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# Sustainability and Risk Assessment of Salyankot Water Supply Project in Post-Earthquake Scenario

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## Abstract

The research work intended to assess the sustainability and risk of Salyankot Water Supply Project for smooth operation and management particularly in post-earthquake scenario. Mulpani, Aginchowk and Salyankot Village Development Committee (VDC) of Dhading District are the service area for the project which is situated at about 120 km from the earthquake 2015 epicenter (Barpak, Gorkha). Qualitative and Quantitative approach was applied with the help of primary and secondary data. Consultation with experts, observation and transect walk, four focus group discussions and a set of questionnaire surveying were done for the study. The functionality index and sustainability index, of the project were analysed for the condition before and after earthquake. The risk at water source due to contamination by flood, disruption by landslide, risk due to drought, human activities, and risk related to cleaning were identified based on probabilistic approach. The risk at distribution system due to water quality at tap level, piping, leakage due to transmission and distribution pipeline/joints, drainage near main pipeline and governance were identified with the help of risk exposure.

The functionality status of the project was found 58.4 % and 71 % functional taking 15 indicators before and after earthquake respectively. The sustainability status of the project was found satisfactory (53.24%) after the condition of earthquake.

From the risk assessment, significant risk were found from landslide, water quality testing and leakage at transmission-distribution pipelines. Medium risk were found from governance. Insignificant risk were found from drought and drainage near pipeline. The risk were found uncertain with contamination by flood, human activities at source and piping.To overcome the risk due to leakage in transmission and distribution pipeline, fittings should be replaced and high density polythene pipe (HDP) should be grounded properly. To feel served to society, tariff should be collected from all water user household and institution should be also charged with view to conserved water used and enhanced financial condition.

**Keywords:** Functionality , Sustainability, water quality, Risk

# I. INTRODUCTION

On 25thApril 2015, an earthquake of a 7.8 magnitude on the Richter scale hit Nepal with an epicentreBarpak of Gorkha District. The epicentre was located 77 km northwest of Kathmandu. Strong aftershocks have been felt since, the most significant of which took place on 12 May 2015, with a magnitude of 7.3 and an epicentre in Dolakha District, east of Kathmandu.

Of 75 districts in Nepal, 39 districts were affected by the earthquakes and aftershocks. Following the 25th April 2015 earthquake, the Government of Nepal (GoN) declared 14 districts as most affected; an additional nine districts were added to the list of most-affected areas after 12 May 2015 earthquake (GoN, 2015).

The quality of water at source could have further deteriorated due to massive earthquake of 7.8 magnitude that occurred in Nepal on 25thApril 2015. Water, sanitation and hygiene (WASH) facilities have also been greatly affected to the country. The Government of Nepal has categorized 14 districts as the most affected and other 12 districts moderately affected also for the WASH sector beside other sectors. ThePost disaster need assessment (PDNA) has reported that there has been damage and losses equivalent of US $ 11.4 billion in the WASH sector. The summary findings of WASH post disaster need assessment (PDNA) shows that out of total of 11,288 Water supply systems in 14 severely affected districts, 1570 sustained major damages and 3,663 partially damaged.

It was also reported that the total needs for recovery and reconstruction using the principle of building back better is estimated as NRs. 18.1 billion. In order to address sector needs, it is very important to ensure that WASH interventions are based on a robust assessment and analysis of disaster risks.

So the study focused to assess the sustanability of Water Supply System after earthquake along with the associated risk in post-earthquake scenario with an example of Salyankot Water Supply Project of Dhading District which is one of the severely affected project from the mega-earthquake 2015. It is significant to take preventive actions for the possible risks from the existing water supply scheme and other stakeholders of the project in their respective work.

The objective of this research was to assess the functional, sustainability status and the possible risks on the major components (source, transmission system and distribution system) of Salyankot Water Supply Project before and after earthquake in post-earthquake scenario.

# 2. LITERATURE REVIEW

## 2.1 Sustainability of project

There is a broad range of definitions of sustainability in rural water supply and sanitation used in different studies. The majority of these definitions are similar in nature but have slight differences in emphasis. As Black (1998) pointed out, sustainability in water supply and sanitation sector was primarily associated with financial aspects of service delivery and the need to make projects self-sufficient, highlighting the need for users to contribute to cost sharing. Mukherjee et al (2003) describes sustainability based on the publication of WSP& IRC (2003) as the satisfactory functioning and effective use of services, and equity as everyone (men and women, rich and poor) having equal access to benefits from projects. Another publication by IRC (Schouten et al., 2003) includes, as part of its definition of sustainability, a statement that a system that reliably and sustainably meets the needs of 80% of the population while leaving the poorest 20% un-served cannot be counted a success. The incorporation of a measure of social equity in the definition of sustainability reflects, in part, a political or ideological position in terms of viewing access to basic services as a fundamental human right.

According to International Union for conservation of Nature (UNCN), United Nations Environment Program (UNEP) and World Wildlife Fund (WWF), sustainability consists of " improving the quality of human life while living within the carrying capacity of supporting ecosystem". Therefore sustainability of drinking Water, Sanitation and Hygiene (WASH) projects need to be viewed as a crucial cross-cutting element that impacts on overall human development.

### 2.1.1 Key Sustainability Dimensions

Sustainability Dimensions are the highest level monitoring indicators adopted by WaterAid in Nepal. For water supply and sanitation facilities , four monitoring dimensions are used: technical, socio-environmental, financial and institutional.

Each sustainability dimension is significantly governed by many factors and sub-factors. As per 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 comparative weights given to dimensions, factorsand sub-factors were determined through participatory methods involving sector professionals and field workers.

### 2.1.2 Conceptual Framework

Sustainability of water supply facilities is determined by four major dimensions (i) technical (ii) Socio-economical (iii) Cost Recovery and (iv) Institutional, which are further governed by major factors and sub-factors.The figure below shows the conceptual framework for the study to assess the sustainability of Salyankot water supply project, Dhading.

