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Sustainability of Water Supply Projects

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Abstract
Sustainability is one of the major issues for Water Supply and Sanitation activities/ projects. The project should have the measuring tools for the sustainable part. Water supply is one of the basic needs for human beings with all living things may come first air then water or soil in the universe to sustain. Sustainability indicators of water supply projects was determined by three major dimensions (i) technical, (ii) Socio-environmental, and (iii) Institutional [15]. Other aspects, functionality has divided with requirements, actions, and results. Sustainability is the combination of functionality index and sustainability dimensions on a fifty-fifty percent shearing base. The research has developed sustainability tools on the basis of available literatures and practical experiences. The tools have developed. The project study has to take consideration for the sustainability from the pre-feasibility study, feasibility, detail study.
Keywords: Water supply, study, operation and maintenance, sustainability, functionality

Introduction
Sustainability is required in each and every step of the activities. Sustainability is one of the major issues for Water Supply and Sanitation Projects (WSSP). One has to take consideration for the sustainability from the pre-feasibility study, feasibility, detail project report (DPR) of the study, construction period, and operation and maintenance phase. The study team for any construction must think about the sustainable part from the very beginning to the life of the project. There is always a problem finding the measuring tools for this issue in water supply projects even though the word sustainability is socio technical. Any project should have the measuring tools for the sustainable part. Water supply is one of the basic needs for human beings with all living things may come first air then water or soil in the universe to survive.

Water is one of the fundamental needs to keep the body alive, because the body needs nutrients and water to work properly. However, billions of people in the world still lack access to safe drinking water and sanitation. According to sustainable goal report 2021, 2 billion (26%) people lack safely managed drinking water, 3.6 billion people lack safely managed sanitation, and 2.3 billion people lack basic hygiene. 129 countries are still not on track to have sustainably managed water resources by 2030 [1].

In this context the research paper has developed the sustainable measuring tools for the completed or substantial completed water supply project.

1. Literature Review and Research Methods

Mukharjee et. al (2003) described sustainability based on the publication of WSP & IRC (2003) as the satisfactory functioning and effective use of services, and equity for men and women, rich and poor everyone having equal access to benefits from projects. Another publication of IRC by Schouten et.al., (2003) included as a part of sustainability that a statement, a system that reliable sustainability met the needs of 80 % of the population wile leaving the poorest 20 % unserved cannot be counted a success [2]. The incorporation of a measure of social equity in the definition of sustainability.

Three Pillars of Sustainability

Since 1980s, when three pillars as (i) economic, (ii) social, and (iii) environmental of sustainability widely popularized in business, government agencies, and other organizations, applied in practice [3].

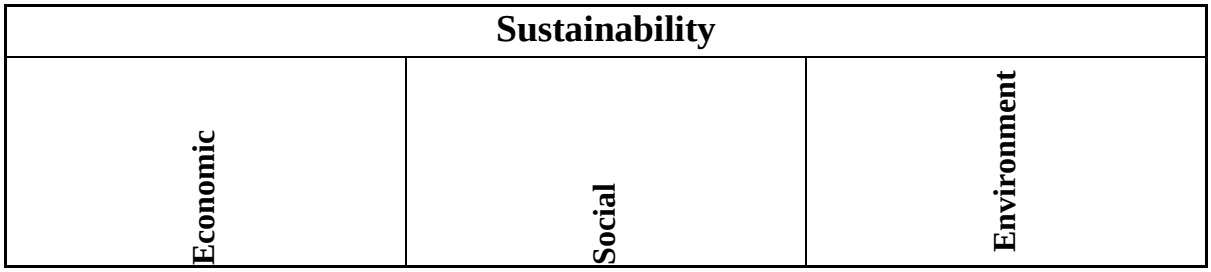

Figure 1: Three Pillars of Sustainability

Source: Moore, 2017

UNESCO Sustainability

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) has played a key role in the development of the United Nations' 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs. It has adopted four pillars (i) Social equity, (ii) Economic development, (iii) Environmental protection, and (iv) Cultural/Human sustainability [4].

UN Sustainable Development Goal

Development agenda of Sustainable Development Goal (SDG6) envisions universal sustainable and equitable access to safe drinking water, sanitation and hygiene and elimination of open defecation by 2030 A.D. The targets of SDG6 for 2030 are [1]:

Target 6.1: By 2030 A.D., achieve universal and equitable access to safe and affordable drinking water for all.

