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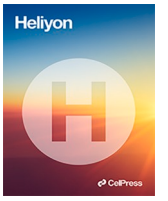

Research article

Development of integrated assessment tool for water, sanitation and hygiene (WASH) services in non-household settings under climate change context

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ABSTRACT

Access to improved water, sanitation, and hygiene (WASH) services is crucial in recognizing human rights to water and sanitation and due to their impacts on education, livelihoods, and human health. However, these services are often inadequate in non-household settings such as prisons, refugee camps, schools, and healthcare facilities. Progress in monitoring to ensure sustainable services in these settings has been limited. Although several tools are available to assess WASH services in both household and non-household settings, they have limitations, and none has taken a holistic approach to evaluate WASH performance in all non-household settings. Furthermore, the impacts of climate change on WASH services are rarely considered in these evaluations, making the inadequacies of WASH services worse. To address these gaps, an integrated tool was developed to assess WASH performance in non-household settings, incorporating financial, institutional, environmental impact, technical, social, and climate change factors. The tool provides scores for indicators to solve the problem of a lack of final aggregated data to enable decision-makers to determine the level of WASH performance in a setting. Moreover, it provides qualitative explanations for each score, allowing decision-makers to identify areas for improvement. This tool offers valuable and insightful data for improving WASH facilities and ensuring sustainable services in non-household settings, particularly for WASH service providers and local governments.

1. Introduction

Water, Sanitation, and Hygiene (WASH) requires proper access to safe, clean water and improved sanitation facilities, as well as maintenance of minimal hygiene standards. WASH programs are a pillar of development because of their connections to education, livelihoods, and well-being, as well as their substantial impact on human health [1,2]. That is why, the General Assembly of the United Nations and the Human Rights Council recognized human rights to water and sanitation (HRtWS) in 2010 [3,4]. Everyone has right to access to sufficient, safe, acceptable, physically accessible, and affordable water for personal and domestic use. Similarly, everyone

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should have access to access to affordable and safe, hygienic, secure, socially, and culturally acceptable sanitation facilities that offer privacy and dignity in all aspects of life [5]. However, most populations, notably in low- and middle-income countries, have difficulty obtaining basic water and sanitation facilities [6]. Data shows that 2.2 billion people worldwide still lack access to safely managed drinking water, and 3.5 billion people lack access to safely managed sanitation services, 419 million people are still practicing open defecation, and 2 billion people lack access to water and soap for handwashing [7].

Climate change significantly impacts water resources, thereby hindering sustainable development goals, SDG 6 on clean water and sanitation. Changes in weather patterns, such as extreme rainfall, floods, and prolonged frequent droughts, place pressure on water sources, leading to reduced quality and quantity of natural water supplies and constructed water systems [8]. Besides water supply, sanitation systems are also impacted by climatic changes. Changes in the precipitation pattern, such as heavy rain, can affect the management of fecal sludge when the access roads to treatment facilities are blocked, causing sewage overflows and exceeding the wastewater treatment capacity. Another alteration in the precipitation pattern, such as drought, may fail water-dependent sanitation systems like toilet flushing and a reduction in and obstruction of sewage overflows [9]. Latrine superstructures, conveyance pipelines, and treatment facilities are all susceptible to destruction by storms or cyclones. People backslide to open defecation when there are inadequate sanitary services. The possible repercussions of climate change for sanitation services overlap with other reasons for failure, such as poor siting or construction and underlying institutional, financial, and social concerns [9].

The majority of the disadvantaged population live in informal settlements, peri-urban and rural areas of developing countries, where open defecation, insufficient sanitation services, and the use of contaminated water persist due to knowledge gaps and attitudes preventing people from practicing basic hygiene [10]. Besides this, the least developed countries (LDCs) struggle to extend services to rural areas, particularly to the poor and vulnerable populations who are most at risk of falling behind [11]. These statistics show that WASH services in household settings are insufficient for complete behavioral change and long-lasting effects. While WASH services are inadequate in such household settings, they are even less adequate in varied contexts outside such settings such as schools, healthcare facilities, workplaces, temporary use settings (such as markets, restaurants, transportation hubs, places of worship, and public WASH facilities), mass gatherings, and dislocated population settings (such as internally displaced camps, refugee camps, prisons, and orphanages) [12]. That is why WASH in non-household settings captured traction from the international development and public health communities [13]. However, progress in ensuring access to these fundamental services in non-household settings remains insufficient, notably in rural developing countries [14]. To address this alarming situation, policymakers require conclusive information on which to base planning, targeting, and prioritizing. Data must be quickly and meaningfully analyzed in order to have an impact on policy. Furthermore, the evaluation system must account for the complexities inherent in non-household settings service delivery [15].

Several tools are available to assess WASH services in both household and non-household settings, such as Water and Sanitation for Facility Improvement (WASH FIT), Joint Monitoring Report (JMP), Sustainability Check (SC), and Empowerment in Water, Sanitation, and Hygiene Index (EWI). WASH FIT was developed to prioritize and enhance services at healthcare facilities and to influence larger district, regional, and national efforts to improve the quality of healthcare [16]. The inclusion of healthcare waste handling and management issues makes the tool unique. However, it also has limitations, such as focusing only on healthcare facilities, a lack of guidance on ensuring the sustainability of improved facilities over time, and a lack of stakeholder involvement such as patient, community, or government officials. JMP indicators were established to offer global reporting on access to drinking water, sanitation and hygiene [17]. It focuses not only on household settings but also on institutional settings such as schools, and healthcare facilities [18]. It also has drawbacks such as depending on national government self-reported data or national survey that may lead to inaccurate data in limited resources countries, limited coverage as it focuses only on measuring the progress of SDG targets, limited numbers of indicators for water, sanitation, and hygiene components, and lack of engagement with local communities. SC was designed to assess the sustainability of WASH projects and examine the circumstances required for sustainability [19]. Its ability to be used not only in household settings but also in schools and healthcare facilities, considering other aspects necessary for sustainability, makes the tool unique. However, it also has disadvantages, including an emphasis on assessing the sustainability of individual programs rather than the entire system, lack of transparency in indicator scoring, and difficulty in measuring outcomes due to the lack of particular ratings for each indicator. The EWI was created to illustrate the connection between WASH-related agencies and enabling factors that result in human well-being outcomes [20]. The ability to assess gender outcomes of WASH project over time makes EWI unique. However, EWI also has shortcomings, including focusing only on women empowerment in WASH services, lack of focus on access to water, sanitation, and hygiene facilities, and lack of consideration of other factors that can influence the sustainability of WASH services.