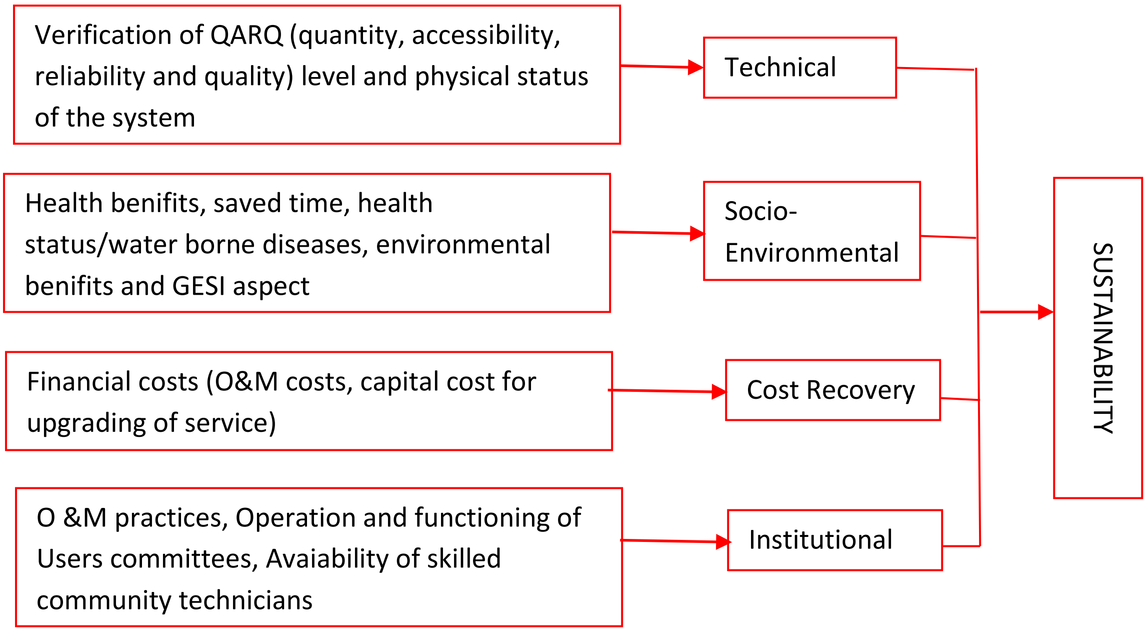


Figure 2.1 Conceptual Framework of Sustainability

## 2.2 Water Safety Plan; Global Context and Context in Nepal

**Global Context:**

Water Safety Plans (WSPs) are a risk-based preventative approach to most effectively protect drinking water safety and are recommended in the WHO Guidelines for Drinking-water quality (third edition 2000). WSPs are now being adopted worldwide, but they are not always fully understood by all stakeholders.

WSPs require a risk assessment encompassing all steps in water supply from catchment to consumers, followed by implementation and monitoring of risk management control measures. WSPs should be implemented within a public health context, responding to clear health-based targets and quality-checked through independent surveillance.WSP follows:

i) Drinking-water safety, including minimum procedures, specific guideline values and how these should be used.
ii) Microbial hazards, which continue to be the primary concern in both developing and develop countries.
iii) Climate change, which results in changing water temperature and rainfall patterns, severe and prolonged drought or increased flooding, and its implications for water quality and water scarcity, recognising the importance of managing these impacts as part of water management strategies.

Chemical contaminants in drinking water, including information on chemicals not considered previously such as pesticides used for diseases vector control in stored drinking water.

- Key chemicals responsible for large scale health effect through drinking water exposure, including arsenic, fluoride and lead, chemicals for public concern such as nitrate, selenium, uranium and disinfected by products.

**Water Safety Plan (WSP) Context in Nepal**

Water Safety Plans are considered by the WHO as the most effective means of maintaining a safe supply of drinking water to the public. Their use should ensure that water is safe for human consumption and that it meets regulatory water standards relating to human health. Comprehensive risk assessment and risk management form the backbone of these plans, which aims to steer management of drinking water-related health risks away from end-of-pipe monitoring and response. In order to produce a plan, a thorough assessment of the water supply process from water source to the consumer's tap must be carried out by the water provider. Hazards and risks should be identified, and appropriate steps toward minimizing these risks are then investigated. There are three key components to any water safety plan (WSP).

- A system assessment, which determines if the drinking water supply chain as a whole is capable of supplying water of sufficiently high a standard to meet regulatory targets.
- Operational Monitoring, in order to identify control measures in the drinking water system and management plans, which document the system assessment, describe actions taken during various operational conditions and define monitoring and communication plans.

## 2.3 Risk Assessment Concepts

There are a number of concepts and terms in risk analysis and risk assessment and to clarify the actual meaning a selection of frequent words are described below. There is of course an extensive nomenclature in the case of risk assessment and the selection below is chosen to fit this project to avoid unnecessary confusion and communicative problems. The definitions are quoted from the standard developed by IEC (1995).

- Identifying the risks affecting project objectives by means of structured interviews or brainstorming
- Classifying the risks by type and degree of impact
- Recording the risks in a risk register
- Assessing qualititatively the risks by frequency and impact scales and ranking them
- Modeling and analyzing quantitatively the important risks (by methods like sensitivity analysis, probabilistic analysis and Monte-Carlo simulation, decision trees, event trees, influence diagrams etc.)
- Formulating a risk response strategy by risk avoidance, reduction, transfer,

acceptance

- Preparing a project risk management plan that summarizes the status of the project on risk issues and the response strategy with a risk action schedule
- Implementing the strategy
- Reviewing periodically the status of identified risks, the risk management strategy and identifying new risks[cited in Mishra & Mallik,2017]

The Risk Management process involves 4 basis ladders towards Risk Resolving viz. Preliminary Activities, Risk Identification and Categorization, Risk Assessment and Analysis and Risk Response Planning. While Preliminary Activities involve defining of objectives and scope of the risk study along with Identification of Stake-holders and Project Requirements, Risk Identification and Categorization involves identifying sources of risk and opportunities. Risk Assessment and Analysis deals with assessing the frequency and impact of risks in qualitative terms, quantifying risks where necessary using quantitative techniques and structuring risk modelling where necessary and applicable apart from prioritizing risks for mitigation. Risk Response, on the other hand, deals with identifying risk mitigation actions and estimating costs and resources needed. Risk Management Review has to be done at each step as to whether or not everything being done is correct and as per the plan.

