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Research Paper

Sanitation planning for resettlement sites in Laos

Souphaphone Soudachanh [a,*], Günter Langergraber [IWA] [b] and Stefan Salhofer [a]

[a] Department of Water, Atmosphere and Environment, Institute of Waste Management, University of Natural Resources and Life Sciences, Muthgasse 107, 1190 Vienna, Austria
[b] Department of Water, Atmosphere and Environment, Institute of Sanitary Engineering and Water Pollution Control, University of Natural Resources and Life Sciences, Muthgasse 18, 1190 Vienna, Austria
*Corresponding author. E-mail: souphaphone.soudachan@boku.ac.at

SS, 0000-0001-8363-7995; GL, 0000-0003-4334-9563; SS, 0000-0003-0727-1703

ABSTRACT

Hydropower plants have been making both direct and indirect impacts on the environment and society on many levels in Laos as they require people who live in downstream and upstream areas to relocate to new resettlement sites. A sanitation planning process for resettlement sites in Laos is evaluated by an evaluating tool which has been developed according to three international sanitation planning guidelines, namely Community-Led Urban Environmental Sanitation Planning (CLUES), the Sanitation Safety Planning methodology by the WHO, and Sanitation 21. Four resettlement sites were selected, based on their differences in terms of project developers, scales, consultancy companies, and the number of people impacted. All four cases had positive performances in their project preparation and the implementation phases which showed a strong institutional arrangement and high engagement by the stakeholders. However, the technical planning phase was overlooked and given a low priority, the boundary of the systems was roughly defined, and there was no clear support to develop a treatment system for the reuse of wastewater, and no health risk assessment. We propose six concise sanitation planning steps and resource-oriented sanitation for resettlement sites which aim to support project developers' decision-making and planning for sanitation systems in resettlement sites.

Key words: hydropower plant, Laos, resettlement sites, sanitation guidelines, sanitation safety planning

HIGHLIGHTS

- Performance assessment tools can be applied and easily adapted to local situations.
- Simplified sanitation planning steps are developed as a support tool and a link to involve more affected people in a decision-making process.
- Improvement of sanitation safety planning in the resettlement site and opportunity for resource-oriented sanitation.

INTRODUCTION

Laos or the Lao People's Democratic Republic (Lao PDR) is one of the least developed countries in Southeast Asia with a total population of 7.2 million people settled in 18 provinces (World Bank 2019). Approximately 63% of the population lives in rural areas. The Mekong River is valued as the main natural resource for socio-economic development by the populace and provides a wide range of commercial opportunities such as tributary and mainstream hydropower development, the expansion of irrigated agriculture, fisheries, and tourism (MRC 2020).

Major economic growth in Laos is primarily driven by foreign direct investment in agriculture, natural resource extraction, and hydropower plants. With its geographic advantages, the country has great potential for hydropower plant development. According to the summary of the 7th Five-Year National Socio-Economic Development Plan 2011–2015 (MPI 2016), there are 369 hydropower plant project contracts, of which 31 are classed as concession agreements with a total installment of 3,970 MW. Presently, there are 22 projects undergoing preparation for the construction phase. According to the plan, 55 projects were expected to be constructed before 2020 with a total installed capacity of 4,130 MW. This left 234 projects in the feasibility study phase.

In the past century, large dam construction has affected and caused the resettlement of almost 80 million people globally. The dispersion of the resettlement was influenced by a number of factors such as the project cycle, stakeholders, political regimes, and the completion time (Kirchherr *et al.* 2019). In Laos, it was estimated that the number of people who needed to be resettled as a direct impact of hydropower schemes ranged from 100,000 to 280,000 and these people were categorized as the poorest households (World Bank 2010). The affected people (APs) were requested to relocate to new resettlement sites, which would be designed, planned, and financed by the project developers and other stakeholders (PMO 2010).