Target 6.2: By 2030 A.D., achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

Target 6.3: By 2030 A.D., improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.
Target 6.4: By 2030 A.D., substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.
Target 6.5: By 2030 A.D., implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.
Target 6.6: By 2030 A.D., protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes.
Target 6.A: By 2030 A.D., expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.
Target 6.B: Support and strengthen the participation of local communities in improving water and sanitation management.

Water Supply Sustainability in Global context

The European Union, America and Africa has discussed on water quality concern more than other issues like sustainability though in western countries there is no problems experienced of uncertainty.
The Dutch Drinking Water Decree outlines the legal requirements for drinking water quality. Limits on the concentrations of lead (10 micrograms per liter) and mercury (1 microgram per liter) in drinking water are among these regulations. The European Drinking Water Directive is the foundation for these standards. The evaluation's findings show that the Drinking Water Directive is a crucial piece of legislation that protects the quality of drinking water in European member states [5].
The Drinking Water Directive (EU 2020/2184), generally known as the Drinking Water Directive, has begun to be implemented in Finland. Making sure there is safe drinking water is the directive's main goal. This will be accomplished by looking at the drinking water quality standards established through risk management. The entire water production and distribution system, from raw water to tap water delivered to customers, must be considered throughout the risk assessment process. The World Health Organization's recommendations are typically revised together with the quality recommendations for drinking water at Finland [5].
Primary and secondary drinking water regulations exist in the USA. The National Primary Drinking Water Regulations (NPDWR) are primary criteria and treatment methods that are legally enforceable for public water systems. Toxin levels in drinking water are reduced by primary standards and treatment methods, protecting public health. The National Primary Drinking Water Regulations (NPDWRs), developed by the EPA, define obligatory water quality limits for pollutants in drinking water [6].

Sustainability context in Nepal

The sustainability of water supply has evaluated in the context of water quality, quantity required by the users, and consistency of water supply service to the consumers have reviewed from the article published in Wash journal in 2023 [7]. The water quantity has been estimated that the urban water supply needs 100 liters to 120 liters that the project usually decides. Consistency has not been fixed yet but there are 24 hours in 360 days also found morning and evening service with enough quantity. Alternately, the supply water available whenever the consumers require is the consistency of supply. Normally, it depends on reasonably earlier repair in major and minor leakage in the system.

Government of Nepal (GoN) was committed for the provision of basic level water supply and sanitation facilities to all citizens by 2017. Water and sanitation are recognized as fundamental human rights [8].

Water Quality context in Nepal

Initially, GoN had adopted World Health Organization (WHO) standard for drinking water purpose but limited in theory only. It could not be made effective. After this effort, it had developed water quality standard in 2005, it stated that the existing water supplies not meeting National Drinking Water Quality Standards (NDWQS) will be improved in phased manner with appropriate treatment measures.

The Government of Nepal (GoN) has developed and made it mandatory to comply with its provisions in all new water supply systems and has triggered a water quality improvement in urban and rural water supplies, in 2022, GoN updated the National Drinking Water Quality Standards. The updated version has two tables Table 'Ka' and Table 'Kha'. The parameters whose test is compulsory listed in table 'Ka' however, some other parameters are added in the Table 'Kha' according to risk and necessity of parameters for the test [9].

Salyankot Water Supply Project was studied on post-earthquake scenario during earthquake period 2015 by Mr. Shah with the dimensions as i) Technical, ii) Socio-environmental, iii) Institutional, and iv) Cost Recovery with corresponding core factors contributing for sustainability, these dimensions were identified [10].

Mangardh Water Supply Scheme was evaluated the water supply coverage aspect. The study was overall performance; technical performance, financial performance(tariff collection), and institutional performance (functionality index) with implementation status on the base of water safety plan (WSP) referring to the risk factor by Joshi et.al in 2020 [11].

Functionality

Performance is the attainment or fulfilment or functionality in the context of any development action. It also shows the sustainability part of the development project or action [12].

Institutional performance was evaluated on Dhankuta Water Supply Project by A.K. Mishra using water safety plan developed by DWSS/NMIP, 2014. The indicators were (i) WUSC registration, (ii) Own staff for maintenance, (iii) O & M fund, (iv) WUSC meetings, (v) Efficient water tariff collection, (vi) Records keeping, (vii) Spare tools & fittings, (viii)

Implementation of water safety plan, (ix) Water supply service reliability, and (x) Accessibility with 100 unit of marks in Likert scale measurement [13].