A research was carried out by authors in [cited in Mishra & Mallik,2017] in Jordon on 'The impact of risk management on construction projects success from the employees perspective' in 2013. The main objective of this research was to study the impact of risk management on construction projects success. The survey directed to the participants was developed according the research design, approach, and data. This survey included two major sections. The first section asked about the procedure followed in the organization to manage the risk. In section two, the survey attempted to specify if the project they experienced achieved the success criteria. 7 criteria factors were defined for construction project success listed in the questionnaire. The results of the study indicated that an impact existed between both Risk identification and Risk assessment on project success, scheduled time, planned budget, and the ability to comply with technical specifications. There was no impact between Risk assessment and avoiding lawsuits or claims. Also the study indicated that there is an impact of Risk response on project success, meeting the scope of work, scheduled time, and achieving the quality standards.

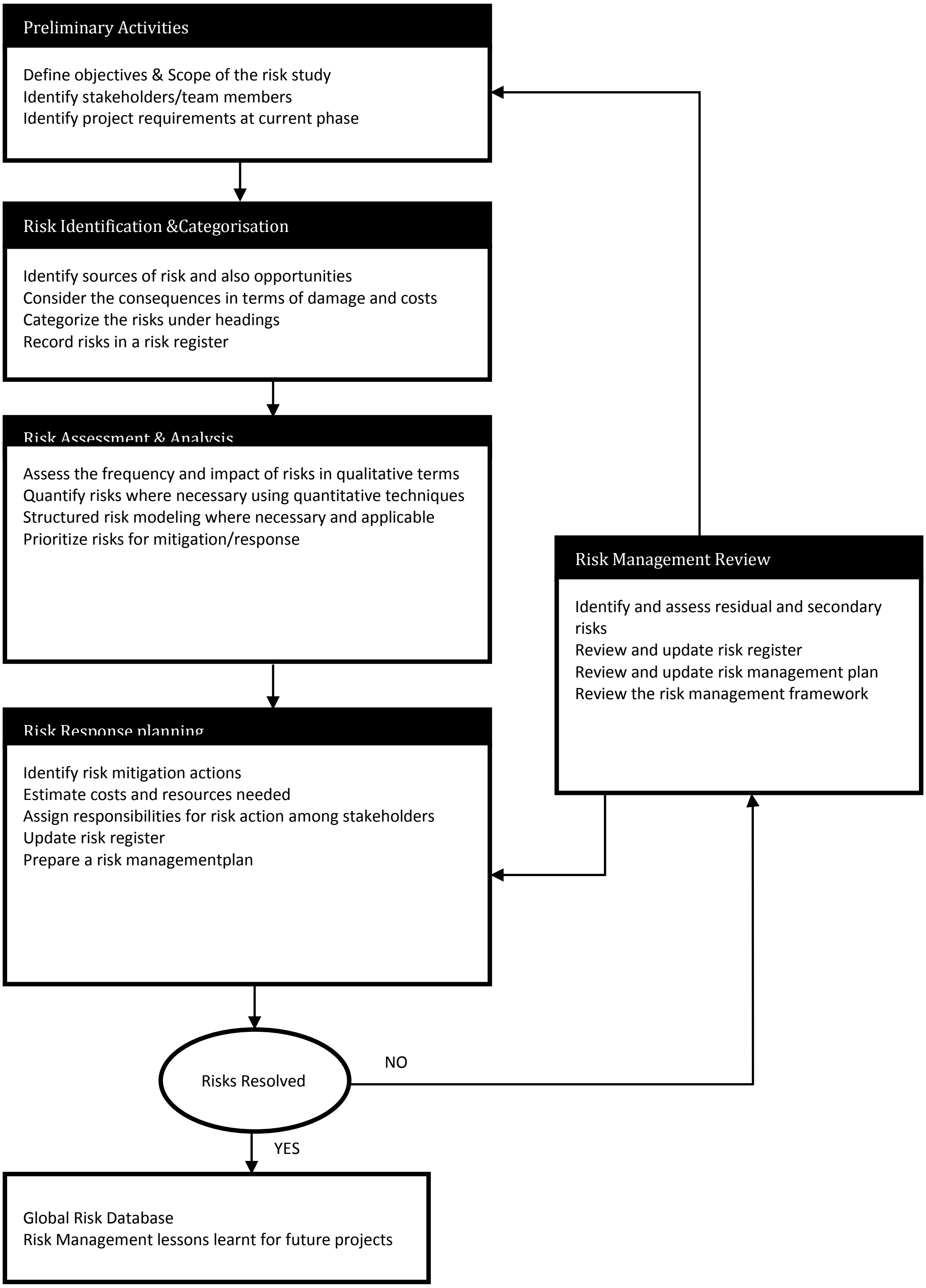


**Figure 2.2:** The Risk Management Process Flowchart [cited in Mishra and Mallik,2017]

**2.4 Risk Assessment Approach**

Hazards may occur throughout the whole system, from water catchment to the point of consumption (Risk assessment of Small Scale Water Supply system, 2012). According to guideline of World Health Organization (1999), risk assessment of the whole system should be done. Once potential hazards and their sources have been identified, the risk associated with each hazard or hazardous event should be compared so that priorities for risk management can be established and documented. Although there are numerous pollutants that can compromise drinking-water quality, not every hazard will require the same degree of attention.

The risk associated with each hazard or hazardous event may be described by identifying the likelihood of occurrence (e.g., certain, possible, rare) and evaluating the severity of consequences if the hazard occurred (e.g. Insignificant, minor, moderate, major and catastrophic). The approach used typically involves a semi quantitative matrix. Simple scoring matrices typically apply technical information from guidelines, scientific literature and industry practice with well informed "expert" judgement supported by peer review or benchmarking. Scoring is specific for each drinking water system, since each system is unique. By using a semi-quantitative scoring, control measures can be ranked in relation to the most significant hazards. A variety of approaches to ranking risk can be applied.

An example of an approach is given in Table 2.2. Application of this matrix relies to a significant extent on an expert opinion to make judgements on the health risk posed by hazards or hazardous events. An example of descriptors that can be used to rate the likelihood of occurrence and severity of consequences is given in Table 2.3.

