Challenges in Tea Plantation-Based Small Community Water Safety Plan Implementation – A Sri Lankan Experience

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Abstract

This paper presents the challenges and scientific approach adopted to overcome those challenges for Rural Water Safety Plan (RWSP) implementation for the water supply schemes (WSS) in the Sri Lankan Tea Plantation sector. Factors positively and negatively impacting WSP implementation were identified through a SWOT analysis. Pooled response from 100 individuals of the Likert scale survey of WSP team members to evaluate the impact of each contributing factor. A Spearman correlation was conducted to evaluate the correlations. Survey results confirmed that top management engagement, availability of financial resources, organizational structure, clustered community, government regulations, quality certifications, and similar cultural practices positively impact the success of WSP implementation. Poor community awareness, learning culture, communication barriers, poor sanitation and hygiene practices, inadequate stakeholder relationships, inadequate resources, skills, and lack of accountability were the factors hindering the WSP implementation. The correlation analysis revealed specific relationships namely, lack of awareness, accountability, and availability of financial support with inadequate resources and skills. Converting the negative factors to positive ones will make the WSP application successful in another similar plantation-based WSS. The major lesson from this intrinsic research study is that socioeconomic and cultural factors in the tea plantation are equally important as the typical technical aspects of the WSP.

Keywords: Challenges; Questionnaire Survey; Tea Plantation; Rural Water Supply, Water Safety Plan

1. Introduction

1.1 Water safety plan and its evolution

All living organisms on the earth need the safe water to survive (Masroor et al., 2020). In the past century, global water consumption increased by six times, and it has continued to rise as a result of the demand for water resources by ecosystems, economic growth, health, and food security together with numerous disasters reported as a result of poor water quality (Wada *et al*., 2016). Thus, it is imperative to make sure that the demand for clean water is met by continuously boosting and optimizing all protocols and practices associated with the water supply. Hence, the water safety plan (WSP) concept has become a globally recognized and accepted approach to drinking water supply management and operation (Alazaiza *et al*., 2022).

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The WSP is a proactive, catchment to end-user risk management approach recommended by the World Health Organization (WHO) in mid-2000 to ensure the supply of safe drinking water. WSP methodology, as recommended by the World Health Organization (WHO), aims to enhance the quality of drinking water for human consumption by implementing best practices throughout water supply systems (Bartram, 2009). It is an effective tool as the approach not only takes into consideration the economic value of water but the value of safe and clean water in a social and environmental context (Global status report on water safety plans, 2017). Its objective is to avoid contamination at every stage, which includes reducing pollution in water sources, eliminating contamination during the treatment process, and avoiding post-contamination during storage and distribution (Bartram, 2009).

The WHO has supplied the WSP in its third and fourth editions, and it is an effective tool for preventative actions that uses a risk assessment and risk management strategy to ensure the quality of drinking water (Bartram, 2009). At present, WSPs have become widely used policy tool and part of legal requirements of certain countries for water utilities (Gunnarsdottir et al., 2012). Through the sustainable development objectives, about 93 countries around the world have demonstrated a strong political commitment to ensuring that drinking water is safe for all (Sutherland and Payden, 2017). By 2008, more than 80% of the population had access to safe drinking water through water utilities implementing WSPs (Gunnarsdottir et al., 2012). According to Sutherland and Payden, 2017, the rate of WSPs implementation have increased rapidly after 2004 due to numerous benefits such as improving system management of supplies, increasing awareness, knowledge and understanding among staff of water supplies, and improving water quality.

The research conducted by Gunnarsdottir et al., 2012 identified a significant decrease in the incidence of diarrhoea in areas where WSPs were implemented in Iceland. Additionally, the Manila Water Company in the Philippines saved approximately 6.4 million Philippine pesos annually in operational costs because of implementing a WSP, which reduced the need for water quality monitoring(Sutherland and Payden, 2017). Furthermore, research conducted by Masroor et al., 2020 focused on the feasibility of the application of WSP for packaged water production companies Abeokuta, southwest Nigeria in assessing hazard identification and risk management. Furthermore, in many countries within the southeast Asia region under the WHO, pipe-borne water is not ubiquitous, and water sources often exhibit faecal contamination (Sutherland and Payden, 2017). Hence, the WHO Water Safety Framework advocates for the utilization of WSPs, providing a comprehensive methodology to assess and mitigate risks at all stages of the water supply system from catchment to consumer (Kumpel *et al*., 2018). Furthermore, in the southeast Asia region, 82% of countries have implemented WSPs at the national scale (Sutherland and Payden, 2017). These countries are actively working to deliver improved drinking water safety through the mainstreaming of WSPs, including activities such as, awareness raising, capacity building, guidance material development, WSP implementation, and integration of WSPs into policies and regulation (Kumpel *et al*., 2018; Sutherland and Payden, 2017).