Despite the unique purposes of these tools and capacity to address one issue at a time, flaws have been found. None of the tools took a holistic approach to evaluating WASH performance and being able to utilize it in all non-household settings. Furthermore, the pressing issue of climate change impacts on WASH services is rarely considered when evaluating WASH performance and sustainability. To close the gaps, an integrated tool was developed to assess WASH services performance in non-household settings. In the tool, financial factors, institutional factors, environmental impact factors, technical factors, social factors, and climate change factors are incorporated, which influences the sustainability of WASH services.

2. Method (steps of tool development)

This section includes four parts: the foundational concept of tool development, the process of developing components and indicator sets, evaluating the performance of WASH services, and tool validation.

2.1. Foundational concept of the integrated WASH assessment tool

The integrated WASH assessment tool was developed based on three main pillars. Firstly, it focuses on non-household settings such as schools, healthcare facilities, workplaces, and dislocated population settings (such as internally displaced camps, refugee camps, and prisons). This is because, access to water and sanitation is a human right, and to achieve SDG 6: leaving no one behind, it is necessary to address WASH services in both household and non-household settings [7,21]. Secondly, it aims to assess WASH services using an integrated approach. This is because, when considering sustainable WASH services, merely knowing the WASH status is insufficient, given the various factors influencing the sustainability of these services, as mentioned in previous literature. Lastly, climate change is included as a significant component in the tool developed as many studies have highlighted the impacts of climate change on WASH services and its potential to hinder sustainable development goals. These three main pillars constitute the foundational concepts of tool development (Fig. 1).

2.2. Developing components and indicator set

In order to develop the tool, firstly, essential components that can be integrated into WASH components were identified. Candidate indicators were then searched by evaluating existing WASH monitoring tools established for non-household settings, WASH monitoring efforts according to human rights to water and sanitation (HRtWS), and WASH standards for each non-household setting. To create a fully integrated tool, the reviewed indicators were consolidated, specific indicators were adjusted, and new indicators were included.

Once indicators were developed, different rubric scoring techniques were reviewed to establish appropriate scores. Upon selecting suitable scoring techniques, scoring definitions for the indicators were set by referencing WASH standards and guidelines for non-household settings. Afterward, the tool was subjected to a validation process by three experts specializing in WASH and public health. The experts were requested to provide feedback on the comprehensiveness of the components and suggestions for potential additions or exclusions. Additionally, the experts were asked to evaluate the clarity of the scoring definitions for each criterion. After thoroughly considering the feedback provided by the experts regarding scoring definitions and made necessary revisions to improve the clarity and effectiveness of the tool.

2.3. Evaluating the performance of WASH services

In preparation for evaluating WASH services, weighing factors to the indicators were assigned. The scales of the weighing factors were 0 = weakly important, 0.25 = less important, 0.50 = moderately important, 0.75 = more important, and 1 = extremely important, respectively [22]. Afterward, the indicators were scored. Once the scores and weighing factors of the indicators were obtained, individual component scores were calculated using Equation (1) [23].

$$CS(a) = \sum_{n=i}^{Ind} Ind_i W_i \tag{1}$$

where,

CS (a) = Net score of component “a”

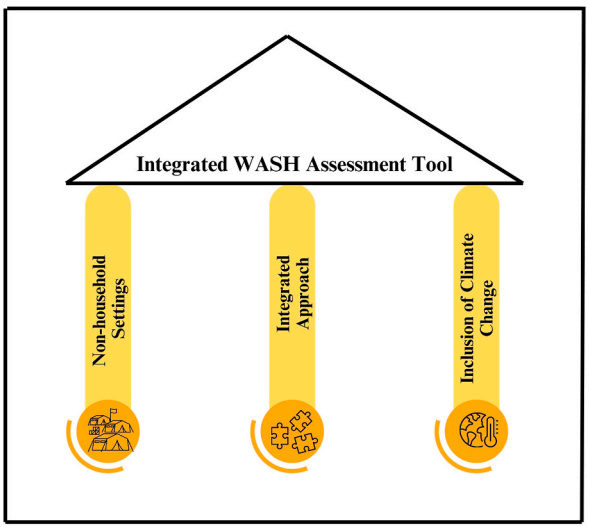

Fig. 1. Foundational concept of the tool development.

Ind_i = Score of indicator "i" of component "a"

W_i = Weighing factor of indicator "i" of component "a"

After getting the component scores, the weighting factors of the components were calculated using the analytic hierarchy process (AHP). After gaining the weighting factors for each component, the final single score (sum of net score components) to evaluate the performance of WASH services was generated by using Equation (2) [23]. Fig. 2 depicts the overall picture of the integrated WASH assessment tool and how to calculate the overall WASH performance score.

$$SAS = \sum_{n=i}^{CS} CS_i W_i \Big/ \mathrm{Sthl_n} \tag{2}$$

where,

SAS = Sum of the net score of components.

CS_i = Net score of components "i" (i = a, b, c,.)