In Laos, there is still a significant disparity between urban and rural water supply and sanitation. This is because improved sanitation facilities are not a priority among the poor. Although clean water is widely sought, sanitation inequities are significantly greater than present-day water coverage. Vientiane Capital still faces a lack of adequate drainage and sewerage systems and is burdened with the poor design of existing sewerage disposal systems or septic tanks. Only on-site wastewater disposal and minimal treatment facilities, such as pour-flush and septic tanks, are used to treat domestic wastewater (UNDP 2015). Many people in rural areas are not aware of proper sanitation and hygiene procedures. Only 28% of children's feces is safely disposed of, and approximately 24% of the population practices open defecation. (UNICEF 2018).

The resettlement sites provide APs with basic facilities as defined in the project resettlement plan. Despite various supports, sanitation planning still tends to follow established practices. As a result, many initiatives fail due to an unsuitable selection of technology, a lack of ownership, an absence of a political will, and a shortage of financial resources. Another challenge is that local developers and planners have limited knowledge and lack the necessary experience to provide feasible solutions for underdeveloped areas with limited water and energy sources.

In recent times, a number of sanitation safety guidelines have been developed to facilitate practitioners in their planning and implementation. They focus on system selection, understanding the diverse contexts, and have been tested in many developing countries. Resource-Oriented Sanitation (ROS) or Ecological Sanitation (EcoSan) is based on source separation, sanitization, and the reuse of human excreta. Its design reduces health risks related to sanitation, contaminated water, and waste, while optimizing nutrient management and water resources, and preventing surface and groundwater pollution as well as the degradation of soil fertility (Werner *et al.* 2004). While new technologies and system solutions may improve appropriateness, sustainability, and inclusivity, they also add to the planning process's complexity.

Therefore, the aim of this study is to introduce a simplified sanitation safety planning (SSP) including the ROS concept as a decision-making support and planning tool for project developers and policymakers, which can be easily implemented in the context of resettlement sites and improve current sanitation systems. To fulfill this, three international guides for sanitation planning were systematically compared and applied to selected resettlement sites to evaluate and address the current sanitation challenges and introduce suitable planning options.

METHOD

The study's methodology is primarily derived from the literature review, thus incorporating different sources such as international sanitation planning guidelines, project reports especially Environmental and Social Impact Assessments (ESIAs), Resettlement Action Plans (RAPs), Environmental Social Management and Monitoring Plan (ESMMPs), and Social Action Plans (SAPs), research papers, and reports. The study was conducted in four steps which are presented in Figure 1.

The first step is the literature review regarding the state of the art of the current sanitation system and identifying the case studies. Four resettlement sites were selected from four different hydropower plants based on their varying scales, the number of AP, the project developers, and the consultancy companies (Table 1).

In the second step, an evaluation tool was developed to get a better understanding of the present planning approaches and to identify the current systems. The tool was designed based on three international guidelines, namely (i) the SSP methodology from the World Health Organization; (ii) Community-Led Urban Environmental Sanitation Planning (CLUES), and (iii) Sanitation 21. These three guidelines all focus on how to facilitate the different stakeholders to best develop and/or improve the existing sanitation systems. Hence, they aim to create the best practices suitable for the current situation of the locations and the users while also taking into account the availability of associated financial and technology resources (Lüthi *et al.* 2011; Parkinson *et al.* 2014; WHO 2015). Although these guidelines were developed and designed by different organizations, they have distinct similarities in terms of contexts and practices and several divergences in terms of steps and orientation.