Implementation of WSPs has been steadily progressing in the Asia Pacific region in the past decade and Sri Lanka has made rapid progress in WSP implementation in a shorter period (Jayaratne, 2020). Several organizations are involved in conducting WSPs and related activities across the country, including National Water Supply and Drainage Board (NWS&DB), non-governmental organizations, and municipal and local water utilities. NWS&DB is the main Sri Lankan government authority which provides more than 49.2% pipe-borne water coverage to their people (NW&SDB, 2017). The NWS&DB strategic plan committed to implementing WSPs in all urban water supply schemes in Sri Lanka by 2020 (NWS&DB, 2017). NWS&DB enhanced the capability for WSP implementations with the establishment of the Water Safety Plan Advisory Unit (WSPAU) in the year 2013. Afterward, WSPs have been successfully implemented in 264 out of 342 NWS&DB operated water supply schemes (Jayaratne, 2020).

NWS&DB is only fulfilling 38.7% of the population's drinking water requirement and the other 61.3% of the population receives their drinking water requirement by community-based water supply

schemes (CBWSS), household dug wells, streams, or by water springs in the country (NWS&DB Annual Report, 2017). NWS&DB provides technological and scientific knowledge for the CBWSS design, operational as well as water quality maintenance including different type of water treatment plant plants such as conventional and other technologies (Tomonori, *et al*., 2016). Furthermore, NWS&DB WSPAU has expanded the WSP implementation to the CBWSS located in rural sectors in collaboration and support from the WHO, World Bank Assisted Water Supply Improvement Project (WaSSIP), and the Department of National Community Water Supply within the Ministry of City Planning and Water Supply.

However, the progress in water safety planning initially faced challenges, primarily due to issues with senior management and stakeholder participation in catchment and distribution zones across Sri Lanka (Water safety plan manual: step-by-step risk management for drinking-water suppliers, 2023). The WSPs team were established at three level, including, WSP implementation, WSP support, and WSP stakeholder team (Water Safety Plan Manual: Step-by-Step Risk Management for Drinking-Water Suppliers, 2023) to address these challenges.

In developing regions such as tea plantations in Sri Lanka, water safety issues carry unique socioeconomic and health consequences. Tea plantations are often located in rural areas where communities rely heavily on local water sources, which may be vulnerable to contamination from agricultural runoff, inadequate sanitation, and limited access to water treatment facilities. Unsafe drinking water here can contribute to high incidences of waterborne diseases, which not only impact the health and well-being of workers and their families but also affect productivity, healthcare costs, and the local economy.

However, the successful adoption of WSPs in Sri Lanka has faced challenges, particularly around engagement at senior management levels and among stakeholders in rural catchment areas (Water safety plan manual: step-by-step risk management for drinking-water suppliers, 2023). To address these, the WSP framework has been adapted to involve multi-level teams focusing on implementation, support, and stakeholder collaboration, demonstrating how the approach can be customized to tackle local challenges effectively. The outcomes have been promising, with advancements in risk management, improved water safety in rural and urban areas, and increased awareness through academic institutions' incorporation of WSP concepts in curricula (Jayaratne, 2020). The implementation of WSPs in Sri Lanka not only ensures safe drinking water but also brings socioeconomic benefits to vulnerable communities, like those in tea plantations, ultimately supporting health, economic stability, and improved quality of life.

1.2 Background

Most of the tea plantation areas in Sri Lanka are located in rural areas where people consume surface water as their main drinking water source (Chandrathilake and Silva, 2011) . Therefore, the application of Rural Water Safety Plans (RWSP) through catchment management is paramount in protecting water resources as these tea plantations are located within the river catchments that account for 2/3 of the drinking sources in Sri Lanka. Moreover, tea exports contributed 14% to the Sri Lankan economy catering to 19 % of the global demand. Thus, assuring the community health in the tea plantation sector is essential to the tourism industry, and social and economic prosperity. WSPAU made several attempts to introduce and implement pilot WSPs in the tea plantation based RWSS in Glassaugh tea estate financed through the WaSSIP project for the first time in Sri Lanka. However, all the attempts made by following WSP guidelines failed. As reported previously, the application of RWSP to the CBWSS faces different challenges compared to the urban water supply sector. Challenges unique to rural and community WSPs have been reported in India, Bangladesh, Japan, New Zealand, South Africa as well as in Taiwan (Summerill *et al.*, 2010; Summerill *et al*., 2011). Poor top management, community involvement, different organizational structures, stakeholder relationships, and quality certifications have been identified as contributing factors hindering the WSP process (Summerill *et al*., 2011). However, these impacts have not been quantified to develop

targeted remedial actions (Summerill, *et al*., 2010). However, none of those studies did propose any numerical method for tracking and solve the difficulties.

The uneducated community in the Glassaugh tea estate was not prepared to learn WSP theories by sitting in one place for hours. Active participation from stakeholders was also not at a satisfactory level from the beginning. The challenges in WPS implementation are execrated by the century-old tea plantation administrative structure imposed during the British colonial establishment. Therefore, to overcome the social, cultural, and administrative barriers hindering the RWSP implementation, an evidence-based approach is warranted. The outcomes of this study are the first step to systematically breaking the barriers for a healthy community within the tea plantation sector in Sri Lanka.

2. Methodology

For the first time in Sri Lanka, from the year 2018, the chlorinated pipe-borne water supply has been introduced to the tea plantation sector funded by WaSSIP. Earlier, plantation sectors' water supply schemes benefitted either with partially treated or untreated water. The community in the Glassaugh Tea plantation, located in the Nuwara Eliya District of the Central Province (Figure 1) consumed untreated water. It was noticed that the implementation of WSP in Glassaugh Estate failed mainly due to community was a difficult task as they were working in the tea plantation during daytime for daily wages. The management is also reluctant to release a considerable number of labourers at once to any other task. Poor communication was another dominating barrier to transferring the message effectively to the community.