W_i = Weighing factor of components "i" (i = a, b, c,.)

$Sthl_n$ = Number of stakeholders.

2.4. Tool validation

Apart from the experts' validation, the tool was tested in one of the non-household settings, Ah Nauk Ye IDP camp. It is located in Pauktaw Township, Rakhine State, Myanmar, facing the challenges of a natural environment not conducive to human habitation [24]. It has a total population of 5405 people residing in 1100 households. All indicators were assigned weighting factor (1) and assumed that all components were equally important. Subsequently, data were collected through individual interviews with key informants (a WASH manager and four camp-based staffs). Based on the experiences gained from the tool testing stage, indicators and scoring definitions were modified to complete the tool development.

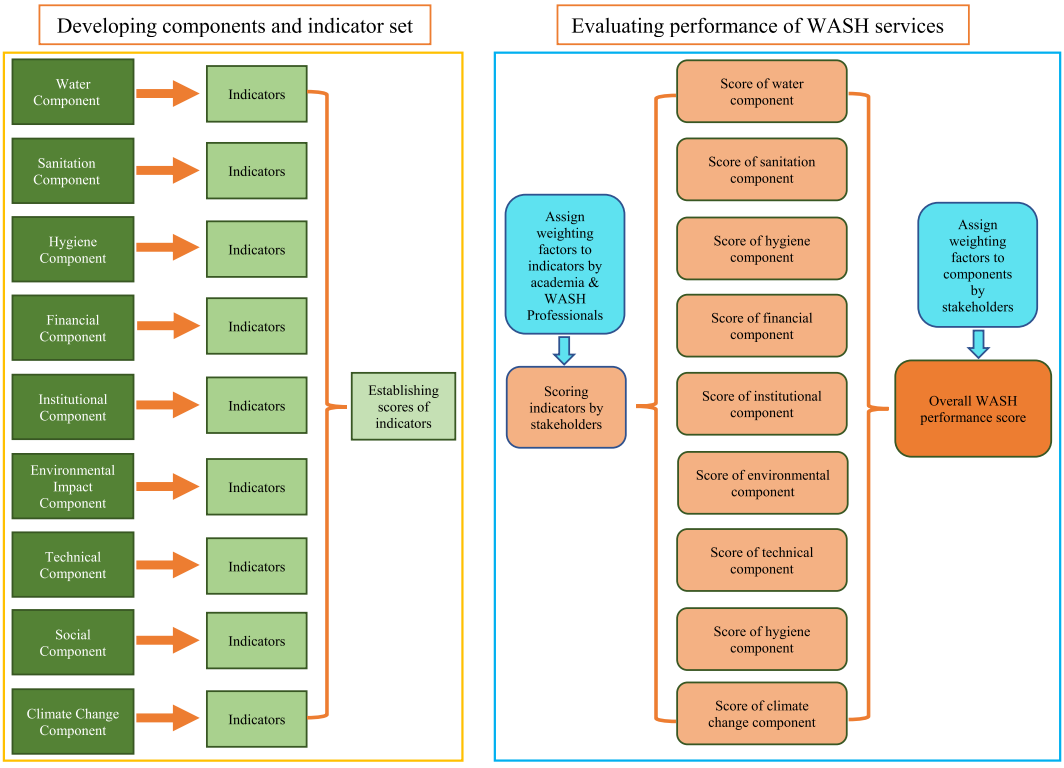

Fig. 2. Overall Picture of Integrated Assessment Tool: Developing components and indicator set, Evaluating performance of WASH services.

3. Results

3.1. Developing components and indicator set

3.1.1. Essential components for sustainable WASH services

In developing countries, water, sanitation, and hygiene (WASH) services are affected by a range of interrelated and ever-changing factors, commonly referred to as (FIETS) factors [25]. These include financial, institutional, environmental, technical, and social factors. These factors originated from the FIETS framework, introduced by WASH Alliance International in 2016 to accelerate sustainable WASH services [26]. Later, in 2021, Daniel et al. used the framework to explore the interaction of factors influencing WASH service sustainability. Strong financial standing will enhance WASH-related institutions by enabling them to carry out their obligations [27]. Social, technical, and WASH factors can be improved if institutional and financial conditions are raised, as financial factors can also impact other elements. Social factors can affect technical aspects; for instance, if a technology is not culturally acceptable, people will not utilize or maintain it. Environmental factors have the least influence on other aspects, as they can improve when others improve [28]. WASH services and social factors reinforce one another. This indicates that accumulating positive social conditions within the community will strengthen the sustainability of WASH services. Favorable social conditions are defined as a supportive community, constructive perceptions or attitudes toward the service, a strong sense of ownership, and active community participation [29–32]. On the other hand, reliable and functional WASH services will raise the community's social standing [33].

Besides these factors, climate change, also discussed in the introduction session, significantly impacts WASH services. Climate change directly impacts water supplies and services, sustaining all economic, social, and environmental functions [34]. The potential consequences of climate change for sanitation services overlap with other causes of failure, such as poor location or construction, as well as underlying institutional, financial, and social concerns [9]. Therefore, rather than the typical approach of considering FIETS factors that humans can control, it is crucial to include climate change concerns in our monitoring tool and take proactive measures for future climate change events. Hence, nine components, three components for water, sanitation, and hygiene, and six components for influencing factors: finance, institution, environmental impacts, technology, society, and climate change were included in the integrated WASH assessment tool. WASH services sustainability depends on the adaptation of these six influencing factors, and each component contributes in a different way to the promotion of sustainable WASH services [35–38]. Fig. 3 shows the integrated WASH assessment tool in its overall context and the interaction of each component.

