Proceedings of 10th IOE Graduate Conference
Peer Reviewed
ISSN: 2350-8914 (Online), 2350-8906 (Print)
Year: 2021 Month: October Volume: 10

An Assessment of Socio-Economic Sustainability of Decentralized Treatment System in Nepal (Case studies from Nala Community DEWATS and Dhulikhel Hospital DEWATS)

Sunita Budhathoki [a], Sangeeta Singh [b]

[a, b] *Department of Architecture, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
Corresponding Email: [a] budhathokisunita42@gmail.com, [b] sangeeta@ioe.edu.np

Abstract

In the South Asian region, Nepal has the fastest rate of urbanization, with sanitation and wastewater management posing some of the most serious difficulties. A large portion of the population still lacks access to toilets, and practically all wastewater and septage is released into rivers and aquatic bodies without treatment. As a result, urban surroundings are severely polluted, public health is compromised, and opportunities for economic growth and development are hampered. Alternatives to the traditional, centralized wastewater treatment systems, which have mostly failed to solve the challenges of inadequate sanitation in Nepal's urban areas, are urgently needed. In Nepal, the concept of environmental sanitation, utilizing technology like as DEWATS, is developing as a viable option. Based on current experiences in Nepal, this thesis assesses the socioeconomic sustainability elements of DEWATS. Case studies from two models, community-based and institute-based, are presented in order to highlight the scope of the associated benefits, identify the main drivers for long-term operation and maintenance (O&M), and reveal the barriers preventing larger-scale adoption and promotion of such systems. The main objectives of this research are to identify the main challenges and success factors of operation and management of the DEWATS system in Nepal; including analyze the performance of the system; and to make recommendations on how the system can be improved and how lesson can be applied to similar type of systems in different areas of Nepal.

Keywords

DEWATS, Socioeconomic Sustainability, Operation and management, Nepal, Anaerobic baffled reactor, Constructed wetlands

1. Introduction

Due to a lack of sufficient fresh water, a large section of the world's population is suffering from water stress. The situation is worse as the world's population grows, resulting in a large decrease in the availability of fresh water per capita. With over 6,000 rivers, Nepal is one of the world's wealthiest countries in term of water resources [1]

Despite the fact that urban areas are growing at a rapid rate, low-income countries' cities lack basic infrastructure such as water supply and sanitation. The majority of metropolitan centers are in a state of flux, with social, political, economic, ecological, and environmental issues. Furthermore, the waste regulatory bodies are inefficient and ineffective[2]. As the haphazard discharge of untreated domestic and industrial wastewater and agricultural runoff are common practices in Nepal, water sources are converting into open sewers with contaminations and water-borne diseases. The conception of treatment or recycling of wastewater before discharging into water bodies is normally considered as unaffordable and consequently adopting rate of treatment technology is very slow [3].

Wastewater is considered as a nuisance containing carbon,nitrogen and sulphur that must be managed,that could be recovered or reused[4]. A typical wastewater treatment process usually contains three important stages: primary treatment, secondary treatment, and tertiary treatment. The primary stage includes preliminary treatment or pretreatment processes. The goal of preliminary treatment is to remove solids, which will be stuck and damage the plant equipment. The purpose of the primary treatment process is to reduce a settle solids or inorganic matters that will settle or float in the tanks. Primary treatment will usually remove 60 percent of suspended solids and 35 percent of the BOD5 (Cornwell, 2008). The next step is secondary treatment process, which helps to remove dissolved organic matter or soluble BOD5. Lastly, the tertiary stage is an process, where nutrients such as nitrogen and phosphorus are removed. Through the entire wastewater treatment process, sludge is produced from the primary and secondary treatment, which will be handled properly in the next stage[?].

Decentralized Wastewater Treatment Systems (DWWTSs) are on-site wastewater treatment systems for small volumes of wastewater produced either from individual homes, cluster of dwellings or businesses. The low in term of costs,expertise and technology, makes DWWTSs a good sanitation choice in developing countries especially for small communities[5].