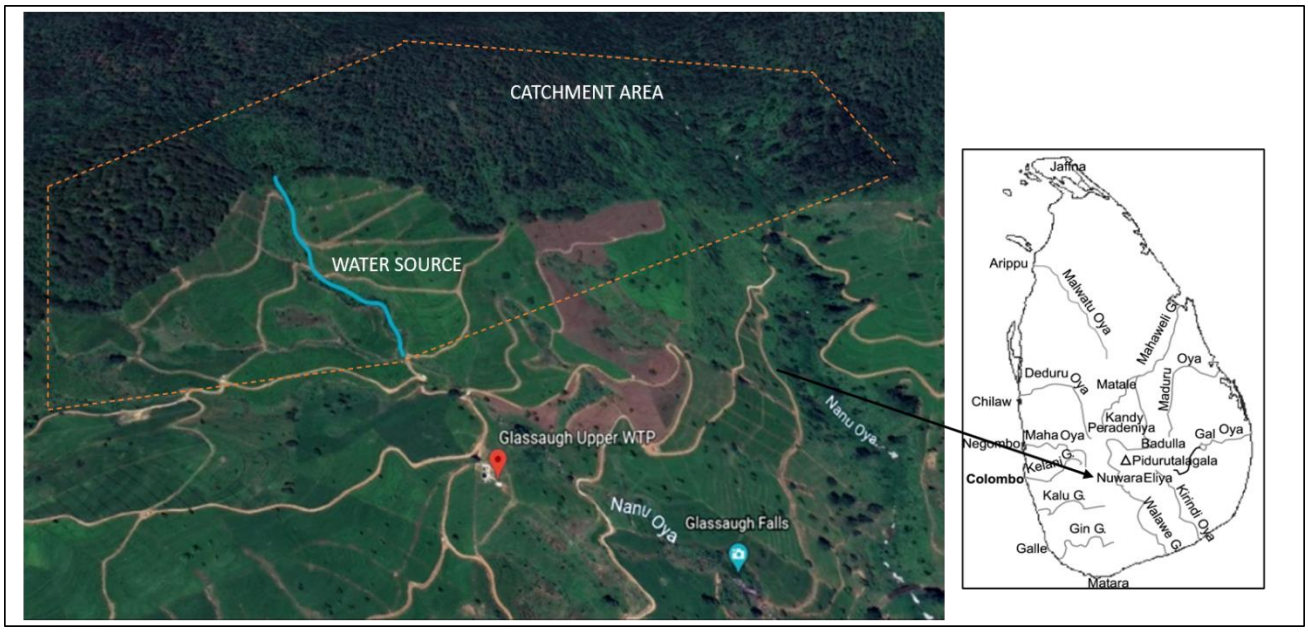

Figure 1: Location map of Glassaugh Water Treatment Plant

For the Glassaugh Estate, a water treatment plant (WTP) consisting of intake, roughing sand filter, slow sand filter, pH correction tank, and chlorination units were built under the WaSSIP Project. As planned, the WaSSIP project initiated as a Community Based Organization/ Water Uses Committee which will be responsible for WTP operations and maintenance. This was done at the starting stage of the WTP construction. Thereafter, WSPAU created the WSP team and started training people to implement WSP in the CBWSS.

However, the term chlorinated and treated pipe-borne water became novel experiences for the WSP team and stakeholders, due to the poor hygiene and related practices in the Tea estate, the application of WSP to the WSS became essential. Thereafter, from the design of WTP, WSPAU attempted to apply RWSPs by following the WHO's RWSP guideline described in Figure 2, though it kept failing.

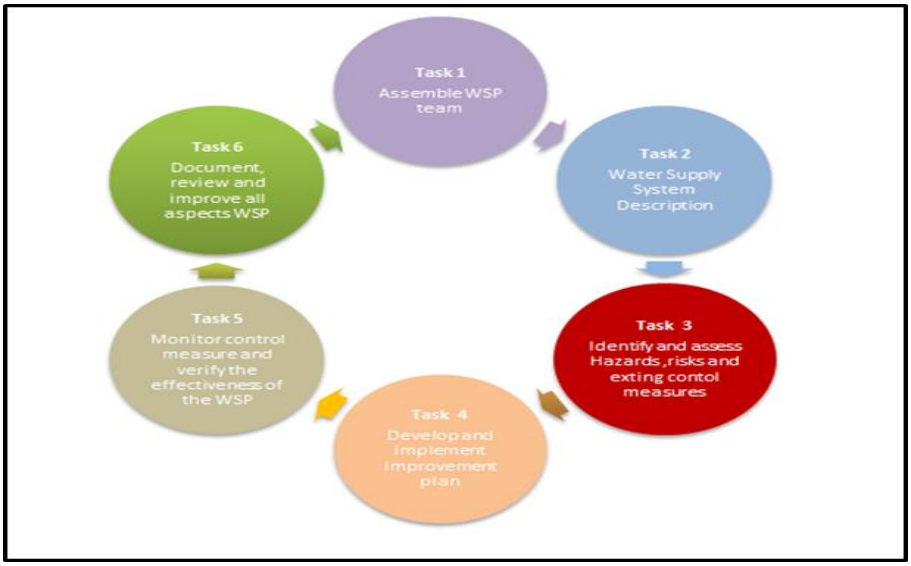

Figure 2: Six modules of rural water safety plan approach introduced by WHO

To track down the root cause of the continuous failure of the RWSP application, the intrinsic case study approach was used. It was used to obtain a multi-faceted understanding of the WSP implementation process.