3.1.2. Indicators under each component of integrated WASH assessment tool

When developing indicators, dimensions for realization of human rights to water and sanitation (HRtWS) were also incorporated into the assessment of WASH services in non-household settings to align with the resolutions taken by the General Assembly of the United Nations (UN) and the UN Human Rights Council in 2010. In doing so, five normative dimensions to measure the different aspects of HRtWS such as availability, quality & safety, physical accessibility, affordability, and acceptability, and human right principles such as equality & non-discrimination, participation, and accountability were considered [39]. In the previous literatures, water and sanitation researchers used these dimensions to measure service levels of water and/or sanitation [40–44].

Availability refers to having sufficient number of water and sanitation facilities to meet the current and future needs of the population within premises or proximate vicinity. Users to facilities ratios must meet minimum standards of each non-households setting. Moreover, there must be enough water constantly available for personal and household use, including for activities like handwashing,

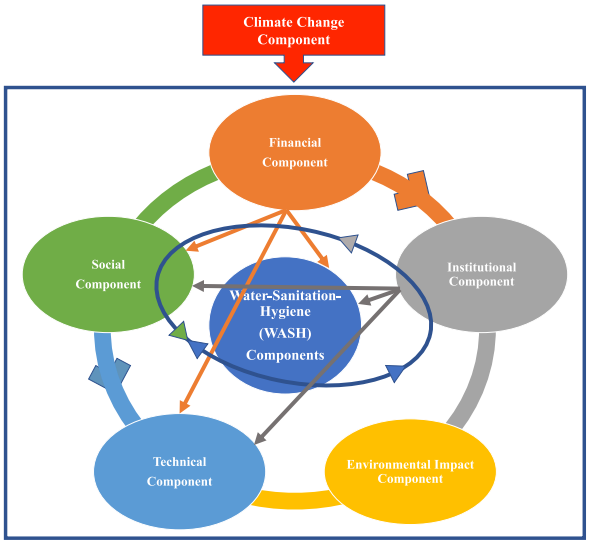

Fig. 3. Components of integrated WASH assessment tool and their interactions.

menstrual hygiene, and managing children's feces [39,40].

Quality & safety refers to ensuring to protect health problems occurred by lack and improper management of WASH services within communities. Thus, safely managed water for drinking and domestic purposes, and safely managed sanitation facilities are essential. This includes ensuring that water and sanitation facilities are securely located, available for use at any time (day and night), hygienic, and excreta are safely contained and disposed [39,40].

Physical accessibility is more than having water and sanitation infrastructures. It refers that every individual including children, the elderly, people with disabilities, and those with chronic illnesses, must be able to easily access these facilities without facing any challenges [39,40].

Affordability means people have financial capacity to manage the costs associated with accessing water and sanitation services. However, as this study focused on non-household settings, and WASH associated costs are taken care by government, or aid organizations. That's why, this affordability dimension was assessed in a different way under financial component such as presence of allocated budget and utilization of the budget, not like in household settings [39,40].

Acceptability refers to the perceptions of communities regarding water and sanitation facilities within a given context. These facilities must be culturally acceptable, gender-segregated, and maintain acceptable hygiene levels. Additionally, they should meet certain quality standards in terms of color, odor, taste, and microbiological water quality. Moreover, consideration must be given to the design, placement, and conditions for using sanitation facilities [39,40].

Equality & non-discrimination means all individuals regardless of race, color, sex, language, religion, political or other opinion, national or social origin, property, birth, or other status, have rights to water and sanitation by all individuals without discrimination. It includes of recognition of different barriers and needs to have access to water and sanitation, and developing measures to reduce these barriers and fulfill the needs [39,40].

Participation refers to the involvement of people affected by decisions in decision-making processes. This is to ensure their concerns and voices are considered for the effective implementation of providing water and sanitation services. Users should be involved in planning, providing services, operation, maintenance, and monitoring to ensure sustainability [45].

Accountability involves developing legislation, regulations, and policies that clearly define who is responsible for each stage of the process. It also includes establishing mechanisms to address and resolve users' complaints. Additionally, there should be monitoring systems in place to ensure compliance with standards and targets, as well as to track which individuals and groups have access to sufficient water and sanitation services and which do not [45].

Indicators to capture these human rights to water and sanitation (HRtWS) issues were built up under the nine components (Table 1).

3.2. Establishing scores and scoring definitions of the indicators

The fuzzy set qualitative comparative analysis (FsQCA) method was used to establish scores for the indicators. The FsQCA scoring method can transform qualitative data into quantitative data by assigning numbers to each condition. The basis for QCA scoring is to set memberships, where conditions are coded according to the degree of inclusion in a set of cases that share a certain characteristic [50]. Three different types of QCA sets were used for scoring: the crisp set, which has binary scores (1 = fully in and 0 = fully out), the three-value fuzzy set with three scores (1 = fully in, 0.5 = neither fully in nor out, 0 = fully out), and the four-value fuzzy set with four scores (1 = fully in, 0.67 = more in than out, 0.33 = more out than in, 0 = fully out). This was because conditions for most indicators required more complex options than yes or no, and few indicators needed only yes or no options. Thus, a four-value fuzzy set was used for most indicators, and a crisp set and a three-value fuzzy set were used for a few indicators. For instance, indicators for "access to improved water supply sources" require more options than just improving water sources. In this circumstance, tiers were established, and scores were assigned to each tier. Thus, four tiers were established for this indicator: 1 = all the water sources are improved sources; 0.67 = most of the water sources are improved sources (> or = 70 %); 0.33 = some of the water sources are improved sources (> or = 50 %); and 0 = only a few water sources are improved sources (<50 %). "Accessibility of handwashing facilities" was an example of a binary score indicator (1 = handwashing facilities are accessible for all, including disabled people and children (i.e., handwashing stations have low height and easy-to-use taps), 0 = handwashing facilities are difficult to use for disabled people and children because of raised height and challenging to use taps). "Provision of menstrual waste or pad containers" was an example of an indicator with a three-value fuzzy set (1 = menstrual waste or pad bins are present in every female latrine, 0.5 = menstrual waste or pad bins are present in few female latrines, 0 = menstrual waste or pad bins are not present at all). A complete list of indicators, the scores established by using the FsQCA method, and scoring definitions are listed in **Appendix A**.