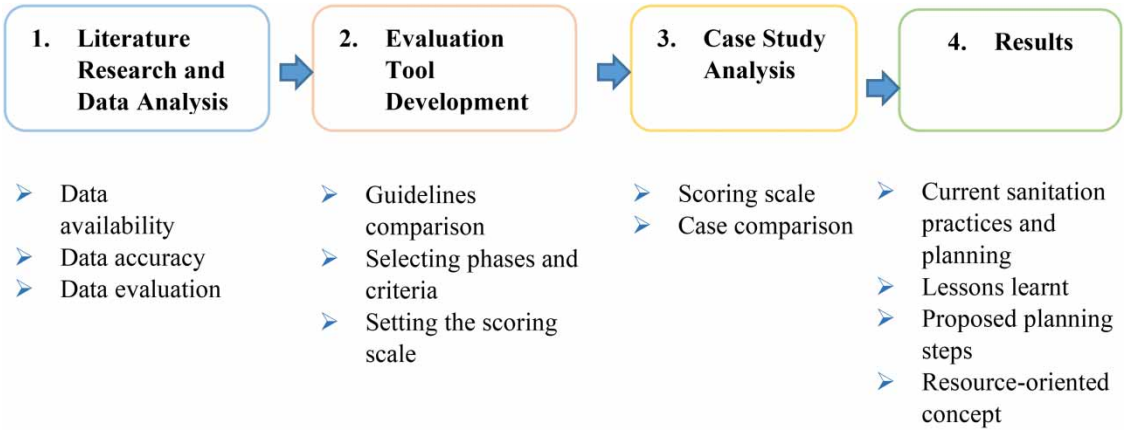

Figure 1 | Research methodology.

The three guidelines were compared, and indicators were selected where similarities and differences were identified. These were then categorized into five planning phases, namely: (i) Preparation Phase; (ii) Sanitation System Boundary Planning Phase; (iii) Technical Planning Phase; (iv) Implementation and Preparation Phase; and (v) Implementation Phase. The evaluation had a total of 26 criteria. The full table used for evaluating the sanitation processes is shown in Supplementary Appendix 1.

A three-point score-based approach was used by the author to analyze the performance of the sanitation planning process for each of the cases and the respective criteria. A score of 0 (factor not presented) was given when there was no factor or information related to the criteria presented. A score of 1 (partially committed) was given when there was information shown in the planning process related to the criteria, but did not include all the relevant parts. For example, the operation and monitoring plan was conducted, but did not specifically cover the sanitation system. A score of 2 (Fully committed) was given when the information included all the relevant parts related to the criteria. Therefore, the degree of fulfilled performance scales ranged from 0 to 52 scores as follows:

- good (scoring from 42 to 52 or above 85%),
- adequate (scoring from 32 to 42 or between 65 and 85%),
- poor (scoring from 22 to 32 or between 50 and 65%), and
- very poor (scoring below 22 or below 50%).

In the third step, the four cases were compared and scored to investigate the sanitation planning patterns and identify room for improvement. In the fourth step, the results were obtained, and the simplified sanitation planning steps were proposed. Subsequent to this, the concepts and examples of ROS were recommended for future planning.

RESULTS

The results are divided into four sections, namely: (i) the comparison of the cases and their performance in the five phases of the planning process; (ii) the current state of sanitation planning in the resettlement sites; (iii) the advantages and disadvantages of the current sanitation planning in the resettlement sites; and (iv) the simplified sanitation planning steps. The scoring results of four cases are shown in Table 2.

Case comparison and the cases' performance in the five phases of the planning process

Phase 1: preparation

Cases 1, 2, and 3 had positive performances in their preparation phase. Their objectives and information were clearly stated and available for public access, although they did not specifically emphasize sanitation aspects. The institutional arrangements were established with very clear definitions for the responsibilities and workloads of each sector. In contrast, Case 4 had a less positive performance because the information was limited and largely restricted from public access. The institutional arrangement was outlined but mostly as a generic scheme for the project management with no clearly specified roles and responsibilities.

Table 1 | Profiles of case study resettlement sites (NORPLAN A.S 2008; NCG 2012; NNP1 2014; THPC 2014; Earth System 2015; NTPC 2017)