This approach is widely employed in a variety of research disciplines, particularly in the social sciences (Crowe, Cresswell, *et al*., 2011). The intrinsic case study, which is also known as the naturalistic design is the best to describe a real-life phenomenon to identify a root course of an issue(Zainal, 2017; Crowe, Cresswell, *et al*., 2011). Accordingly, three steps process was used to identify the causes of WSP implementation failures as described below.

- SWOT Analysis
- Questionnaire Survey
- Statistical Analysis
- Frequency Analysis
- Spearman Correlation Analysis

2.1 SWOT analysis

The SWOT analysis was undertaken to systematically identify factors contributing to the success or limitations of Water Safety Plan (WSP) implementation in Rural Water Supply Schemes (RWSS). In RWSS, key operational tasks, including maintenance activities and bill collection—are managed by members appointed by the Community-Based Organization (CBO) or the water users committee. Members of the CBO, such as the plant operator, meter reader, and caretaker, are integral to daily operations and are compensated through funds collected within the community. The plant operator, meter reader, and caretaker are members of the CBO and are paid by the same.

The data for the SWOT analysis was collected from focused group discussions with diverse stakeholders, the community, the WaSSIP project team, and the RWSP team, established (Table 1). Field observations, project team experiences, and feedback from the RWSP team further supplemented the SWOT findings. Additionally, social and environmental screening reports from the project were utilized as secondary resources to provide context and support the analysis. Based on the SWOT analysis below 12 leading factors were used for further analysis. Accordingly, to ensure the SWOT analysis was inclusive and representative, sample demographics covered a broad range of participants from the WSP team.

1. Involvement of Top Management (ITM)
2. Availability of Financial Support (AFS)
3. Organizational Structure (OS)
4. Regulations & Quality Certifications (RQC)
5. Similar Cultural Practices (SCP)
6. Poor Community Awareness & Learning Culture (PALC)
7. Communication Barrier (CB)
8. Poor Sanitation & Hygiene (PSH)
9. Poor Stakeholder Relationship (PSR)
10. Inadequate Resources & Skills (IRS)
11. Lack of Accountability (LA)
12. Clustered Community (CC)

Table 1: The composition of the water safety plan project team

Team	Members
Advisory Team	Chief Engineer - WSPAU
	Senior Chemist – WSPAU
	Senior Hydrogeologist
	Senior Health Manager – WaSSIP
	Sociologist -WSPAU
	Environmental Officer - WSPAU
	Engineering Assistant - plantation human development trust
	Technical Officer – (PHDT)
	Environmental Officer - WaSSIP
	Public Health Inspector
	Estate Manager
	Estate Medical Officer
	Engineer – WaSSIP
	Engineering Assistants – WaSSIP
	Sociologist - WaSSIP
Stakeholder team	Divisional Secretary
	A representative from the Local Authority
	Divisional Forest Officer
	Central Environment Authority
	A representative from Natural Disaster Management Centre
	National Building & Research Organization
Implementation Team	Caretaker – WSS (plant operator)
	Meter reader
	Child Development Officer
	Estate Welfare Officer
	School Principal

	Youth leaders
	Field officer
	Committee Members (05)
	Community Development Assistant - WaSSIP

2.2 Questionnaire Survey

As the SWOT analysis does not provide grounds for an analytical means to identify the relative impact of factors (Mainali, Ngo, *et al*., 2011), a questionnaire survey; a commonly used research tool for the rapid collection of data from a population under a study (Hewitt, Hernández-Jiménez, *et al*., 2017) was used to gather an in-depth perspective for each factor and undertake the quantitative analysis. To quantify the data from the questionnaire a Likert analysis was undertaken. The five-point Likert scale adopted for this study is (1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly agree.

A sample of 30 comprising members of the WSP advisory team, stakeholders, and the RWSP implementation team was interviewed through the questionnaire survey. The purpose of the questionnaire was explained to the respondent by a surveyor with the help of a translator as multi-language (Sinhala, Tamil, and English) cultures were found on the plantation. The surveyors visited some of the respondents who were in different places and in some cases, small group meetings were also held. For the collected data, statistical techniques Tea estate. Analysis of mean, standard deviation, frequency analysis, and correlation analysis was performed for the collected data. The relative frequency of each factor was determined by Frequency analysis (A tabular summary of data showing the number (frequency) of observations in each of several non-overlapping categories).