3.3. Evaluating the performance of WASH services

To evaluate WASH services performance, weighing factors were assigned to the indicators according to the scales mentioned in the methodology session (0 = weakly important, 0.25 = less important, 0.50 = moderately important, 0.75 = more important, and 1 = extremely important). The authors assumed that all the indicators were extremely important and assigned 1 to each indicator. After obtaining the weighting factors, the indicators were scored. The authors gave the best optimum score (1) to the indicators for the best performance scenario, the least optimum score (0) to the indicators for the poor performance scenario, middle scores such as 0.67 for four values indicators or 0.5 for three values indicators with the combination of the best optimum score 1 or the least optimum score 0 in binary score indicators for average performance and below-average performance scenarios. Afterward, individual component scores were calculated using Equation (1). Table 2 summarizes each component's good, moderate, below-average, and poor

Table 1
Indicators of integrated WASH assessment tool.

No	HRtWS Dimensions	Water Component Indicators	References
1	Availability	Access to improved water supply sources (examples of improved water supply sources - piped water supply and protected handpumps and protected open wells)	[16,19,46,47]
2	Availability	Functionality of water supply sources (function of extracting, collecting, and distribution of water)	[19]
3	Availability	Water points (hand pumps, open well, public tap, etc.) to users' ratio	[47]
4	Availability	Flow rate of water points (hand pumps, open well, public tap, etc.)	[47,48]
5	Physical accessibility	Distance between water points (taps, hand-dug wells, open wells, etc.) and households	[19,46,47]
6	Quality &Safety	Distance between water points (taps, hand-dig wells, open well, etc.) and excreta containment facilities (e.g., latrines)	[47]
7	Physical accessibility	Water fetching time	[19,46,47]
8	Acceptability	Water quality (Turbidity)	[19,47,48]
9	Acceptability	Water quality *(E_coli)*	[47]
10	Availability	Availability of water for drinking and personal hygiene (quantity, reliability and continuity)	[16,47,48]
11	Availability	Contingency plan for water shortage	[47]
12	Quality &Safety	Provision of water containers with lids for fetching and safely storage water	[16,47]
13	Quality &Safety	Monitoring water quality testing (*E_coli*)	[47]
No	**HRtWS Dimensions**	**Sanitation Component Indicators**	**References**
1	Availability	Access to improved latrines (Example of improved latrines - flush/pour flush to piped sewer system, septic tank, pit latrines, ventilated improved pit (VIP) latrines, pit latrine with slab, composting latrines)	[16,19,46,48]
2	Availability	Latrines to users' ratio	[47,48]
3	Physical accessibility	Distance to latrines from users	[47–49]
4	Quality & Safety	Cleanness of the latrines (free from feces and insects (flies))	[47]
5	Availability	Availability of an adequate amount of water to clean latrines	[19,47,48]
6	Physical accessibility	Conditions of the latrines (superstructure)	[47]
7	Quality & Safety	Presence of vectors (flies, mosquitoes, rats, etc.)	[47,48]
8	Quality & Safety	Vector Control Activities (flies, mosquitoes, rats)	[47,48]
9	Quality & Safety	Presence of cleaning materials inside latrines	[47]
10	Quality & Safety	Presence of fecal sludge management activities	[48]
11	Quality & Safety	Presence of waste segregation system and waste management facilities	[16,46]
12	Quality & Safety	Presence of waste disposal bins	[47]
13	Quality & Safety	Waste collection system	[47]
14	Quality & Safety	Frequency of waste collection	[48]
15	Quality & Safety	Proper waste disposal	[16,47,48]
No	**HRtWS Dimensions**	**Hygiene Component Indicators**	**References**
1	Availability	Availability of handwashing facilities	[16,19,46,47]
2	Physical accessibility, equality & non-discrimination	Accessibility of handwashing facilities	[46]
3	Availability	Provision of hygiene items	[46,47]
4	Physical accessibility, equality & non-discrimination	Provision of menstrual waste or pad bins	[47]
5	Availability	Presence of laundry space	[47,48]
6	Availability	Presence of bathing space	[47,48]
No	**HRtWS Dimensions**	**Financial Component Indicators**	**References**
1	Affordability	Allocation of annual budget for maintenance of WASH facilities	[16,19]
2	Affordability	Allocation of budget for daily operation of WASH facilities	[16,19]
3	Accountability	Utilization of allocated budget for maintenance of WASH facilities	[16,19]
4	Accountability	Utilization of budget for daily operation of WASH facilities	[16,19]
5	Affordability	Allocation of budget for disaster mitigation, prevention, preparedness, and response	[34]
6	Accountability	Utilization of allocated budget for budget for disaster mitigation, prevention, preparedness, and response	[34]
No	**HRtWS Dimensions**	**Institutional Component Indicators**	**References**
1	Accountability	Existence of clear policies for provision of WASH services	[47]
2	Accountability	Existence of policies for Solid Waste Management	[47]
3	Participation	Existence of WASH facility management structure	[16]
4	Participation	Presence of community-based associations or groups to maintain WASH facilities	[19]
5	Participation	Functioning of community-based associations or groups to maintain WASH facilities	[19]
6	Participation	Building capacity of WASH committee/water committee/sanitation committee, parent teacher association (PTA), or other community-based associations or persons who are involved in WASH facilities operation, maintenance, monitoring, and management	[19]
7	Accountability	Existence of WASH monitoring system	[19]
No	**HRtWS Dimensions**	**Environmental Impact Component Indicators**	**References**
1	Quality & Safety	Free from human feces in an environment where people live, learn, and work	[16,47]