Table 2.1 Example of a simple risk scoring matrix for ranking risks

| **Severity of consequences** | | | | | |
|---|---|---|---|---|---|
| **Likelihood** | **Insignificant** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
| Almost certain | 5 | 10 | 15 | 20 | 25 |
| Likely | 4 | 8 | 12 | 16 | 20 |
| Moderately likely | 3 | 6 | 9 | 12 | 15 |
| Unlikely | 2 | 4 | 6 | 8 | 10 |
| Rarely | 1 | 2 | 3 | 4 | 5 |

| Risk score | < 6 | 6-9 | 10-15 | > 15 |
|---|---|---|---|---|
| Risk rating | Low | Medium | High | Very high |

(WHO guideline, 2011)

Table 2.2 Examples of definitions of likelihood and severity categories used in risk scoring

| **Item** | **Definition** | **Weighting** |
|---|---|---|
| **Likelihood categories** | | |
| Almost certain | Once per day | 5 |
| Likely | Once per week | 4 |
| Moderately likely | Once per month | 3 |
| Unlikely | Once per year | 2 |
| Rare | Once every 5 years | 1 |
| **Severity categories** | | |
| Catastrophic | Potentially lethal to large population | 5 |
| Major | Potentially lethal to small population | 4 |
| Moderate | Potentially harmful to large population | 3 |
| Minor | Potentially harmful to small population | 2 |
| Insignificant | No impact or not detectable | 1 |

(WHO Guideline, 2011)

## 2.5 Water Quality Parameters and Water Borne Diseases

The substances of concern in water can be classified according to their intrinsic characteristics (such as physical, chemical and microbiological) and other characteristics associated with their uses, functions or physical conditions.

**Physical Parameters:** The parameters whose presence affects the physical characteristics of water are included in this category. Turbidity, PH, colour, taste and Odour, Total dissolved solids (TDS) and electrical conductivity are kept under this category.

**Chemical Parameters:** The Parameters whose presence affects the chemical characteristics of water are included in this category. The parameters included in this category are Iron, Manganese, Arsenic, Cadmium, Chromium, Cyanide, Fluoride, Lead, Ammonium, Chloride, Sulphate, Nitrate, Copper, Total hardness, Calcium, Zinc, Mercury, Aluminium and Residual Chlorine.

**Micro-biological Parameters:** These parameters affect the biological characteristics of water. The parameters included in this category are Escherichia coli (*E.coli*) and total coliform which are the indicators used in water quality standards.

The Common Pathogens and water borne diseases common in Nepal are:

Table 2.3 Common Pathogens and water Borne Diseases in Nepal

| | **Pathogens** | **Diseases** |
|---|---|---|
| Virus | Rotavirus<br>Hepatitis A | Diarrhoea, Gastroenteritis<br>Infectious Hepatitis |
| Bacteria | Vibrio-Cholera, Salmonella Typhi, Shigellae, dysentery,<br>Escherichia Coli | Cholera, Typhoid, Paratyphoid, Bacillary Dysentery, Diarrhoea |
| Protozoan | Entamoeba Histolitycya<br>Giardia/Lamblia | Amoebic Dysentery<br>Giardiasis Diarrhoea |

(DWSS/WHO, 2000)

The detection of all these diseases causing organism in above is not possible, so it is enough to detect only indicator bacteria of the same origin e.g. Total coliform and *E-coli*.

**Escherichia coli-**

Total coliforms include both faecal and environmental types of coliforms so in large numbers indicate overall poor quality. Escherichia coli (*E.coli*) is a thermos tolerant coliform (group within total coliforms) often found in association with faecal pollution. Therefore, WHO (2011) recommends *E.coli* as the best indicator of faecal contamination in water supplies.

According to National Drinking Water Quality standards (NDWQS), *Escherichia coli* must not be detectable in any 100 ml samples. For treated water entering or in, the distribution system the same recommendation is also given for total coliform bacteria, with a provision for up to 5% positive samples within the distribution system. The rationale for this additional criterion is the greater sensitivity of total coliforms for detecting irregularities (not necessarily faecal contamination) in treatment and distribution.

The concentration limits allowed by NDWQS 2005 is shown in table.

Table 2.4 List of Parameters and Concentration Limits

| S.N | Category | Parameters | Units | Concentration limits |
|---|---|---|---|---|
| 1 | Physical | Turbidity | NTU | 5 (10) |
| 2 | | PH | | 6.5-8.5 |
| 3 | | Colour | TCU | 5 (15) |
| 4 | | Taste and Odour | | Non-objectionable |
| 5 | | TDS | mg/L | 1000 |
| 6 | | Electrical Conductivity | µs/cm | 1500 |
| 7 | Chemical | Iron | mg/L | 0.3 (3) |
| 8 | | Manganese | mg/L | 0.2 |
| 9 | | Arsenic | mg/L | 0.05 |
| 10 | | Cadmium | mg/L | 0.003 |
| 11 | | Chromium | mg/L | 0.05 |
| 12 | | Cyanide | mg/L | 0.07 |
| 13 | | Fluoride | mg/L | 0.5-1.5 |
| 14 | | Lead | mg/L | 0.01 |
| 15 | | Ammonium | mg/L | 1.5 |
| 16 | | Chloride | mg/L | 250 |
| 17 | | Sulphate | mg/L | 250 |
| 18 | | Nitrate | mg/L | 50 |
| 19 | | Copper | mg/L | 1 |
| 20 | | Total Hardness | mg/L as CaCO3 | 500 |
| 21 | | Calcium | mg/L | 200 |
| 22 | | Zinc | mg/L | 3 |
| 23 | | Mercury | mg/L | 0.001 |
| 24 | | Aluminium | mg/L | 0.2 |
| 25 | | Residual Chlorine | mg/L | 0.1-0.2 |
| 26 | Micro-biological | Escherichia coli | MPN/100 ml | 0 |
| 27 | | Total coliform | MPN/100 ml | 0 in 95% sample |

*(Source: GoN, 2005)*

## 3. METHODOLOGY

### 3.1 Study Area

Salyankot Water Supply project which is the major water source for Mulpani, Aginchowk and Salyankot VDC, Dhading was the study area for this research. This project was selected for the study due to the reason that it is near (about 120 km) from the epicentre of Nepal Earthquake 2015 and it is only one of the major scheme from which about 802 HHs and 4300 population of 3 VDC survived. Also it is the large project in the Northern part of Dhading constructed by WSSDO, Dhading. The source (Intake) and the collection chamber of this water scheme lies in Phulkharka VDC ward no 9 Majuwa and the beneficiaries from this project are of Mulpani ward no 2, 4, 5, 7 and 8, Aginchowk ward no 4, 6 and 7 and Salyankot ward no 1, 2, 3, 5 and 6. The system was existed in 2003.

