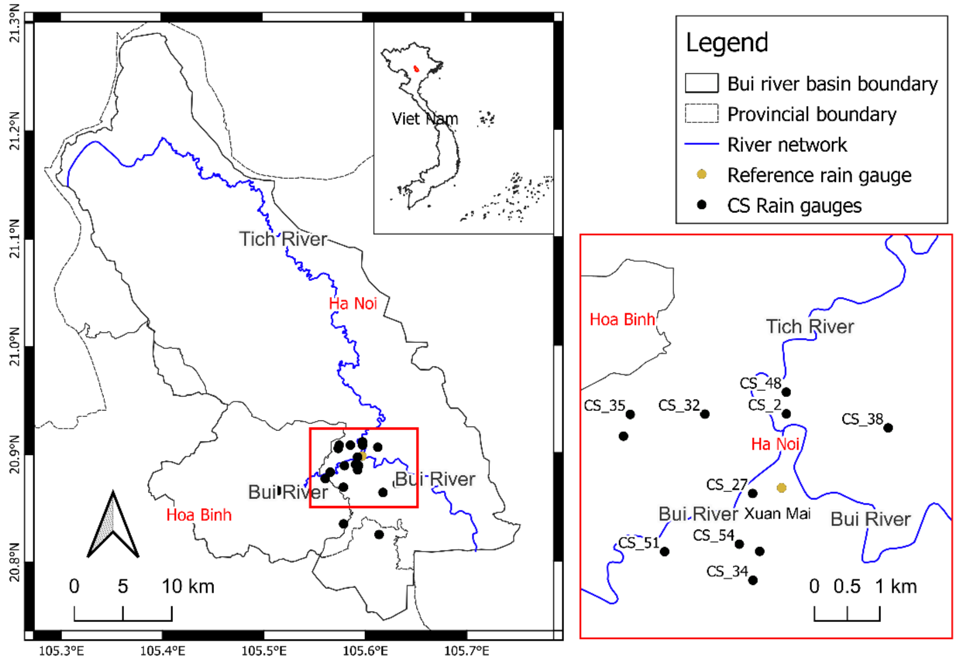

Figure 1. Map of Bui River Basin and locations of citizen science rain gauges

The Bui River Basin is located in northern Vietnam, covering parts of Hoa Binh Province and Hanoi City, the capital of Vietnam (Figure 1). Drained by the Tich and Bui Rivers, this basin has one of the highest densities of meteorological stations in the country, with an average of one station per 10 km² [7]. Since 2016, automatic rainfall measurement stations have been installed throughout the Bui River Basin and other basins in Vietnam to support water resource management and improve flood prediction capabilities [8]. However, Bui River Basin, particularly around the confluence of the Bui and Tich Rivers, still experiences frequent flooding, leading locals to refer to this area as the “flooded villages” of Hanoi [9]. This study focuses on establishing citizen science rain gauges in communities near the Tich-Bui confluence and surrounding areas within the Bui River Basin (Figure 1). The rainfall data from the automatic Xuan Mai rain gauge station, located near the Tich-Bui confluence, will provide a basis for comparison and analysis (Figure 1).

2.2 Methodology

In this study, we adopted the approach of the citizen science program proposed by Bonney et al. [10] to develop the community-based rainfall network in the Bui River Basin. Firstly, a questionnaire was designed to collect general information from participants and data on rainfall measurements. This was done by using data collection applications, such as Open Data Kit (ODK) Collect and the Web application Kobo toolbox. Secondly, locals living in Bui River Basin and aged over 12 years old were recruited through various approaches, including outreach programs, personal relationships, field trips, and social media. The recruited participants were provided with low-cost rain gauges, which were installed at their residence, and were instructed on the use of data collection applications for monitoring rainfall. The low-cost rain gauges, as proposed by Davids et al. [1], were made of plastic bottles, concrete, glue, and rulers. Then, citizen scientists were asked to measure rain regularly in rainy periods, and less regularly in periods with less rain. Finally, citizen science rainfall data were controlled and then published at the website (https://data.smartphones4water.org/ , accessed on November, 11 2024) and social media platforms to draw the attention of locals to the citizen science program.

To evaluate the reliability of the citizen science data, the monthly rainfall data from a citizen science rain gauge with the longest measuring period was compared with the reference data obtained from an official meteorological station. The data variability and Pearson correlation coefficient (R) between the two data sources were investigated [11]. The equation of R is expressed below:

$$R = \frac{N \sum_{i=1}^{n} R_{CS} \cdot R_R - (\sum_{i=1}^{n} R_{CS}) \times (\sum_{i=1}^{n} R_R)}{\sqrt{(N \sum_{i=1}^{n} R_{CS}^2 - (\sum_{i=1}^{n} R_{CS})^2) \times (N \sum_{i=1}^{n} R_R{}^2 - (\sum_{i=1}^{n} R_R)^2)}} \quad (1)$$

with R_{CS} = citizen science data; R_R = reference data; N = number of data pairs; j = the j_{th} measurement/observation.