(*continued on next page*)

Table 1 (*continued*)

No	HRtWS Dimensions	Water Component Indicators	References
2	Quality & Safety	Overflow or leakage from excreta containment facilities (e.g., latrine pits, septic tanks, or other black water treatment units)	[48]
3	Quality & Safety	Presence of stagnant water near water points	[47]
4	Quality & Safety	Management of drainages	[47]
5	Quality & Safety	Signs of releasing leachate from temporary waste collection site	[47]
6	Quality & Safety	Wastes are not littered and accumulated in the premises	[16,47]
No	**HRtWS Dimensions**	**Technical Component Indicators**	**References**
1	Acceptability	Quality of Construction	[19]
2	Acceptability	Easily maintained with local capacity and skills	[19,47]
3	Acceptability	Consideration of potential local hazards during construction	[19]
4	Availability	Accessibility of technicians	[47]
5	Quality & Safety	Safety usage of WASH facilities at night	[47,48]
6	Quality & Safety	Provision of safety, operation, and maintenance training to desludging workers	[46,47]
7	Quality & Safety	Safety equipment for sanitation workers	[16,47,48]
No	**HRtWS Dimensions**	**Social Component Indicators**	**References**
1	Acceptability	Existence of culturally accepted latrines	[19,47]
2	Physical accessibility, Equality & non-discrimination	Existence of disabled-friendly latrines	[47]
3	Physical accessibility, Equality & non-discrimination	Existence of child-friendly latrines	[47]
4	Equality & non-discrimination	Existence of gender-segregated latrines	[47]
5	Accountability	Presence of a functioning complaint mechanism	[19]
6	Equality, non-discrimination	Conflict among different user groups or conflicts with host communities	[19]
7	Participation	Participation of users and/or host communities in WASH activities	[19,47]
8	Equality, non-discrimination, participation	Involvement of women in the decision making process	[19,47]
No	**HRtWS Dimensions**	**Climate Change Component Indicators**	**References**
1	Quality & Safety	Weather change events which can impact on WASH services.	[34]
2	Quality & Safety	Impacts of weather change events on water points	[34]
3	Quality & Safety	Impacts of weather change events on sanitation facilities	[34]
4	Quality & Safety	Impacts on health after weather change events	[34]
5	Availability	Presence of plans for reducing the quantity of water	[34]
6	Availability	Presence of plans for deterioration of quality of water	[34]
7	Availability	Mitigation of natural disaster impacts on water infrastructure damage	[34]
8	Availability	Presence of plans for water infrastructure damage	[34]
9	Quality & Safety	Mitigation of natural disaster impacts on latrines and other sanitation facilities.	[34]
10	Affordability, physical accessibility, participation	Presence of plans to respond to latrines and other sanitation facilities damage	[34,47]
11	Availability, participation	Presence of emergency response plans to prevent WASH disease outbreak after climate change events	[34]
12	Participation	Building capacity of users	[34]

performance scores.

Afterward, weighting factors of each component were calculated. The weighing scales were identified from 1 to 9 (1 = equal important, 3 = moderate important, 5 = strong important, 7 = very strong important, and 9 = extreme important) [51]. The authors assumed that all the components were equally important. A pair-wise comparison matrix was constructed based on the obtained weighing factors. Then, a normalized pair-wise comparison matrix was generated, averaging the values in each column. Afterward, the weighting factors of each component were calculated by averaging all the values in the role of the normalized pair-wise comparison matrix. The consistency of the pair-wise comparison can be checked by calculating the consistency ratio (CR). If CR is equal or less than 0.1, the pair-wise comparisons are consistent, and weighing factors are reliable. After gaining the weighting factors of each component, the final single score (sum of net score components) to evaluate WASH services performance was generated using Equation (2) [23]. Table 3 summarizes the sum of net component scores of good, moderate, below-average, and poor performance. The detailed calculations of component scores and the sum of net component scores can be found in **Appendix B.** A Step-by-step evaluation of the performance of WASH services is demonstrated in Fig. 4.

3.4. Tool validation results

3.4.1. Results of tool application

According to the tool testing results, Ah Nauk Ye IDP camp had moderate level of performance (4.60) in terms of WASH services provision contributed by moderate performance in the water (8.94), financial (4.0), environmental impact (4.14), and social component (4.67), and below average performance in sanitation (7.93), hygiene (1.63), technical (3.80), and climate change (1.47) components.

Table 2
The component scores and their level of performance.

Components	Water Component	Sanitation Component	Hygiene Component	Financial Component	Institutional Component	Environmental Impact Component	Technical Component	Social Component	Climate Change Component
GoodPerformance	9.38–13	10.72–15	4.02–6	4.02–6	4.19–7	4.52–6	4.53–7	5.69–8	9.68–12
Moderate Performance	7.38–9.37	8.72–10.71	2.02–4.01	2.02–4.01	2.69–4.18	2.02–4.51	4.03–4.52	2.69–5.68	0.68–9.67
Below-average Performance	3.64–7.37	4.30–8.71	1–2.01	1–2.01	1.33–2.68	1–2.01	1.99–4.02	1.33–2.68	0.34–0.67
Poor Performance	0–3.63	0–4.29	0–0.99	0–0.99	0–1.32	0–0.99	0–1.98	0–1.32	0–0.33

Table 3
The sum of net component scores and their level of performance.

Level of WASH Services Performance	Sum of Net Score of Components (SAS)
Good Performance	6.24–8.80
Moderate Performance	3.55–6.23
Below-average Performance	1.75–3.54
Poor Performance	0–1.74

Fig. 4. Steps to evaluate performance of WASH services.