The Spearman correlation was selected as it is particularly suited for evaluating monotonic relationships between variables, especially when data is ordinal or non-parametric in nature. In this study, variables like perceived water quality improvements, health impacts, and socioeconomic factors are often ranked or do not meet the assumptions of normality required for Pearson correlation. By employing Spearman correlation, associations between these variables without assuming a linear relationship was assed. Spearman's method also demonstrates robustness against outliers and can provide reliable insights in cases where relationships between variables may be influenced by external, non-linear factors, such as seasonal changes or variations in water quality across different regions. This makes it an ideal tool for environmental and community-based data, as it increases the reproducibility and validity of the study's findings under real-world conditions. Data analysis was performed using statistical analysis packages like RStudio (Version 1.1.463) and Minitab 16.0.

3. Results and discussion

3.1. SWOT Analysis

The internal (Strengths, Weaknesses) or external (Opportunities, Threats) factors identified in the analysis are shown in Figure 3. Based on SWOT analysis, it was identified that both strengths and opportunities can be considered as bridges to implementing the WSPs whereas weaknesses and threats are barriers to implementing the WSP in this estate. However, available strengths were used to overcome both weaknesses and threats. Mainly, the involvement of top management was significant as they can pressurize the Estate WSP team and community directly and indirectly to overcome their weaknesses.

The WSPAU team had to develop its strategy to communicate the idea and importance of the WSP to the Top management as their common goals are different. One of the key goals of the tea plantation sector is to be certified by the Rainforest Alliance (RFA) as it raises the reputation of the plantation company as a sustainable tea producer. RFA is an international standard carried out to ensure sustainable agriculture and farming (Highlights of the Rainforest Alliance's Global Sustainability Efforts, 2017). It monitors the economic, social, and environmental sustainability of rural communities engaged in the agricultural sector

and evaluates compliance with their auditing standards before offering the certification. Hence, the WSP is aligned with this RFA goal of estate management to strengthen the environmental and social sustainability within the utility.

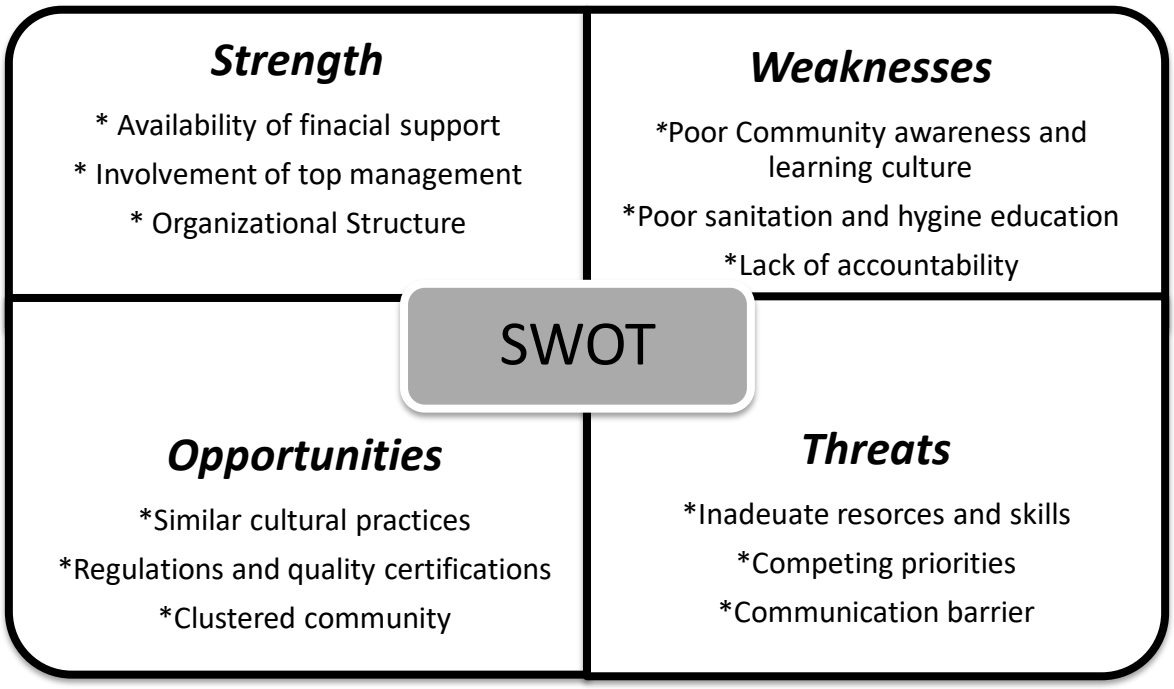

Figure 3: SWOT analysis for water safety plan external and internal environment analysis

3.2. Correlation analysis

The Spearman correlation analysis was conducted to identify the relationship between the 12 variables (Figure 4). Strong significant relationships were observed between the lack of accountability and inadequate resources and skills ($\rho = 0.74$, $P = 0.00$). Therefore, the WSP team may neglect their responsibility due to insufficient physical resources such as construction materials to carry out WSP improvements. In the same way, unskilled human resources may reflect a lack of accountability. Moderate correlations were observed availability of financial support with inadequate resources, skills ($\rho = 0.69$, $P = 0.00$) and with poor community awareness and learning culture ($\rho = 0.63$, $P = 0.00$). Having strong financial support is essential to acquire resources and skills, where it is lacking. Similarly, Financial Support is important for community awareness as awareness and knowledge can be improved through various training activities that require financial support. The moderate relationship between lack of awareness and lack of resources and skills can be justified by the fact that; if the community is unaware of the importance of water safety, they do not try to acquire physical resources to improve their water systems. In terms of human.skills, people with poor learning cultures will not try to be skilful human resources to improve WSP activities.