	Resettlement sites			
	Case 1	**Case 2**	**Case 3**	**Case 4**
Name of Hydropower Plant (HPP)	Theun-Hinboun HPP	Nam Theun 2 HPP	Nam Ngiep 1 HPP	Nam Phay HPP
Company	Theun-Hinboun Power Company (THPC)	Nam Theun 2 Power Company (NTPC)	Nam Ngiep 1 Power Company (NNP1)	Nam Phay Power Company Ltd. (NPPC)
Capacity	600 MW	1,070 MW	290 MW	86 MW
Shareholders	EDL-Generation (60%), GMS Power (20%) and SN Power (20%)	Electricite de France (40%), Lao Holding State Enterprise (25%) and Electricity Generating Public Company Limited (35%)	KPIC Netherlands, a subsidiary of Japan's Kansai Electric Power (45%), EGAT international of Thailand (30%) and the Lao Holding State Enterprise (25%).	China-based Norinco International Cooperation Ltd.; (85%) and Electricite du Laos (15%)
Environmental and Social Consultancy	Norplan	NTPC*	Earth Systems Group	Safe; NCG
Number of APs	1,107 APs	6,289 APs	3,000 APs	866 APs
Location	Hinboun District, Khammouane Province	Nakai District, Khammouane Province	Bolikhan District, Bolikhamxay Province	Longchaeng district, Xaysomboun province
Water Supply and Sanitation	• ensured clean and sufficient domestic water supply all year round • built toilets and bathrooms on each house plot • toilet size is about 1.56×2.5 m • included a water tap, a shower water storage tank and toilet bowl	• provided all year access to water and an advanced drainage facility • distribution system to supply water to house/farm as well as to irrigate rice fields • one groundwater hand pump linked to a bore per every five households • Each house has a permanent bathroom with a pour-flush latrine and a septic tank • ensured the water quality of the bores by regularly monitoring and testing them	• provided each household with two water taps fed by gravity and a filter system • constructed a toilet • Septic tanks of brick/concrete were provided for wastewater • a solid waste disposal area with 1.5 hectares including 6 pits with the dimensions Width 35 m×Length 15 m×Depth 3 m	• new water system and/or the improvement of the existing system • one tap for every 10 households • constructed a pour-flush latrine of appropriate size for each household
Relocation period	2013–2017	2006–2008	2015–2017	2015–2017

*It is represented by the company.

Table 2 | Scoring results from the evaluation tool for the four case studies

Case	Overall (Max: 52)	Phase 1 (Max: 8)	Phase 2 (Max: 12)	Phase 3 (Max: 14)	Phase 4 (Max: 12)	Phase 5 (Max: 6)
C1	36	7	9	6	8	6
C2	39	7	10	8	8	6
C3	35	7	9	6	7	6
C4	33	6	9	5	7	6

Phase 2: sanitation system boundary identification

Case 2 had the most positive performance for its sanitation system boundary identification. The primary and secondary data were well collected and arranged by the consultants, although not specifically for the sanitation aspect. Nevertheless, it was adequate to cover relevant criteria such as water resources, irrigation, and water quality management and monitoring. The sanitation system was mapped along with the water supply line and the irrigation system. The laws and regulations were listed, and there was also guidance from the WHO. For Cases 1, 3, and 4, the studies and data collection were also conducted by consultants; however, the assessment was primarily focused on the main environmental and social impacts of the hydropower plant and means of mitigating negative effects. The planning for the resettlement sites emphasized the measures taken for compensation and livelihood development, while the sanitation aspect was not a priority concern.

Phase 3: technical planning

It can be clearly seen that all four cases had challenges and difficulties to meet in their sanitation planning process for the technical planning phase. The development of the sanitation system in terms of the entire value chain, treatment, disposal, and the reuse of wastewater including the health risk assessment of hygiene and sanitation were absent in the planning process. The bulk of the technical planning was dedicated to housing and resettlement sites' layout, which were mandatory components in the infrastructure and facilities stipulations. The sanitation aspect was only included in the small section regarding the water supply system, built-in toilets with septic tanks, and water quality monitoring (which was mainly for the water in the hydropower plant areas). Besides this, there was no prompt technical planning for building the waste management system such as a waste treatment plant, fecal sludge management and treatment, wastewater treatment, and resource-oriented sanitation for agricultural purposes.

Phase 4: implementation preparation

This phase was one of the most difficult for evaluation because there was no precise evidence to show that prior to the implementation where each case had done a reevaluation of their plans and budgets. However, within the project management scheme, there was a resettlement site committee in four of the cases. It was responsible for reviewing the reports, progress, quality management, project performance, and all related activities. For this phase, Cases 1, 2, and 3 had a clearer institutional arrangement than Case 4, as their performance fulfillment received higher scores. Apart from this, all cases had operating and monitoring plans but they were not specifically for the sanitation system.