Several decentralized wastewater treatment systems have been built in Nepal by various groups to minimize public health and environmental problems associated with uncontrolled discharge of untreated or poorly treated wastewater. The first community scale treatment system in Nepal has been built by ENPHO in 1997 for Dhulikhel Hospital. Since then, more than 20 new community and institutional level on-site wastewater treatment systems have been built by ENPHO and other organizations in Kathmandu valley and other areas of Nepal[6].

This paper aimed at assessing the socioeconomic sustainability of existing DEWATS. The assessment of DWWTSs may cover the life cycle perspective (benefits and disadvantages), policies that relate to each technology, and the technologies themselves. Therefore, the assessment should be based on environmental, managerial, socioeconomic aspects.

2. Literature review

2.1 Decentralized Wastewater Treatment System

DEWATS are based on four treatment steps. • Sedimentation and primary treatment in sedimentation tanks, septic tanks or Imhoff tanks

• Secondary anaerobic treatment in fixed bed filters or baffled septic tanks (baffled reactors)

• Secondary and tertiary aerobic/anaerobic treatment in constructed wetlands

• Secondary and tertiary aerobic/anaerobic treatment in ponds

2.2 Decentralized Wastewater Management System

The treatment modules generally used in DEWATS systems are Settler/ Septic tank, Biogas reactor, Anaerobic baffled reactor, Anaerobic filter, Horizontal subsurface flow constructed wetland, Vertical subsurface flow constructed wetland and Waste stabilization ponds.

2.3 Sustainable Technology

Sustainable technology is technology that does not threaten the quantity and quality (including diversity) of the resources[7]. The interaction of the technology with the environment is schematically represented in Fig. 1. The demands of the end user are translated into functional criteria that must be fulfilled by the technology[7].

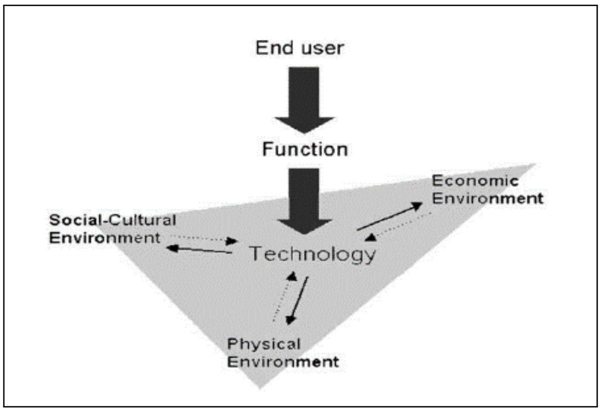

Figure 1: Technology interacting with the environment

2.4 Criteria for Assessing Socio-economic Sustainability of Wastewater Treatment Technologies

Land availability, affordability and social(public) acceptability are major constrainsts dictating the choice of wasterwater treatment systems[8].

3. Methodology

Research is explanatory and descriptive in nature. Therefore, strategy required to focus on specific case

Table 1: Indicators for Economic Dimension

Parameters	Indicators
Economic performance	· Construction cost
	· Land cost
	· Operation cost
	· Maintainance cost
	· Energy Cost
	· Administration cost
Land Requirement	· Total area of plant facility
	· Buffer zone around the plant facility
	· Preferred land conditions

Table 2: Indicators for Social Dimension

Parameters	Indicators
Health and safety	· Public Health and Safety
	· Workers health and Safety
Impacts on local community	· Local job creation
	· Community Support
Nuisance	· Impacts of construction work on community
	· Impacts of operation on the community
Acceptance	· Public perception

from wider perspective, so research demand the use of mixed methods. Data types are mixture of qualitative and quantitative.

3.1 Data Collection Method

Direct field observation, household surveys, key informant interviews, telephone interviews, and group discussions are all used to gather primary data. Data from books, journals, government publications, reports, and websites are also used to acquire secondary data.

3.2 Household Survey

Sample Frame: The study's goal was made explicit during the survey. A basic random sampling method was used to conduct the survey. The survey was carried out until all of the data had been collected.In this research total of 72 questionnaire survey on Nala community DEWATS which is nearly 20% of 368 total household and 32 questionnaire survey on Dhulikhel Community Hospital i.e. 20% of nearly 160 houses of hospital periphery and interaction was done and since information seemed to be repeated, further sample survey was not done.