Salyankot Water Supply Scheme was implemented by Water Supply and Sanitation division Office, Dhading. The communities were also involved in each steps of the project cycle. The implementation was done in a close coordination with local water users committee. The local water users also contributed substantial community contributions. 15% of the total cost of the project was contributed by community. All the lands required for the construction of various structures were provided by the local community.

### 3.2 Population of the Research Area

The universe of this research is 2, 4, 5, 7 and 8 ward of Mulpani Village Development committee (VDC), ward 4, 6 and 7 of Aginchowk VDC and ward 1, 2, 3, 5 and 6 of Salyankot VDC. The project covers 250 HH/1325 population of Mulpani VDC, 198 HH/1049 population in Aginchowk VDC and 354 HH/1947 population in Salyankot VDC. The details of the total HH and population for each ward is given below:

Table 3.1 Total HH and population of Mulpani, Aginchowk and Salyankot

| Ward | Mulpani VDC | | | Aginchowk VDC | | | Salyankot VDC | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total HH | Benifited HH | Sample HH | Total HH | Benifited HH | Sample HH | Total HH | Benifited HH | Sample HH |
| 1 | 50 | - | - | 191 | - | - | 187 | 72 | 8 |
| 2 | 124 | 52 | 6 | 81 | - | - | 84 | 53 | 6 |
| 3 | 146 | - | - | 107 | - | - | 104 | 75 | 9 |
| 4 | 83 | 32 | 4 | 115 | 72 | 8 | 112 | - | - |
| 5 | 64 | 64 | 7 | 102 | - | - | 99 | 46 | 5 |
| 6 | 55 | - | - | 207 | 61 | 7 | 203 | 108 | 13 |
| 7 | 155 | 48 | 6 | 110 | 65 | 8 | 105 | - | - |
| 8 | 104 | 54 | 6 | 110 | - | - | 117 | - | - |
| 9 | 121 | - | - | 73 | - | - | 97 | - | - |
| **Total** | **902** | **250** | **29** | **1096** | **198** | **23** | **1108** | **354** | **41** |

(Field visit 2016 & DDRC Dhading census 2015)

## 3.3 Layout of Salyankot Water Supply Project

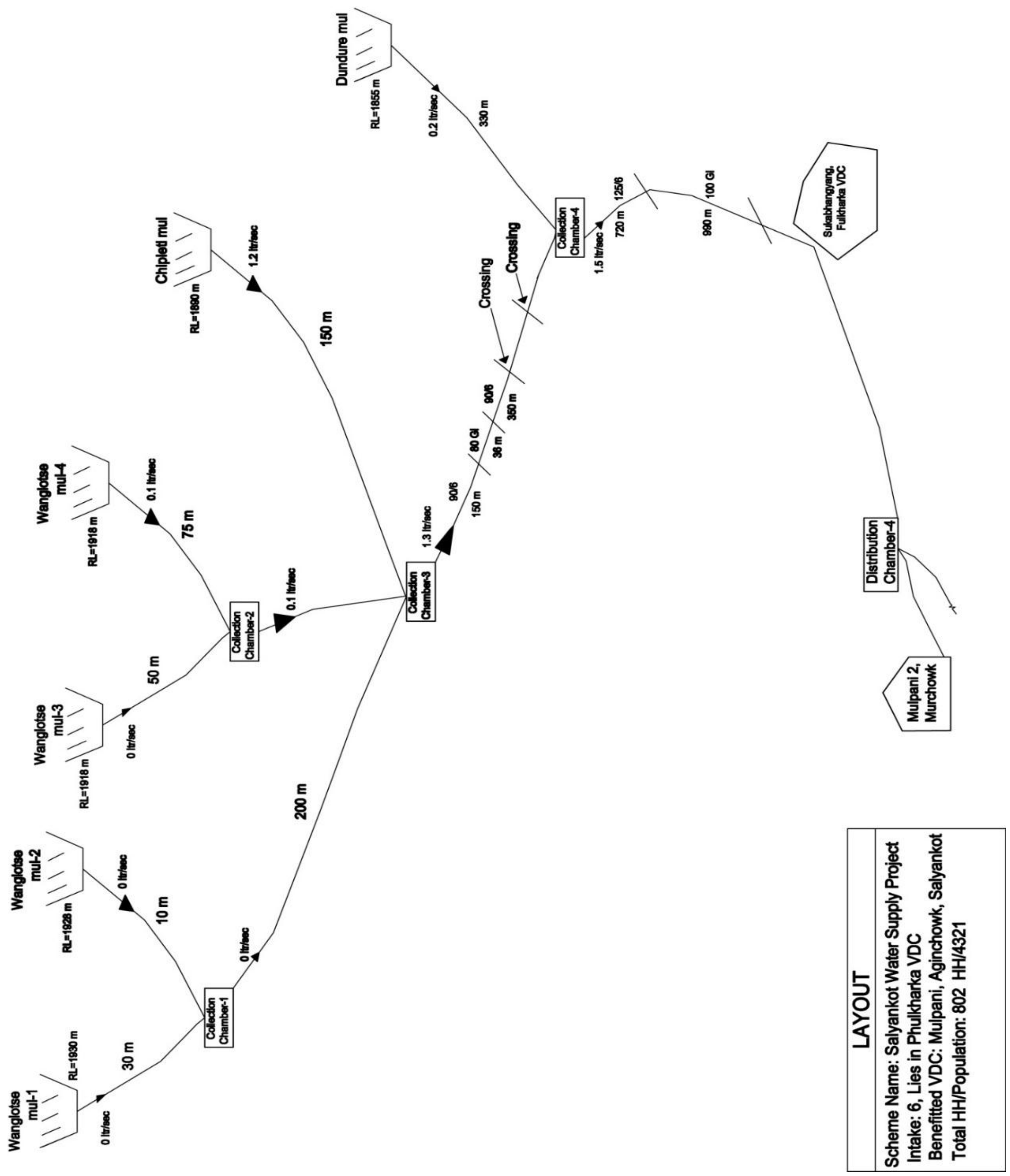


Figure 3.1 Layout of Salyankot Water Supply Project

### 3.4 Salient Features of the Project

| | |
|---|---|
| Base year (2004) HH and population | 614 HH and 3438 population |
| Design year (2019) HH and population | 915 HH and 5126 population |
| Design water demand (lpd) | 2.5 ltr/sec |
| Scheme type | Gravity flow |
| Benefited area | Mulpani VDC, ward no 2, 4, 5, 7, 8<br>Aginchowk VDC, ward no 4, 6, 7<br>Salyankot VDC, ward no 1,2, 3, 5, 6 |