3.3. Questionnaire Survey

The survey results are presented in Table 2 and responses were illustrated in Figure 5. Accordingly, the areas where the WSP team should have focused and improved were prioritized. ITM, OS, PSH, CB, and PALC factors were identified as key areas to which the WSP team should pay attention. Figure 5 shows the level of responsiveness of both positive and negative factors, respectively. According to those figures, the majority of the respondents agreed with the given factors. The WSP concept was introduced at the construction stage of the WSS, and the risks pointed out by WSPAU were accepted by the WaSSIP project. They started the necessary physical improvements to mitigate the risk, while holding the catchment protection activities until the WSP team gets prepared. Once the WSP team was formed, all the catchment development activities (tree plantation, silt trap development, buffer zone management, and display of

awareness boards) were successfully completed by the community and plantation management with the support from the stakeholders. It was the strategy implemented.

Community and Cultural Context

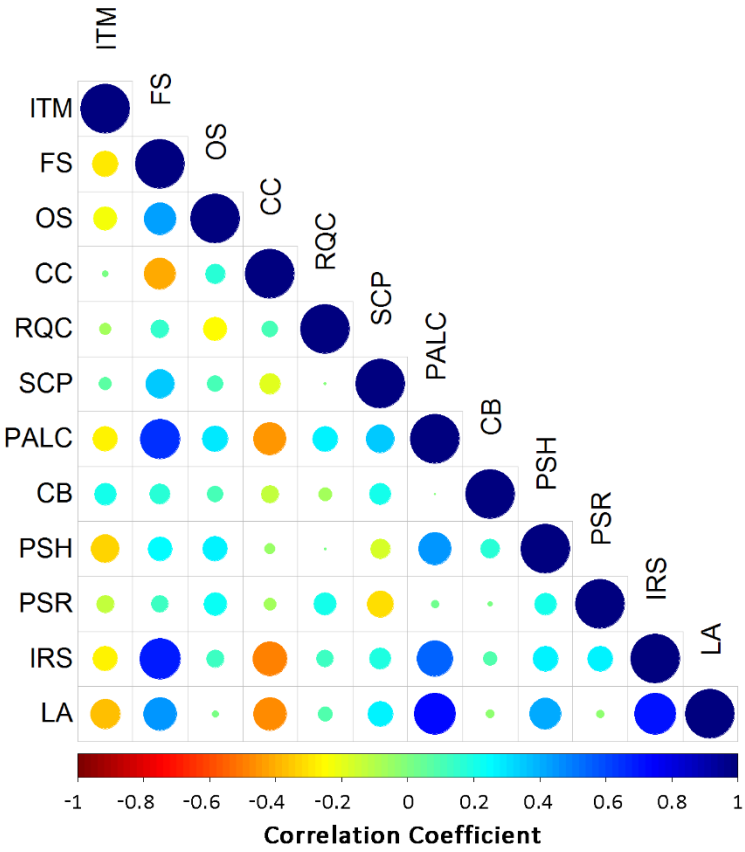

Figure 4: Spearman correlation coefficients among the Likert scale variables

As per the Table 2 data, as identified, in the tea plantation communities, several cultural factors influence the engagement and effectiveness of WSP implementation. These communities tend to follow a simple, day-to-day lifestyle where immediate earnings and personal leisure hold higher importance than long-term health and environmental considerations. The emphasis on daily wages, rather than future health risks or environmental preservation, lead to a lower priority placed on proactive measures like WSPs. Additionally, entertainment and social gatherings are deeply rooted in plantation culture, further highlighting the need for creative and culturally resonant methods to communicate the importance of WSP activities. The correlation analysis described in section 3.2 too revealed significant links between resource availability, financial support, and community awareness. For example, a strong positive correlation ($\rho = 0.74$, $P = 0.00$) was observed between lack of accountability and inadequate resources and skills, suggesting that the community's sense of responsibility may wane when resources are insufficient. Similarly, a moderate correlation between financial support and inadequate resources and skills ($\rho = 0.69$, $P = 0.00$) highlights that robust financial backing is crucial for acquiring necessary resources and building skills. To address these issues, WSP awareness efforts should incorporate visual, relatable education methods, such as picture-based storytelling, videos, and culturally familiar approaches like street dramas. Reinforcing the benefits of WSP

through field observations, sharing past incidents, and small-group discussions within clustered communities can help overcome language barriers, foster understanding, and strengthen social bonds that support WSP activities.

Policy Implications

Policy recommendations for WSP improvement should focus on structured management involvement, accountability, and targeted training. Given the importance of accountability highlighted by the correlation between lack of accountability and resource shortages, policies should establish advisory committees, periodic audits, and active top-management participation. Integrating WSP roles into existing organizational structures can support accountability and effective communication.

Financial resources are also essential; hence, securing external funding and linking WSP goals with quality certifications can ensure ongoing support. Addressing language and cultural barriers by using bilingual personnel and culturally relevant teaching methods will make communication more effective, while repeated training sessions with visual aids can foster a culture of learning. Moreover, peer-led accountability and community involvement in WSP activities will be strengthened by localized, clustered awareness sessions that align with the community's structure. Finally, addressing skills shortages through continual training and involving educated community members will build long-term capacity for WSP management.