Selection of Indicators: From the pool of indicators from literature, context specific indicators suitable for sustainability assessment were selected and verified by supervisors. The framework of the research will be generated based on the following list of indicators parameters and their key performance indicators.

4. Data Analysis and Findings

The analysis was conducted using the case area indicators listed in the previous chapter, field observations, and DEWATS interviews. To arrive at a conclusion, all of the data was organized and analyzed using excel charts. The necessary conclusion and recommendations for the DEWATS sustainability assessment will be drawn after that.

4.1 Study Area

Nala Bajar is a peri-urban settlement located in the Kavre District approximately 30 kilometres from Kathmandu. The Nala DEWATS has been designed to serve 294 households and is under operation since December 2012 and therefore presents the most recent example of community-led sanitation management in Nepal. This project was selected as a case study, as it is based on the community based module [?].Dhulikhel Hospital, a Kathmandu University hospital, is an independent, not for profit, non-government hospital in Dhulikhel, Kavrepalanchok, Nepal. The original hospital wastewater treatment system, constructed in 1997, was the first constructed wetlands for wastewater treatment in Nepal. Due to hospital expansion, the treatment system was upgraded and expanded in 2008 to meet current and future flows. According to the ENPHO this kind of the project fall under the DEWATS-SME (Hospital). There is not any funding agency for this project.

4.2 Results

Table 3: Results of Socio Culture Analysis Dimension of Nala Community DEWATS

Parameters	Key Indicators	Results
Health and Safety	Public Health and safety	Medium Sustainable: About 70% of respondent said that they haven't any health related problems through the discharge water whereas 30% said that they have some health related diseases like diarrhea and typhoid .
	Workers Health and Safety	High sustainable: Workers are used to be provided the precaution and safety measures.
Impacts on local community	Job creation	Low sustainable: From the household survey, respondent told that from plants there is not so much job opportunity
Public involvement and acceptance	Public participation for the community organization	Medium sustainable: 45% participate for the meeting, 23% actively involved in the meeting and 17% involved just for holding membership.
	Usefulness of community organization in solving problems related to sanitation	High sustainable: Around 85% told that this system is useful for solving the problems related to sanitation.
	Acceptance of current treatment system among community	High sustainable: Almost all the people, except one person interviewed think that current treatment system is a good solution for their wastewater treatment.
	Connection to the sewer system	Medium sustainable: According to the survey 15 houses have not the connection to the sewer system.
	Willingness to pay for wastewater discharge	High sustainable:Up to today the wastewater is directly discharged into river Almost all the people except 2 persons interviewed were willing to pay for wastewater discharge so they could use for agriculture.
	Acceptance of current wastewater charges	Medium sustainable: According to the survey 55% of respondent said that the charges is reasonable.
Environmental impact	Nuisances	Medium sustainable: Some of the houses which are near by the plant said that sometimes the plant produces the bad smell
Cultural Impacts	Cultural belief on site	High Sustainable: According to the local people and site observation there is not any cultural beliefs in the land which is occupied by DEWATS

Table 4: Results of Analysis of Economic Dimension of Nala Community DEWATS

Parameters	Key indicators	Results
Economic Performance	Construction cost	Total expenditure for constructing the entire network of sewers and treatment system amounted to NPR. 12.6 million
	Capital Cost	Medium Sustainable: Capital cost for the connection to the sewer system is 12000 per house . As per the results from economic situation they would not have problem to connect this system.
Expenditure	Capital expenditure	Medium Sustainable: The sewer and treatment system has been built and all the payments have been settled. Still the sludge drying bed has not been constructed and still discussions are going on how it is made and financing for that.
	Cost of capital	High Sustainable: Loans have not been used to finance for this treatment system. Therefore, no any capital expenditure involved in this case.
	Operating and minor maintenance expenditure	High Sustainable: Total expenditure per year 96,000NPR (960USD.According to the information from the treasurer, that amount can be totally compensated by the initial payment from household for new connection.
	Capital maintenance expenditure	Medium Sustainable: When, need for a capital maintenance expenditure arises, if there are enough savings from income, financial difficulties will not occur.
Household economic situation	Employment	High Sustainable: Almost all the people have income source through various medium. So that community are ready for the payment of operation and maintenance cost.
	Economic Situation	Medium Sustainable:42% Family with monthly income 10000-20000 Nrs.
Land Requirement	Area of land	Low Sustainable: The total land coverage by the system is about 508 sq.m approximately. There is no enough buffer space and there is also no enough space for the future expansion.