Phase 5: implementation

All four cases fulfilled the criteria for the implementation phase. The construction plan was planned, designed, and reviewed before the implementation. The recruiting process went through the tendering procedure to ensure transparency and the most suitable contractor/sub-contractor for implementing the project. All four cases fulfilled the public participation aspect prior to and after implementation by conducting project consultations and organizing the inauguration ceremony to summarize the projects' outcomes and to build awareness of the different topics including the livelihood development program for the AP after moving to the resettlement sites.

Current state of sanitation planning in resettlement sites in Laos

SSP has a low priority in the project development process. The planning mainly focuses on water supply and irrigation to ensure water quality and prevent water scarcity in the resettlement sites. Basic sanitation that was introduced such as toilets designed with pour-flush latrines and septic pits was for housing units and community usage rather than individual households. Many technical aspects are still missing from the planning phase particularly with regard to sanitation waste collection, treatment procedures, monitoring, and maintenance. Despite this, additional capacity building such as the water, sanitation, and hygiene (WASH) program was often conducted after the relocating period. Table 3 summarizes the positive and negative aspects of the current sanitation planning practices for the resettlement sites.

Simplified sanitation planning steps

To facilitate the planning process for developers of resettlement sites in Laos, the most important planning steps were selected and streamlined to make them easy to implement, adjust, and follow for first-time users. The simplified sanitation planning steps are displayed in Figure 2.

Table 3 | Advantages and disadvantages of current planning practices for resettlement sites focusing on sanitation planning

Positives	Negatives
• Resettlement regulations and procedures are available, which partially cover the sanitation aspects and health risks of the APs • A strong engagement between institutional agencies and stakeholders is practiced in the public consultation process, with the data collection being carried out on an interview-based technique • There is a clear basis for the process given through the description of responsibilities and duties for each sector • To be able to build awareness for the APs, and the communities in the project areas • The basic water supply, irrigation systems, and the basic use of toilets were presented with consideration of the current context • Provision of the necessary capacity building programs for sanitation awareness and management	• Lack of sanitation data • Low priority and insufficient budgeting were given to sanitation planning • Lack of sanitation planning guidelines and regulations for the entire sanitation system, wastewater, and fecal sludge management • Lack of further development plans for the technical aspects of the sanitation system • No consideration for the utilization of ROS • There were no health assessments and no identification of potential exposure groups in the value chain