Table 2: Results of the questionnaire survey

No	Factors Influencing WSP Improvements	Response (%)					Results	Recommendation
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
01	Involvement of top management (ITM)	0	0	0	67	33	The majority of respondents agreed that the involvement of top management is helpful for WSP implementation. Managers must regularly ensure their commitment is being communicated to the employees as it is a motivation for the community (Flin, 2003).	Regular monitoring of WSP and the participation of managers to review and revise is essential.
02	Organizational Structure (OS)	0	0	0	53	47	The Tea plantation's top management itself already has a properly built chain of commanding, reporting, and communication. Therefore, the same can be utilized in WSP implementation.	Direct inclusion of WSP to the line of command and authority maintained in the plantation organizational structure shall strengthen the WSP improvement.
03	Poor Sanitation & Hygiene (PSH)	0	0	0	57	43	Proper Sanitation & Hygiene obstruct the proper implementation of WSP in this plantation sector. Water and sanitation hygiene (WASH) promotions were conducted at the initial stage; despite no change in prevailing habits	The periodic monitoring, water quality testing, and awareness by the estate medical officer and public health inspector shall exert control over the situation.
04	Communication Barrier (CB)	0	0	3	50	47	The awareness sessions become less attractive to the community due to the time taken to translate. The strength of the language barrier can reduce to some extent with the application of prop as described in factor PALC.	The use of resource personnel fluent in both languages shall be most effective.
05	Poor Community Awareness & Learning Culture (PCALC)	3	3	0	53	40	Listening to awareness sessions, training, workshops, and group activities was a new experience for them. Therefore, repeated sessions of training, on-site explanations, and exposure visits, to transfer this message effectively are required.	A preliminary and simple approach using creative tools such as picture depictions, street dramas, videos, and sharing past events are identified as essentials to educate and convince this community. Catchment awareness boards and frequent meetings of committee members are vital to remind the importance of WSP activities.

06	Lack of Accountability (LA)	0	10	0	43	47	The vast majority is agreed that the lack of accountability negatively affects the WSP implementation. Observations showed that the appointed committees are reluctant to complete their duties and escape from the responsibility easily and only the caretaker is left to do every step.	Therefore, adequate post-monitoring and involvement of the advisory committee are essential to avoid such problems. Further, periodic reporting to top management, review, revision, and audits are required to ensure accountability. The involvement of the community in ground-level activities such as catchment protection will enhance the sense of ownership.
07	Similar Cultural Practices (SCP)	0	0	17	53	30	In the plantation culture, people are used to a simple lifestyle based on day-to-day earnings. Entertainment is an integral part of their culture. Hence, the priority levels were significantly different from rural or urban cultures. The prime target of the estate is to profit maximization from tea cultivation. The workers' aim is on their wages. The community is not concerned about environmental or health risks that require immediate preventive actions.	An explanation of risk prioritization, and guide them for field observation to identify risks with past incidents are required.
08	Availability of Financial Resources (AFR)	0	23	0	33	43	The availability of a sufficient amount of financial resources could step up the implementation of WSP in Glassaugh. Some of the risk management measures such as intake and catchment improvement, repairs, and water quality testing required Financial Resources.	As the plantation community is easily drawn foreign attention, development needs can easily be fulfilled through the aid of these external parties. Proper management and allocation of these development funds to WSP improvement shall also be considered important.
09	Regulations &Quality Certifications (RQS)	0	10	13	67	10	These certifications are the extra motivation for the WSP and it enhances the standard of a well-established WSP.	Merging the WSP goals with the scope of the rainforest alliance certificate will ensure the sustainability of WSP.
10	Poor Stakeholder Relationship (PSR)	0	27	3	53	17	Proper involvement of external stakeholders plays a vital role in implementing WSPs because some administrative decisions can be taken against violation of regulations imposed by government organizations such as the forest department, central environmental authority, Natural Resource Management Centre, etc.	Awareness of the stakeholder before WSP introduction, periodic communication, and reporting of status, the participation of stakeholders in WSP review, and the revised process shall be boosted.

11	Clustered Community (CC)	0	33	0	23	43	Efficient communication of a message during an emergency, exchange of duties when necessary, and monitoring of the distribution system easily are some of the advantages of this arrangement. In the same manner, this cluster arrangement is beneficial in the design of a water supply system.	If the mass-scale awareness is not effective small group discussions and awareness sessions can be organized in a nearby location to those clusters
12	Inadequate Resources & Skills (IRS)	3	33	3	47	13	It was observed that knowledge has not been grasped effectively by the community. To avoid such knowledge gaps, continual knowledge sharing, training, and awareness and involvement of external resource persons are important.	Human resources can be strengthened by delivering the WSP knowledge to people with secondary or higher education and also by introducing the concept to school students. Further technical skills shall also be improved by being aware of the students regarding water treatment.