Er. Ajita Devkota studied Anbukhaireni Water Supply and Sanitation Project in 2023 and found the performance which was analyzed based on the quality of water supply, reliability, and sufficiency, in which quality of water supply measured in accordance with the National Drinking Water Quality Standards [14].

Research Methods

Sustainability of water supply and sanitation projects has been reviewed on the past studies. The projects/ schemes have been tried to re-evaluate with the available tools. The practical experiences have fitted in the tools and further improved in detail so that there could be eased to evaluate without biasness.

The developed tools have further tested and found reliable to measure sustainable using Likert scale experience outcome from more than fifty water supply projects in Nepal. The findings have been discussed hereunder.

The developed tools have chances of 10 per cent bias or 90 per cent level in unbiased. It is improved on the previous versions. Furthermore, this improved tool is easy to use for the water supply and sanitation projects.

Sustainability Dimensions

Sustainability Dimensions are the highest-level monitoring indicators adopted by WaterAid in Nepal. For water supply and sanitation projects, four monitoring dimensions are used (i) technical, (ii) socio-environmental, (iii) financial, and (iv) institutional. The dimension is significantly governed by many factors and subfactors. Principles of multi-criteria approaches, each set of criteria is rated depending upon its potential contribution or its significance in making the case sustainable. The weights given to dimensions, factors and sub-factors were determined through participatory methods involving sector professionals and field workers [15].

Conceptual Framework

Sustainability indicators of water supply projects was determined by three major dimensions (i) technical, (ii) Socio-environmental, and (iii) Institutional [15]. Next, functionality has divided with requirements, actions, and results. Sustainability is the combination of functionality index and sustainability dimensions.

The research design has been conceptualized as sustainability has two pillars (i) Functionality index, and (ii) Sustainability indicators with sub-indication as figured below.

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Sustainability of the Projects/Actions					
Functionality			Sustainability Index		
Requirements	Actions	Results	Technical	Socio-environmental	Institutional
WUSC Registered, WUSC meetings, and Record keeping	Own Staff, O& M Fund, and Tariff Collection	Tools & Fittings, Water Safety Plan, Reliability, and Accessibility	Verification of QARQ (Quantity, Accessibility, Reliability, and Quality) level and physical status of the system	Health benefits (including water borne diseases) Time save, Environmental benefits, and GESI aspects	Operation and functioning of Users Committee, Skilled Technicians, O & M practice, and Financial aspects (O & M cost, Institutional support, Capital cost recovery/ upgrading the system)

Figure 2: Conceptual Framework of Research Sustainability
Source: Author, 2024

2. Results and Discussions

Functionality

Functionality index for Water Supply and Sanitation Projects (WSSP).

Table 1: Functionality index table

Indicator	Sub-...	Weightage	Not Serviceable	Up to 20%	20%-50%	50%-80%	80%-100%
			Very Bad	Bad	Satisfactory	Good	Very Good
		0-5	1	2	3	4	5
Requi	WSU		Not Registered	Registered but not	Audited but not renewed	Renewed & GB till 2 yrs. back	Renewed & GB conducted

				Renewed & Audited			
		Yes (5), No (0)	1	2	3	4	5
	WSUC Meetings		No meetings or once in a year meeting	Meeting in the desires of Chairperson	Regular less than tri-monthly meetings	Regular tri-monthly meetings	Regular monthly meetings
		Regular Yes (5), No (0)	1	2	3	4	5
	Record keeping		Rarely record keeping of connection & Tariff	Record keeping of connection & Tariff in random system	Poorly records keepings, records are available but audited till before last year	Meetings, Water connection and tariff records keeping till last months	WUSC meetings, Staff meetings, Water connection and tariff updated records keeping
		Proper (5), No (0	1	2	3	4	5
Action (A)	Having own staff with		No Staff	Poorly Staff hired with in daily wise basis	Poorly Staff hired with in monthly basis	Poorly managed Enough Staff	Sufficient staff with Job description
		Yes (5), No (0)	1	2	3	4	5
	O & M Fund		No fund	Poorly allocated fund for O & M	Fund less than 3% of the Construction Cost	Fund about 5% of the Construction Cost	Sufficient fund more than 5% of the Construction Cost