5. Analysis of Findings of Nala Community Dewats

5.1 Social Sustainability

To examine the social sustainability of the Nala Community DEWATS, data was collected on several aspects using various methods such as questionnaires, home surveys, and interviews. By evaluating all social data, it can be discovered that more than 80% of individuals have a favorable opinion of the Nala community group DEWATS. As a result of the findings, the system can be classified as socially sustainable.

5.2 Economic Sustainability

The wastewater charges collected from households are the primary source of revenue for the community organization responsible for the operation and management of the wastewater treatment system. Since there are presently 368 residences linked to the sewer system, 257,600NPR is collected per year. (At

Table 5: Results of Socio Culture Analysis Dimension of Dhulikhel Hospital DEWATS

Parameters	Key Indicators	Results
Health and Safety	Public Health and safety	Medium Sustainable: About 55% of respondent said that they haven't any health related problems through the discharge water.
	Workers Health and Safety	High sustainable: Workers are used to be provided the precaution and safety measures.
Impacts on local community	Job creation	Medium sustainable: While going through the employee record of Sanitation Department it is found that (35-40) % employee are of the same Dhulikhel Municipality.
Public involvement and acceptance	Usefulness of community organization in solving problems related to sanitation	High sustainable: Around 92% told that this system is useful for solving the problems related to sanitation.
	Acceptance of current treatment system among community	High sustainable: Almost all the people, except one person interviewed think that current treatment system is a good solution for their wastewater treatment.
	Willingness of Community to implement the system on the community	High sustainable: Most of the people wants to implement the system on the community.
	Acceptance of current wastewater discharge	Medium sustainable: According to the survey 62% of respondent said that the discharge water is beneficial for irrigation.
Environmental impact	Nuisances	Medium sustainable: While taking with the caretaker of Gynecology ward,she stated that during rainy season the system used to produce the bad odour.
Cultural Impacts	Cultural belief on site	High Sustainable: According to the local people and site observation there is not any cultural beliefs in the land which is occupied by DEWATS

the current household rate of 700 NPR) According to the results of a household poll, this is a reasonable quantity for the community. For future selling compost or dried sludge for use in agricultural lands is another source of income.. As a result of this conversation, it is clear that the system is financially sustainable.

6. Analysis of Findings of Dhulikhel Hospital DEWATS

6.1 Social Sustainability

During the household survey, many people stated that there are no health risks associated with utilizing treated water on the farm. As a result, it is certain that the locals will not complain about the treated water in the future. Staff working in the sanitation department also stated that they had no issues while on the job. By examining all social statistics, itis clear that more than 90% of people's (locals, employees, and the municipality) opinions of the Dhulikhel hospital DEWATS are positive. As a result, the system can be classified as socially sustainable, based on the findings.

6.2 Economic Sustainability

Funding collected from various agencies on the hospital is the organization's main source of money