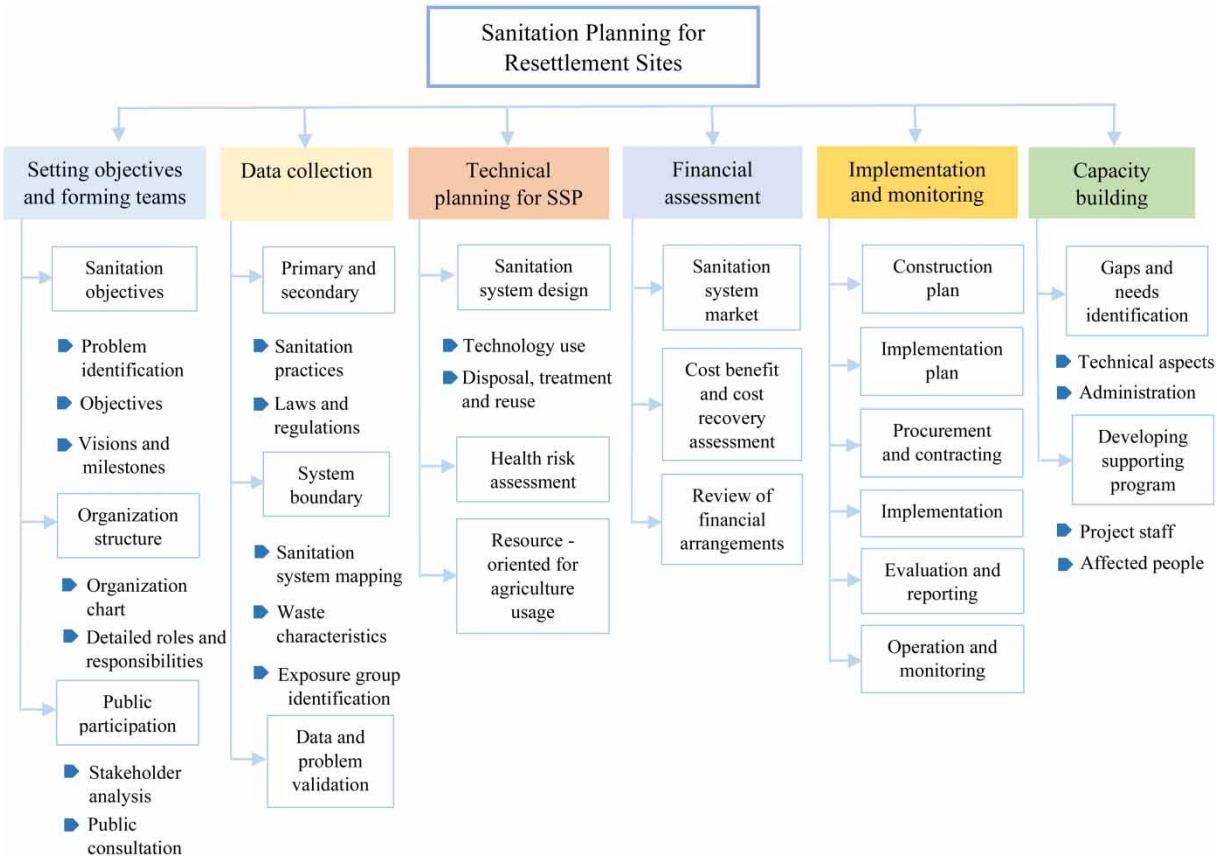

Figure 2 | Proposed sanitation planning steps for resettlement sites.

Setting objectives and working teams

The first important step for achieving successful sanitation planning is to define the objectives, conduct a stakeholder analysis of the sanitation system, and establish the working teams to carry out the project activities. The objectives can be varied depending on the conditions of the resettlement site, but it is critical to focus on how to improve the quality of the sanitation

system. This concerns the safety and quality management for both formal and informal settings of waste collection and treatment. In addition, they determine whether or not to reuse human waste in agriculture, as well as means to improve public health. The objective can be adjusted to be more appropriate for the local conditions and the priorities of the sanitation scheme.

The stakeholder analysis is one of the most important components of gathering and analyzing information about various stakeholders involved in the SSP process. To ensure the project's productivity in planning and implementation, an institutional arrangement must be established with clear details for responsibilities and roles. This consists of, but is not limited to, collaboration of the board management team, the coordination team, the management team, team leaders, task leaders, and multi-stakeholder teams.

Data collection

One of the most crucial stages of sanitation planning is data collection. It is a means of collecting and analyzing primary and secondary data which are most relevant to the sanitation aspect of the study areas. These encompass existing laws and regulations, the control and mitigation measures, the mass-flow of the sanitation system, mapping the system boundary, identifying waste characteristics, recognizing potential exposure groups, determining the transmission routes, assessing the willingness of the target groups, gauging the feasibility of implementing resource-oriented sanitation, and enhancing the capacities of the communities in the areas.

To identify the appropriate mitigation measures, the project must fully understand the relationships between the individuals who associate with the system and the sanitation system components themselves. Furthermore, this is a necessary foundation for analyzing and providing the best feasible solutions for future sanitation system decision-making.

Technical planning

The APs, the neighboring communities, and the long-term potential of urban development will all benefit from deciding which type of sanitation system the resettlement site will develop. The development of an effective treatment plant, the control of the disposal routes, and the reuse of sanitary waste will require a significant amount of technical planning and assessment, especially if it is first hands-on experience. As they are directly related to human health and different players in the food chain, this approach necessitates comprehensive technical planning of the treatment system and a health risk assessment. These must be properly prepared and conducted with appropriate measures by specialists. As the livelihood and income development plan for the APs in previous resettlement sites was mainly focused on the agricultural base, it is recommended that developers consider resource-oriented sanitation for agricultural and/or aquatic usage.