| **During commencement of the project (2004)** | **Present status (2016)** |
|---|---|
| Total Served HH=614<br>Benefitted population= 3438<br>Health post- 1 no, VDC office- 1 no<br>Schools- 2 no | Total served HH= 802<br>Benefitted population= 4321<br>Health post- 1 no, VDC office- 1 no<br>Schools- 2 no |
| Total water demand per day (ltr)- 172,800 | Total water demand per day: 2,05,445Ltr (taken 45 lpcd) |
| Total water supply per day (ltr)- 216,000 | Total water supply per day (ltr)- 129,600 ltr (1.5 ltr/sec) |
| Intake- 6 no | Intake- 6 no |
| Collection Chamber- 4 no | Collection Chamber- 4 no |
| Distribution chamber- 3 no | Distribution chamber- 3 no |
| Suspension crossing- 2 no | Suspension crossing- 2 no |
| Break pressure tank- 2 no | Break pressure tank- 2 no |
| Reservoir tank- 7 no (20$m^3$, 14 $m^3$, 20 $m^3$, 10 $m^3$, 20 $m^3$, 20 $m^3$, 10 $m^3$) | Reservoir tank- 7 no (20$m^3$, 14 $m^3$, 20 $m^3$, 10 $m^3$, 20 $m^3$, 20 $m^3$, 10 $m^3$) |
| Transmission line: 13.6 kms | Transmission line: 13.6 kms |
| Distribution line: 11.5 Kms | Distribution line: 11.5 Kms |
| Institutional tap: 4 no | Institutional tap: 4 no |
| Public tap: 116 no | Public tap: 116 no |

(Source: Field visit, 2016)

### 3.5 Sample Size and Techniques

The total beneficiaries' household of Mulpani VDC is 250, Aginchowk is 198 and Salyankot VDC is 354 (Source: Field visit). As beneficiaries are the main source of primary data in this study, using qualitative versus quantitative study of study area to obtain a representative sample from given household population by using stratified random sampling method (supposed as representation from all cluster, wards and ethnicity) 93 beneficiaries were taken for questionnaire survey and to make it proportionate 29 beneficiaries from Mulpani, 23 from Aginchowk and 41 from Salyankot VDC were taken.

There are three water source so in order to assess the water quality, one major water source (Chipleti Mul) was taken.

In order to assess the microbial water quality at tap, area sampling technique were used and 12 taps were selected.

Sample size calculated by using Cocharent formula:

$$n= Z^2pqN/e^2(N-1)+Z^2pq$$

Where, n= Sample size, Z=1.645 for 90% confidence level, p=Percentage of picking choice expressed decimal (0.5), q=0.5, e=0.08, N=whole size (802 HH)

### 3.6 Methods of Data Collection

The study includes both qualitative and quantitative method of data collection. Both primary and secondary data is used to carry out this study. Regarding secondary data, Water Supply and Sanitation Division Office Dhading, District Administrative Office, Research papers and journals were reviewed. The collected data on the performance and risk assessment using the following method are mentioned below:

The following processes was adopted while conducting the assessment:

- Checklist for physical structure index, scheme functionality index, sustainability index and risk for each component of system were prepared with experts' consultation.
- Observation and transect walk of the scheme and its catchment area were carried out for inspection of the scheme and community.
- Four focus group discussions were conducted with Water Users and Sanitation Committee members and water users to find before and after earthquake situation in the scheme, its functionality, risk, and management practice for operation and maintenance after reconnaissance of the field.
- Questionnaire method was deployed for the water Users after it had been translated in to local language (Nepali).
- Water quality test (Physical, chemical and micro-biological) was carried out from one major source and microbial test was conducted from taps.

### 3.6.1 Primary Data

Primary data was collected using various tools and techniques as discussed hereunder.

**i)** **Consultation with Experts:** To prepare the checklist for physical structure index of major components of the Project, scheme functionality index and sustainability index, water supply expert of CARE Nepal and Engineer of WSSDO Dhading were consulted.

**ii)** **Observation and Transect Walk:** Physically observe the condition of the scheme was followed to assess after earthquake physical structure status of major components of the project. Intakes (water source) to stand posts were also assessed to find the risk on the components of scheme.

iii) **Focus Group Discussion:** Focus group discussion with Main Water User Committee and water users were carried out to find the physical and functional condition of major components of the project before earthquake, likelihood and severity of different risks, system of water tariff collection, and to find the change in management system before and after earthquake and perception of group to improve the management system of the project.

Three FGDs with the sub-WUSC of each VDC of Mulpani, Aginchowk and Salyankot were conducted to get information of serviceability condition (schedule of water flow in tap, quality of water and epidemics from water borne diseases).

iv) **Questionnaires:** Questionnaire method for the Water Users were deployed for the assessment of household water consumption behaviour, accessibility condition and reliability condition. A total of 250 HH were benefitted from the scheme at Mulpani VDC, 354 HH at Salyankot VDC and 198 HH were benefitted in Aginchowk VDC. Out of which 29 HH in Mulpani, 23 HH in Aginchowk and 41 HH in Salyankot VDC was selected using stratified judgement sampling method.

v) **Water Quality Testing:** The quality of water of a scheme was carried out (taken from main source) using laboratory test to find the physical, chemical and microbial quality of water and also the presence of *E.coli* at taps were tested using P/A vile test method (field kit test method).

### 3.6.2 Secondary Data

Secondary data was collected through related journals, research papers, different agencies like Water Supply and Sanitation Division Office, District Administrative Office and concerned people was consulted in need based.