The important findings of WASH conditions in the camp are IDPs faced water difficulties every year during the dry season. Due to its proximity to the sea, obtaining fresh water from handpumps or wells was not feasible. Ponds were therefore the main sources of water in the camp, which were not considered improved sources. In this given situation, WASH service provider (INGO) constructed a water treatment unit (WTU) in the camp. Water from the ponds was treated in WTU and delivered to the camp communities through public standpipes. The WASH service provider also distributed ceramic water filters, and water containers with lids and taps to store water at home. During the dry season, the ponds dried up and rendering them unable to provide water. To address this, the WASH service provider implemented a contingency plan, supplying 7.5 L of water per person daily, sourced from Sittwe city and distributed to the camp across the sea. Additionally, water storage containers were constructed in the camp to store contingency water for two days to mitigate potential disruptions to water distribution due to local authority permissions or weather conditions. However, the allocated 7.5 L per person were insufficient for domestic use, causing the IDPs to experience annual water stress.

The WASH service provider constructed latrines with septic tanks, maintaining a user's-to-toilets ratio of 1:30 while minimum standard was 1:20 in the displaced settings [47]. Latrines were located within 30 m for more than 70 % of users. However, almost half of the latrines were not clean, and water to clean latrines was not easily available for every person during the dry season. More than 70 % of latrines were useable or in need of minor repairs, while the rest needed major repair.

Handwashing stations were not located near the latrines, there was no common bathing space, only one common laundry space for the whole camp, and hygiene kits were distributed according to the organization's convenient schedule. Budgets were allocated for operation and maintenance and daily operation, but not for disaster mitigation and response.

Regarding the institutional component, the WASH service provider had clear policies and strategies for the provision of WASH services. They formed community-based groups and built the capacity for them. Regarding the environmental impact component, open defecation was evident near toilets and on roads, as people in the camp were still practicing it and had habits of throwing waste openly, resulting in waste littering in some parts of the camp. Desludging activity was carried out every two weeks, minimizing overflow from the latrines.

Regarding the technical component, some latrines required major repairs, and they were not designed considering potential local natural hazards despite the area being prone to cyclones. Additionally, lights on the way to the latrines were often non-functional. From a social perspective, latrines were culturally acceptable, and there were child-friendly latrines, but no disabled-friendly ones. Conflicts arose regarding resource-sharing with host communities, especially concerning water usage. Despite women's participation in committees and meetings, they did not voice their opinions effectively. Regarding climate change, the WASH services provider had no preparation for natural disasters, except for responding to WASH-related disease outbreaks in the camp.

3.4.2. Tool adjustments after testing

After testing the tool at Ah Nauk Ye IDP camp, some ambiguities and limitations were found. Therefore, some indicators and the scoring definitions were updated/adjusted. For example, environmental impact performance could be captured more effectively by using binary scores. If open defecation occurs near toilets or overflow or leakage from excreta containment facilities occurs, it can still spread pathogens through flooding and runoff, contaminating water sources [52]. These environmental impact indicators must meet the minimum standards.

Moreover, based on the tool testing, necessity to include more indicators to reflect the capacity of non-household settings regarding climate change consequences, were discovered. Therefore, indicators capable of capturing existing hazards, vulnerabilities in WASH services, and the capacities of WASH service providers (such as weather change events impacting WASH services, the effects of weather change events on WASH facilities, mitigation of natural disaster impacts on WASH infrastructure damage, and the presence of plans for addressing WASH infrastructure damage) were added to the climate change component. For some indicators that might lead to ambiguities or misunderstanding, instead of asking the respondent 'what is users to WASH facilities ratio in this area', the user-to-WASH facilities ratios was calculated ourselves after determining the number of WASH facilities and the population of the tested areas. Additionally, for water quality (*E-coli*), the latest water testing result was taken from the respective area instead of collecting water samples and measuring the *E-coli* count in the laboratory.

4. Discussions

This section includes discussions on the components of the tool, indicators for each setting and flexibility for indicator exclusion, three level of scores, weighing factors of the indicators and components, and strengths and weaknesses of the tool.

Climate change was considered a significant component in the integrated WASH assessment tool, in addition to the factors identified through the literature review, i.e., financial factors, institutional factors, environmental impact factors, technical factors, and social factors. Including a climate change component informs stakeholders whether WASH infrastructure is climate change-resilient and enables them to develop disaster response and adaptation plans for particular communities. Over the past few years, the WASH sector has been slow to adopt and mainstream climate change adaptation activities, as it is prioritizing "more immediate challenges" of improving WASH services [53]. The integrated WASH assessment tool can assist in identifying the specific vulnerabilities of non-household WASH services to climate change impacts such as extreme weather events, water scarcity, and changes in water quality. The tool can guide the implementation of targeted adaptation strategies to strengthen the resilience of WASH services to the effects of climate change by identifying these vulnerabilities. Climate change adaptation measures can help mitigate the adverse effects of climate change on WASH services and assure their continuous availability to vulnerable populations. Adaptation measures may include creating and constructing extreme weather-resistant water supply and sanitation infrastructure, implementing water conservation measures to overcome water scarcity, and promoting water treatment technologies to handle changes in water quality [54]. Incorporating climate change adaptation in the integrated WASH assessment tool can also benefit institutions and communities in raising their capacity to deal with the effects of climate change [55]. The tool can increase awareness and facilitate community engagement in climate change adaptation initiatives by providing information on climate change consequences and adaptation measures.