Financial assessment

Following the discussion, design, and planning of the sanitation system, which may include the consideration of other choices, the budget must be determined and reviewed to guarantee appropriate costs and cost–benefit efficiency. The project developers and other stakeholders will examine the facts gathered and possible scenarios before making a final decision. For budget estimation, it is necessary to consider the sanitation market pricing in nearby areas, possible suppliers, products, and the technology available in the immediate region, and, if necessary, the international market. It is suggested that developers investigate the potential market opportunity for ROS toward agricultural use, which could be a future source of income for APs, and could attract and encourage APs to become more actively involved in system maintenance after the resettlement period ends.

Implementation management and the monitoring measures

Once the sanitation system is selected, the implementation and construction plan as well as operational and monitoring plan are developed. It is advisable that the tendering process be employed for the procurement and the contracting/sub-contracting companies. This will allow the project to have a greater choice of the most suitable and experienced companies/contractors. There will be different levels of operations and monitoring for sanitation systems, which will involve technicians and associated skilled workers, who for example need to monitor the frequency of waste collection, the flow rates for waste applications, and conduct sanitary surveillance of the physical, chemical, and biological aspects.

Capacity building

To keep the sanitation system running, a lot of effort is required, as well as qualified staff with a basic understanding of system maintenance and practices for monitoring the system. It is essential to identify the gaps and the needs within the sanitation

system and to find the best mitigation measures and create a sustainable sanitation system. The capacity building program will include technical and administrative training for project workers as well as people in the resettlement site who will be in charge of operating the sanitation system in the future. These programs include a basic knowledge of sanitation, WASH, safe drinking water, sanitation system maintenance in the household unit, and how to reuse sanitation waste for agricultural usage on small and large scales. The training of trainers must be conducted, and a training center should be established within the concerned communities.

DISCUSSION

The current sanitation planning strategy does not consider all aspects of the sanitation system, including technical sanitation design, storage, collection, treatment, disposal, safe reuse, monitoring, and maintenance. The sanitation data baseline presents a significant challenge, as there is very limited data available, and it is largely outdated. Authorities and developers are unwilling to invest time and resources in planning as it is very time-consuming and the expected returns are not top priorities for the resettlement sites' development.

In previous years, there were a number of frameworks and tools established trying to fill in the gaps and overcome these sanitation challenges, especially in developing countries searching for cost-cutting engineering solutions to make these technologies more accessible and inexpensive (BMGF 2021).

Domini *et al.* (2017) applied the WHO SSP and CLUES methodologies in Iringa, Tanzania, in order to develop an SSP for improving the sanitation system in peri-urban areas. This study showed that the methodology assisted the research team to identify the in-depth condition of the sanitation system in the areas and hazardous event identification. Moreover, it helped to prioritize health protection and promote resource recovery.

The WHO SSP is very flexible and adaptable to local situations and needs. It was shown that even in low-income setting countries or cities, reducing human health risks can be easily feasible when combining different measures (Winkler *et al.* 2017).

However, most of the current research focuses on analyzing the existing condition and picking a preferable alternative, assuming that a suitable collection of sanitation system decision options is already available. Engineering consultants are frequently tasked with identifying locally relevant sanitation system planning choices. As a result, there are several flaws in such a knowledge bias. When asked to assess a vast and diverse range of sanitation technologies and systems, consultants are frequently found to be unfamiliar with novel possibilities, lacking statistics on their effectiveness, and are overwhelmed with the tasks assigned to them. It is recommended to have all stakeholders present throughout the planning process (Spuhler & Lüthi 2020).

Completing a comprehensive sanitation strategy can take a long time, particularly in developing nations with inadequate data, budgeting, and human resources. It takes around 18 months to implement the complete planning process using the CLUES framework. For example. Mtika and Tilley (2020) took 22 months to apply the entire process for CLUES in a small Malawian town. It is very time-consuming and expensive to follow the entire process as outlined. The researchers in this case suggested a simplified version that could be conducted on smaller-scale sites to put a focus on finding gaps, needs, and priorities which are beneficial for addressing the environmental sanitation issue as well as the long-term planning activities.