## 3.7 Scheme Functionality Index

For the assessment of functional status of water supply scheme as whole year supply, have water supply and sanitation technician (WSST), adequate tools, WSUC registered and operation and maintenance fund NMIP 2014 have developed some of the functionality indicators. Including these indicators some other indicators are important for functionality status assessment of the scheme. Hence in addition to the above indicators other indicators have been added and the weightages have fixed by consulting/discussion with experts. The index gives the functional status of the scheme to sustain the services. Following weightages have assigned to the following 15 indicators, the full mark being 150. The current functional index have been derived in percentage by the following equation below:

$$\text{CFI score in \%} = (\text{Total Score}*150)/100$$

There was no any study report to check the functionality status of this water supply scheme before earthquake so this was taken based on the record file of the project, perception of Main and sub-WUSC in each VDCs.

Table 3.2 Value assignment to the indicators of Scheme Functionality Index

| **SN** | **Indicators** | **Weightage** | **After Earthquake** | **Before Earthquake** |
|---|---|---|---|---|
| 1 | Timely general assembly | Yes (10), No (0) | | |
| 2 | O& M fund | Sufficient (10), less (5), No (0) | | |
| 3 | Efficient Water Tariff collection | Yes (10), Partial (5), No (0) | | |
| 4 | O&M workers (CT) | Yes (10), No (0) | | |
| 5 | Active involvement of WSUC | Yes (10),Vital persons only active (5) No (0) | | |
| 6 | WSUC meetings | In proper time (10), Yes but not in schedule (5), No (0) | | |
| 7 | At least 33 % Woman involvement in WSUC | Yes (10), No (0) | | |
| 8 | Woman involvement in decision making role | Yes (10), No (0) | | |
| 9 | Proper record keeping mechanism | Yes (10), No (requires to be systematised, 5), No record (0) | | |
| 10 | Availability of tools and maintenance tool box | Sufficient (10), Inadequate (5),<br>No (0) | | |
| 11 | Physical and functional condition of each component | % of index | | |
| 12 | Quality of water | Good (10), poor (0) | | |
| 13 | Demand meet/Quantity of water | Sufficient (10), Moderately sufficient (5), less (0) | | |
| 14 | Reliability (daily supply) | Yes (10), No(0) | | |
| 15 | Accessibility | Yes (10), No(0) | | |
| | Total | | | |

### 3.8 Scheme Sustainability Index

To analyze the sustainability of the system after Earthquake four key sustainability dimensions i)Technical ii) Socio-environmental iii) Institutional and iv) Cost Recovery, were defined and the corrosponding core factors contibutiong to these dimensions were identified. The core factors were given weightage. Table 3.3 below shows the weightage given to the score factors of the sustainability dimensions.

Table 3.3 Sustainability weightage to the Core Factors

| Sustainability Dimensions | Core factors to assess the sustainability Dimensions | Weightage | Remarks |
|---|---|---|---|
| Technical | Quantity of water | 0-5 | |
| | Quality of water | 0-5 | |
| | Accessibility of water taps | 0-5 | |
| | Reliability of water | 0-5 | |
| | Physical status of the system | 0-5 | |
| Institutional | Timely General Assembly | 0-5 | |
| | water Tariff collection | 0-5 | |
| | Active involvement of WUSC team | 0-5 | |
| | Record keeping Mechanism | 0-5 | |
| | Community Technicians for O&M | 0-5 | |
| Socio-Environmental | Gender Equity and Social Inclusion status in team | 0-5 | |
| | Social equity | 0-5 | |
| | Security Risk for woman | 0-5 | |
| | Health status/water borne diseases after the project | 0-10 | |
| Cost Recovery | Managing Operation and Maintenance fund | 0-10 | |
| | Managing system replacement fund | 0-10 | |
| | Availability of local fund | 0-5 | |

### 3.9 Risk Assessment Index

Based on the checklist prepared by FEDWASUN for mapping and analysis of disaster risks of water supply schemes in severely affected districts and risk assessment guideline published by World Health Organization (1999) and with the consultation with experts on water supply, likelihood and severity and their score has been finalized and given for major possible risks at source, treatment system and distribution system. The index gives the risk status of each component of the project to sustain the services. Different physical components were observed after the post-earthquake condition and ranked to different category.

Risk is being calculated using the equation:

Risk= Likelihood of occurrence *Severity of consequence

The table for the possible risk at Source, Treatment system and Distribution system has been given in Annex 1.

## 4. RESULTS AND DISCUSSION

### 4.1 Functionality of the Project

Salyankot Water Supply User Committee of Salyankot Water Supply Project was registered under District Water Resource Committee (DWRC). There were 2 working staff (community technician) in the project named Arun Khatri and Sunil Thapa. The project had no timely general assembly, no sufficient operation and maintenance fund, no efficient tariff collection, only the vital persons active for operation of project, WUSC meeting not held in time, no proper record keeping and no involvement of woman in decision making process was the weak indicators for functionality of the project for after earthquake condition.

Table 4.4 Calculation of Functionality Index

| S.N | Indicators | After earthquake | | Before earthquake | | Remarks |
|---|---|---|---|---|---|---|
| | | Status | Mark obtained | Status | Mark obtained | |
| 1 | Timely general assembly | No | 0 | No | 0 | # Field observation and FGD for after earthquake<br><br># FGD with WUSC including CTs for before earthquake situation analysis |
| 2 | O& M fund | Yes, but not sufficient | 5 | Yes, but not sufficient | 5 | |
| 3 | Efficient Water Tariff collection | Not efficient | 5 | Efficient | 10 | |
| 4 | O&M workers (Community technician) | Yes (CT training is required) | 9 | Yes (CT training is required) | 9 | |
| 5 | Active involvement of WUSC | Vital person only active | 5 | Vital person only active | 5 | |
| 6 | WUSC meetings | Yes, but not in time | 5 | Yes, but not in exact time | 5 | |
| 7 | At least 33 % Woman involvement in WUSC | Yes | 10 | Yes | 10 | |
| 8 | Woman involvement in decision making role | No | 0 | No | 0 | |
| 9 | Proper record keeping mechanism | No (requires to be systematised) | 8 | No (requires to be systematised) | 8 | |
| 10 | Availability of tools and maintenance tool box | Yes, but not sufficient (only major tools are available) | 5 | Yes, but not sufficient | 5 | |
| 11 | Physical and functional condition of each component | Satisfactory | 5.6 | Good | 9.5 | |
| 12 | Quality of water | Good | 10 | Good | 10 | |
| 13 | Demand meet/Quantity of water | Partial/moderately sufficient | 5 | Sufficient | 10 | |
| 14 | Reliability (daily supply) | Sometime | 5 | Yes | 10 | |
| 15 | Accessibility | Yes | 10 | Yes | 10 | |
| **Total** | | | **58.4%** | | **71%** | |

Calculating the current functionality index after earthquake (CFI) and functionality index (FI) before earthquake as per table 4.1.3 below indicates the functionality status of before and after earthquake scenario of the project.