		Sufficient (5), No (0)	1	2	3	4	5
	Efficient water tariff		No tariff collection system	Poorly managed tariff collection system up to 40% of the billings	Tariffs collection 40-80%	Tariffs collection 80-95%	Tariffs collection 95% or more
		Yes (5), No (0)	1	2	3	4	5
	Tools and fittings		No tools & spare parts	Tools are available but no spare parts	Poorly manage tools & spare parts	Good managed tools & spare parts	Well managed tools & spare parts stock for 3 months
		Sufficient (5), No (0)	1	2	3	4	5
Results (R)	Water	Functional (5), Nonfunctional (0)	1	2	3	4	5
	Reliability (360		Rarely Water Supply	Poorly Water Supply	Safe Water Supply in 4hrs (2mor +2eve)/360	Safe Water Supply in 8hrs (4mor +4eve)/360	Safe Water Supply in 24/360
		Yes (5), Six month (0)	1	2	3	4	5
	Accessibility of supply		Rarely Water Supply time to collect more than 30 min.	Poorly Water Accessible on the court yards with public tapstands within 30 min.	Manageable Water Accessible on the court yards	Sufficient Water Accessible on the court yards	Sufficient Water Accessible on the top of 3 story building
		15 minutes (5), More than 30 minutes (0)	1	2	3	4	5

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The calculation score of functionalities will be higher to the lower based on risk factors as the indicators of the index.

The calculation of sustainability will be in weighted 50% for functionality and 50% for Sustainability dimension for the whole activities or project considering risk factors.

Sustainability Dimensions

Sustainability index or dimension of Water Supply and Sanitation Projects (WSSP) has been modified in the three-pillar system as (i) Technical, (ii) Socio-environmental, and (iii) Institutional as stated earlier.

Table 2: Sustainability Dimension Table

Sustainability Dimensions	Sub-Dimensions	Weightage	V. Bad	Bad	Satisfactory	Good	Very Good
			1	2	3	4	5
Technical	Quantity of water	1-5	1	2	3	4	5
		%	30-	40+	50+	80+	90+
	Physical Quality of water	1-5	1	2	3	4	5
	Nos. 5 compulsory(C) +1=6 of parameter within limit		2C-	2C+	3C+	5C	6/6
	Chemical Quality of water	1-5	1	2	3	4	5
	Nos. 12 compulsory(C) +1=13 of parameter within limit		5-	5+	7+	12	13/13
	Biological Quality of water	1-5	1	2	3	4	5
	Microbial parameter % samples within limit		50-	50+	80	95	100
	Reliability of water supply	1-5	1	2	3	4	5
	As per risks						
	Physical status/ Structures of the system	1-5	1	2	3	4	5
	As per risks						

Institutional	Timely General Assembly	1-5	1	2	3	4	5
	As per risks						
	Water Tariff collection System	1-5	1	2	3	4	5
	Active involvement of WUSC team	1-5	1	2	3	4	5
	Record keeping Mechanism	1-5	1	2	3	4	5
	Community Technicians for O&M	1-5	1	2	3	4	5
Socio-environmental	Gender Equity and Social Inclusion status in team	1-5	1	2	3	4	5
	Social Security Risk for woman	1-5	1	2	3	4	5
	Environmental Health status/water borne diseases after the project	1-5	1	2	3	4	5
	Managing Operation and Maintenance fund	1-5	1	2	3	4	5
	Tariff collection	1-5	1	2	3	4	5
	Collection in %		Less than 20	20-40	40-60	60-80	80-100
	Economy Availability of fund from local bodies and others	1-5	1	2	3	4	5

	organizatio n						

Source: Author, 2024

Risks will be categorized by the researcher as the sustainability sub-dimensions of the system. The score of the risks will be prejudiced as the higher to the lower.

Conclusion and Recommendation

The project sustainability will be adopted in weighted 50% for functionality index and 50% for Sustainability dimension for the whole activities or project considering risk factors. The criteria has been fixed as per the experience on water supply and sanitation projects with reviewing the available literature.

Sustainability is one of the serious issues for Water Supply and Sanitation Projects (WSSP). One has to take consideration for the sustainability from the pre-feasibility study, feasibility, detail study. Further research and criteria could be reviewed for the project, as per the time advanced and complexity come to the situation.

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