Results of this study also show that the guidelines approach can be adapted and combined to be most suitable for the local setting. Conducting the SSP for a resettlement site in Laos may be difficult and require extra time, effort and budget at first, but it can also be conducted in parallel with the project's ESIA and RAP. These studies proceed along similar lines and they can support the long-term development and improvement of environmental and human health in the project setting. Furthermore, the resettlement site will already have a supportive foundation as there are existing control measures and monitoring systems. This means risk assessments can be easier to be implemented compared to general public settings (Jackson & Vuong 2014).

The simplified planning steps will support the project developers and practitioners to organize resources and activities efficiently and effectively. It helps them to stay focused on the objectives and find solutions that meet people's needs and legal requirements set by government agencies. Additionally, the planning steps will serve as a basic guideline to support decision-making for the best available and affordable choice of a sustainable sanitation system.

In the fast-growing communities of developing countries, there is limited access to clean water, water supplies, and sanitation, as well as the extra burden of food scarcity, thus sustainable urban planning is needed. The resettlement sites for

the hydropower projects in Laos have the potential to develop new settlements for the APs, which is a great opportunity to build more sustainable and environmentally friendly water supplies and sanitation systems.

Introducing the ROS concept in the resettlement communities will provide positive impacts on APs and people living at the community level such as health benefits from the safe utilization of an adequate sanitation system, the beneficial use of waste nutrients to increase food production, and the production of organic compost fertilizer to supply to local markets. These advantages will enable them to generate more income. The technology used can be selected from a wide range of available modern and traditional technical options which can be combined with the ROS system. To make it work, the system needs to be affordable, suitable, and acceptable with cultural and social values, easy to use in practice and in maintenance, and to be as comfortable as conventional systems (Langergraber & Mullegger 2005).

A shortcoming of this study was that it was based on an analysis that used only three sanitation guidelines and frameworks (WHO SSP, CLUES, and Sanitation21) which could indicate a risk by lacking comprehensiveness in sanitation strategic planning, background information, and the consideration of uncertainties. It is worth exploring additional information packages such as the 'Compendium of Sanitation System and Technologies' for a holistic collection of technical sanitary options (Tilley *et al.* 2014). Apart from this limitation, the simplified framework can provide developers with a starting point to collect data and implement SSP in the future.

CONCLUSION

This study gives an overview of the current state of sanitation planning in the resettlement sites, where it identifies the challenges, gaps, and needs to put strategic planning into practice. The existing sanitation planning strategy does not fully reflect the entire sanitation system including technical, social, and environmental components. One major stumbling block is that authorities and developers are unwilling to devote time and resources to comprehensive planning.

Therefore, to improve the planning process of the sanitation sector for the resettlement sites, this study introduced six simplified SSP steps to support and serve as an initial indication in the planning steps for project developers and decision makers. It has taken the perspective of resettlement sites into account and suggested planning steps that are precise, systematic, and flexible. Additionally, it recommends to consider applying planning tools and examples from the three international guidelines as they have been tested in many developing countries, and been found to be practical and user friendly. Resource-oriented sanitation approaches should be one of the essential considerations for long-term city planning since they benefit not only community health and the environment, but also contribute to community income and food security.

To provide safely managed sanitation in developing countries such as the Lao PDR, better decision-making and planning approaches are required. Since the population is continuing to grow, proper infrastructure is needed as it will ensure the good health and well-being of the people living in and around development zones. The prevention of dangerous diseases not only benefits those who are affected by the hydropower plant projects but the wider population as a whole. Moreover, there is a high potential to bring innovation into the system as it is a new design, independent of existing sewer networks, and more adaptable to local environmental changes. A resettlement site can be a good example for promoting a sustainable community where there are clean and safe toilets, efficient disposal of wastewater with an adequate wastewater treatment system, and the safe use of human excreta in agricultural production.

DATA AVAILABILITY STATEMENT

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

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