Table 6: Results of Analysis of Economic Dimension of Dhulikhel Hospital DEWATS

Parameters	Key indicators	Results
Economic Performance	Construction cost	The Construction Cost for the DEWATS of Dhulikhel hospital is NRs. 2,500,000 (US$ 39,683).
	Land Cost	The land is belongs to the Dhulikhel Hospital institute. The present value of these land is about 2 crore.
Expenditure	Capital expenditure	High Sustainable: the sewer and treatment system has been built and all the payments have been settled.
	Cost of capital	High Sustainable: Loans have not been used to finance for this treatment system. Therefore, no any cost of capital involved in this case.
	Operating and minor maintenance expenditure	High Sustainable: The average operation and maintainece cost is about US $ 150 annually. Although for the Dhulikhel hospital this cost is nominal as comparison to the other different system of the hospital.
	Capital maintenance expenditure	Medium Sustainable: When, need for a capital maintenance expenditure arises, if there are enough savings from income, financial difficulties will not occur.
Household economic situation	Employment	High Sustainable: Almost all the people have income source through various medium.
	Economic Situation	Medium Sustainable:42% Family with monthly income 10000-20000 Nrs.
Land Requirement	Area of land	Medium Sustainable:The total land coverage by the system is about 2 ropani approximately. There is enough buffer space and there is also enough space for the future expansion.

for the operation and maintenance of the wastewater treatment system. Dhulikhel Hospital receives a significant amount of funds and donations from a variety of sources. So that the hospital could simply access the costs of operation and upkeep. During the construction period, the hospital did not take out any loans. As a result, there is no capital expense. Similarly, the hospital administration is responsible for other administrative costs. As a result, the system's cost is extremely low. As a result of this conversation, it is clear that the system is financially sustainable.

7. Conclusion

Through performance and socioeconomic studies, the article analyzed the sustainability of DEWATS of two types of models. According to the responses of the majority of affected stakeholders, DEWATS were more popular in densely populated areas of small villages. However, the results revealed that the sustainability levels of the evaluated systems were medium on the socioeconomic dimension. Similarly, this paper demonstrates that for the community, community-based DEWATS is one of the best solutions for addressing sanitation-related issues. According to the poll, it is socially viable; however, if the community does not pay for the discharge, it will be financially difficult to maintain. According to the results of the second survey, DEWATS is the best solution for solving sanitation-related problems for the institute. According to the results of the survey, the operating and maintenance costs for any institute are minimal after implementation. As a result, when compared to community-based DEWATS, institutional-based DEWATS are more sustainable in terms of the socioeconomic dimension.

8. Recommendations

Several recommendations are suggested for DEWATS of Nala:

• Reuse of treated wastewater for irrigation.

• Take measures to prevent excessive influx of storm water at rainy seasons:

Several recommendations are suggested for Dhulikhel Hospital.

• Expand the size of the DEWATS.

• Take measures to prevent excessive influx of storm water at rainy seasons.

References

[1] R. R. Shrestha, R. Haberl, J. Laber, R. Manandhar, and J. Mader, “Application of constructed wetlands for wastewater treatment in nepal,” *Water Science and technology*, vol. 44, no. 11-12, pp. 381–386, 2001.

[2] H. M. U. Herath, *Management and operation of onsite wastewater treatment systems-an analysis of success factors*. PhD thesis, UNESCO-IHE, 2014.

[3] A. K. Jha and T. Bajracharya, “Wastewater treatment technologies in nepal,” *IOE Graduate Conference*, vol. 44, no. 11-12, pp. 76–81, 2014.

[4] P. Wongburi, *Sustainable Wastewater Treatment Technologies for Thailand*. PhD thesis, 2018.

[5] A. S. Kazora and K. A. Mourad, “Assessing the sustainability of decentralized wastewater treatment systems in rwanda,” *Sustainability*, vol. 10, no. 12, p. 4617, 2018.

[6] B. Pandey and S. Shakya, “Rural drinking water quality status in central development region, nepal: A comparative study of spring water and ground water,” *Hydro Nepal: Journal of Water, Energy and Environment*, vol. 9, pp. 52–56, 2011.

[7] A. J. Balkema, H. A. Preisig, R. Otterpohl, and F. J. Lambert, “Indicators for the sustainability assessment of wastewater treatment systems,” *Urban water*, vol. 4, no. 2, pp. 153–161, 2002.

[8] W. Singhirunnusorn, N. Sahachaisaeree, and M. K. Stenstrom, “Socio-economic criteria for wastewater treatment system selection: a case of municipality contextual determinants in thailand,” *Proceedings of the Water Environment Federation*, vol. 2011, no. 16, pp. 1486–1492, 2011.