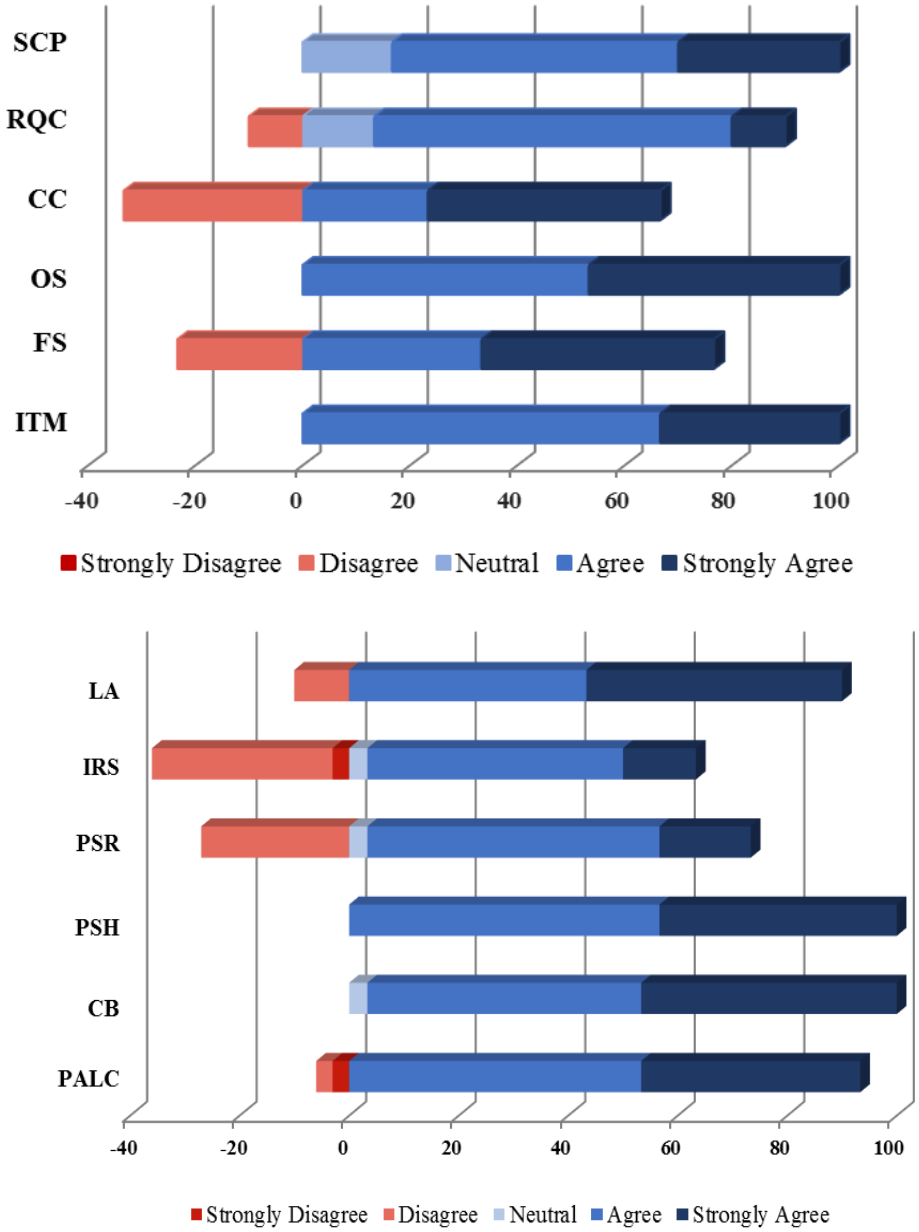

Figure 5: Frequency distribution of the responses received for the pre-identified negative of WSP implementation in Glassaugh Estate (n=30)

4. Conclusion

The insights derived from this study have broader applicability in similar rural or plantation settings where community priorities, cultural practices, and limited resources pose challenges to WSP implementation. The findings underscore that weaknesses and threats identified in the SWOT analysis such as accountability issues, communication barriers, and limited resources can be transformed into strengths and opportunities by addressing the root causes of WSP failures. The positive correlations observed, particularly between accountability, resource availability, and skills, indicate that strengthening one area can have a cascading effect on others, improving overall WSP efficacy. However, some factors, while not

statistically correlated, display significant interrelations in real-world applications, highlighting the importance of holistic strategies.

The results of the questionnaire and correlation analysis point to several impactful recommendations for rural WSP (RWSP) application in the plantation sector such as top management should lead WSP initiatives, leveraging their influence to drive the program's success. The WSP team should use repeated, visually engaging training and awareness sessions to convey WSP knowledge effectively, especially to uneducated community members, with visual aids like awareness boards and posters reinforcing these messages across the plantation. Selecting a highly capable implementation team, assessing their training comprehension, and providing ongoing monitoring will ensure stability in WSP processes. Lastly, recognizing and fostering a sense of ownership among staff is essential for long-term commitment to WSP goals.

Further, by carefully selecting a knowledgeable WSP implementation team, followed by ongoing training assessments, will help maintain high capacity within the team. Additionally, continuous monitoring is essential until stable WSP processes are established, ensuring that staff receive appropriate recognition and a sense of ownership in the project's success. This study highlights that strategic, culturally sensitive, and well-supported WSP programs can successfully engage rural communities, providing a replicable framework for sustainable water safety practices across similar settings.

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