The authors acknowledge that each non-household setting has a unique challenge. For instance, schools may struggle to provide sufficient menstrual hygiene management facilities for female students, while healthcare facilities may struggle to handle infectious waste. In prison, the overcrowding of inmates can bring challenges in managing sanitation facilities such as toilets, showers, and sinks, whereas limited access to clean water, poor sanitation facilities, and lack of privacy are challenges in refugee camps. Therefore, the integrated WASH assessment tool addresses the individual demands of these settings and includes indicators appropriate for WASH monitoring in non-household settings. While striving to develop all-encompassing indicators for non-household settings, the authors realized that some vital indicators for one particular setting may not be necessary for other settings. For example, "water fetching time" is a crucial indicator for displaced camps, health care facilities, and schools where these settings might share water points with nearby communities or use communal water points. However, in the case of prison, this indicator may not be relevant, as prisons have water points or tanks within their premises, which makes this indicator non-applicable. Hence, the tool allows flexibility to exclude the indicators which are not necessary for each setting.

Users will obtain scores in three steps when utilizing the integrated WASH assessment tool. Firstly, users will receive the scores of each indicator. Secondly, the component scores, and finally, the aggregated or overall WASH performance scores. The results obtained at each level will provide useful information for stakeholders and users. For instance, if users want to see the level of access to improved water supply status, they simply need to review that indicator's calculated score. If users want to know the performance of the water component, they can calculate the component score using Equation (1). By computing each component's score, users can gain insight into how well each component is doing and compare them to see which ones are strong and on the right track. Users who wish to see the overall WASH performance can proceed the calculation using Equation (2). It's entirely up to users whether they want to see the overall WASH performance score, or component scores, or individual indicator scores.

Before evaluating the performance of WASH services, users are encouraged to assign weighting factors to the indicators. This gives users flexibility when evaluating WASH services, as they might assume that some indicators are less important in some contexts. Thus, assigning higher or lower weighting factors to the indicators is appropriate depending on the specific context in which the tool is being used. This approach ensures that the tool is adaptable and can be customized to suit the needs of various non-household settings. To accomplish this step, users can engage with academia and/or WASH professionals who possess knowledge of water and sanitation systems. Afterward, users can engage with stakeholders such as provincial/district public health officers, education officers,

international and national NGOs, donors/private sectors, and representatives of each setting such as teachers, students, heads of hospitals, camp leaders, WASH committees and WASH services users or local communities to score the indicators [56]. The stakeholders can score the indicators by selecting established fuzzy scores (0 or 0.33 or 0.5 or 0.67 or 1) suitable for conditions in their areas.

Before calculating the sum of net component scores, users are encouraged to request stakeholders to assign weighting factors to the components. The purpose of giving weighting factors to the components is to reflect stakeholders' preferences. Thereby, greater emphasis is placed on the components they consider more important, such as the financial, institutional, environmental impacts, technical, social, and climate change components, which are included in the analysis [23].

Furthermore, the authors recognize that it is challenging for decision-makers to identify whether a setting has good WASH performance or not due to a lack of final aggregated data. The tool addresses this issue by offering scores for each indicator and data aggregation method, allowing decision-makers to assess WASH performance quickly and simply across areas. Decision-makers can identify areas that require improvement by using the qualitative explanations provided in the score definition for each indicator. In addition, the participatory nature of the assessment, such as prioritizing indicators and components providing weighting factors, can increase awareness and improve the commitment of all stakeholders to implement necessary action plans. Although the tool contains a wide range of indicators, users may eliminate indicators and adjust score definitions based on the local context by collaborating with relevant stakeholders.

5. Conclusions

An integrated assessment tool was developed to assess water, sanitation, and hygiene (WASH) services in non-household settings by reviewing four existing WASH monitoring tools, WASH monitoring efforts related to human rights to water and sanitation, and WASH standards in non-household settings. The primary objective was to develop an integrated WASH monitoring tool that can be applied in all non-household settings. Therefore, the advantages of the reviewed tools were carefully considered, and their limitations were addressed. Climate change was therefore included as a significant component to fill the gaps of previously developed tools. The tool was composed of nine components: water, sanitation, hygiene, financial, institutional, environmental impact, technical, social, and climate change. There are a total of 80 indicators distributed among these nine components: 13 indicators for the water component, 15 indicators for sanitation, 6 indicators for hygiene, 6 indicators for finance, 7 indicators for institutions, 6 indicators for environmental impact, 7 indicators for technical component, 8 indicators for social factors, and 12 indicators for climate change. Hence, the tool offers a holistic approach to evaluating WASH services. Furthermore, the tool provides scores and scoring definitions of the indicators to transform qualitative data into quantitative data, and a data aggregation method is also provided to calculate the scores to determine whether WASH services performance is good, moderate, below-average, or poor. When evaluating WASH services, the tool provides scores at three different levels: 1) indicator scores, 2) component scores, and 3) aggregated score, or overall WASH performance score. Thus, the tool provides valuable and insightful data for improving WASH facilities and ensuring sustainable services, particularly for WASH service providers and local governments.

However, this tool development was the very first attempt to evaluate WASH services in all non-household settings in an integrated way. As a result, the tool has not been utilized on a broad scale yet, despite its applicability being tested and validated, and tool testing results being presented. This represents the limitation of the study. Therefore, water and sanitation researchers are encouraged to extend its application for validation of the tool across different cultural backgrounds and enhance its applicability.

Ethical approval

This study received approval from the Walailak University Ethics Committee in Human Research (Approval Number: WUEC-23-114-01).

Data availability statement

The developed tool and data for calculating the scores can be found as supplementary materials. Tool testing data can be obtained from the corresponding author upon reasonable request.

CRediT authorship contribution statement

Cho Zin Win: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **D. Daniel:** Writing – review & editing, Resources. **Ni Made Utami Dwipayanti:** Writing – review & editing, Resources. **Warit Jawjit:** Writing – review & editing, Visualization, Supervision, Resources, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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