3 Results and discussion

395 rainfall data were collected by 19 citizen scientists from January 2022 to August 2023. Ten citizen scientists, representing 53% of the total number of participants, only observed rainfall during their first month. A citizen scientist, designated CS_48, observed rainfall from May 2022 to August 2023, representing the longest measurement period conducted by citizen scientists, with a total of 72 observations. The monthly variability of rainfall observed by CS_48 and the reference station is similar (Figure 2). CS_48 did not record rainfall during the dry seasons (i.e., January–May) of both 2022 and 2023. In general, the monthly rainfall measured from the reference station is higher than that measured from CS_48 in the majority of months. The difference may be influenced by the evaporation factor [1], as the citizen scientist did not measure rainfall every day. The Pearson correlation coefficient between citizen science and reference station rainfall is 0.90, indicating a high level of agreement between the two data sources. This result is consistent with the findings of the research’s

Fehri et al [11].

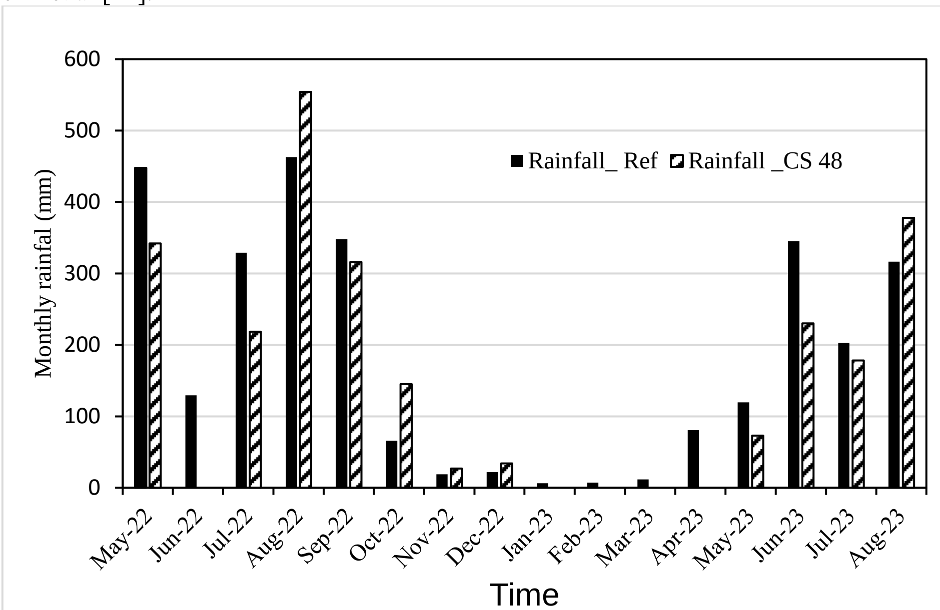

Figure 2. Variability of monthly rainfall data of the reference station and CS_48

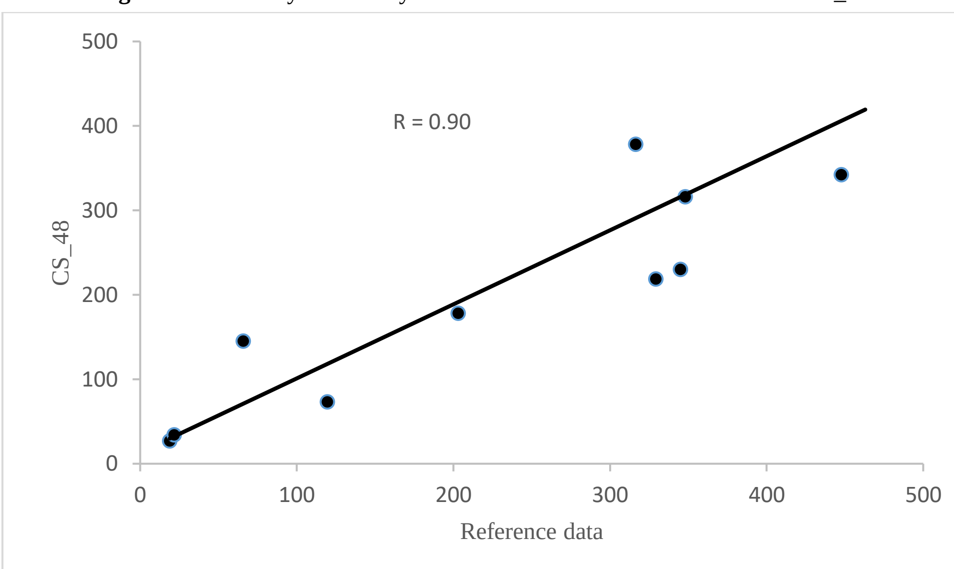

Figure 3. Correlation of monthly rainfall between reference data and citizen science measurement

4 Conclusion

This research demonstrates the ability of citizen science to monitor rainfall in Bui River Basin in Vietnam. The variability of monthly rainfall between citizen science and the reference station is similar, and they have high correlation. Although, the participation of participants is not regular and long-term, it shows a promising approach to enhancing the existing rain gauge monitoring network in Vietnam. In addition, rainfall monitoring can create a good communication channel between locals and researchers to gather other water-related data and information, such as flooding, land-use, and flood impact. Citizen science remains a novel approach to providing information. Therefore, it is necessary to develop a new community-based monitoring protocol in response to the data-scarce areas.

5 Acknowledgements

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