It shows that the project was running with partial functional status at present with 58.4% CFI and 71% FI before earthquake.

Current functional Index (CFI)=58.4% which shows that the system was partially functional with respect to Manageable, financial, serviceability, physical condition with the need of more improvement in documentation, tools and fittings and meeting times and need to seek of another water source to meet the water quantity demand of community.

## 4.2 Sustainability of the Project

The sustainability of SWSP has been checked and found that cost recovery and institutional parts of the system remain weaker than other. Timely General Assembly and managing internal O&M fund seems totally lacking.

Table 4.5 Sustainability weightage to the Core Factors

| **Sustainability Dimensions** | **Core factors to assess the sustainability Dimensions** | **Weightage** | **Mark obtained** | **Remarks** |
|---|---|---|---|---|
| Technical | Quantity of water | 0-5 | 3.15 | water deficit by 75,845 ltr per day |
| | Quality of water | 0-5 | 5 | Within NDWQS |
| | Accessibility of water taps | 0-5 | 5 | Within 100 m distance for HHs |
| | Reliability of water | 0-5 | 0.75 | |
| | Physical status of the system | 0-5 | 2.84 | From physical status index |
| Institutional | Timely General Assembly | 0-5 | 0 | |
| | water Tariff collection | 0-5 | 2.5 | Not efficient |
| | Active involvement of WUSC team | 0-5 | 2.5 | Vital person involved |
| | Record keeping Mechanism | 0-5 | 4 | Requires to be systematised |
| | Community Technicians for O&M | 0-5 | 4.5 | Need capacity build training |
| Socio-Environmental | Gender Equity and Social Inclusion status in team | 0-5 | 2.5 | No female in vital position |
| | Social equity | 0-5 | 2.5 | Moderate condition |
| | Security Risk for woman | 0-5 | 1 | High security risk |
| | Health status/water borne diseases after the project | 0-10 | 8 | No epidemic of water borne diseases yet |
| Cost Recovery | Managing Operation and Maintenance fund | 0-10 | 5 | Dependent of VDCs, DDC and WSSDO |
| | Local fund for O&M | 0-10 | 0 | No system |
| | Availability of local fund | 0-5 | 5 | Tariff system |
| Total | | 100 | 53.24 | |

(source: Field Visit, 2016)

## 4.3 Risk Assessment of the Project

Based on the checklist prepared by FEDWASUN for mapping and analysis of disaster risks of water supply schemes in severely affected districts and risk assessment guideline published by World Health Organization (1999) and with the consultation with experts on water supply, likelihood and severity and their score has been finalized and given for major possible risks at source, transmission and distribution system.

Different physical components were observed after the post-earthquake condition and ranked as followed:

Risk is being calculated using the equation:

Risk= Likelihood of occurrence*Severity of consequence

### 4.3.1 **Possible Risk at Source and Transmission system**

Table 4.6 Risk due to Contamination by Floods

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| Once in more than 5 year | 1 | Minor/no contamination | 1 | Uncertain Risk |

Since the project is in hill and no river nearby the project there was no chance of occurrence of flood and no severity from it so it is concluded as uncertain/minor risk due to flood.

Table 4.7 Risk due to Disruption by Landslides

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| Once or more in a year | 5 | Major damage which affects large % of beneficiaries | 5 | Risk=25=risk score 4=significant risk |

The project had suffered from landslides every year in monsoon period and damaged transmission pipelines. After the earthquake there has arisen of large number of big voids in the place of transmission pipeline and intake. After the heavy rainfall there was more probability of landslide in this area and swift away the transmission pipeline as a result there can be major damage which affects large percentage of beneficiaries. So there was significant risk due to landslide.

Table 4.8 Risk due to Drought

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| Once or more in a year | 5 | Water source less than 20% dried up | 1 | Risk=5=risk score 2= Insignificant risk |

According to the perception of community people, there was insignificant risk due to drought. Though the likelihood of drought was once in a year, its severity was less and only the water source less than 20% dried up.

Table 4.9 Risk due to Human Activities and Cattle Grazing

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| May occur only in exceptional circumstances; has not been observed in the field | 1 | Rare human activities and Cattle grazing | 2 | Risk=2=risk score 1= uncertain risk |

The source was in inaccessible place to the cowboy and for other people. It was far away from the community too so there was less chance of human activities and might occur only in exceptional circumstances. Therefore there was uncertain risk due to human activities.

Table 4.10 Risk related to Cleaning (including area near source and other structures)

| Cleaning frequency | Risk score |
|---|---|
| More than year/Never | 4 (significant risk) |
| Six month to one Year | 3 (Medium risk) |
| Three to six month | 2 (Insignificant risk) |
| Less than three month/Monthly | 1 (Uncertain) |

According to perception of WUSC and community people they used to clean the intake, collection chamber and area near to the source is in range of six month to one year. So there was medium risk from the risk related to cleaning.

### 4.3.2 **Possible Risk at Distribution System**

Table 4.11 Risk due to Water Quality Testing at Tap Level

| Testing done | Risk score |
|---|---|
| Testing on regular basis | 1 (uncertain risk) |
| Never | 4 (Significant risk) |

There was no system of water quality testing at tap level. So there was significant risk due to water quality at tap level.

Table 4.12 Risk due to Piping

| Types of pipe | Risk score |
|---|---|
| Grounded | 1 (uncertain risk) |
| Exposed | 4 (Significant risk) |

All most the pipe of the project were grounded. So, there was uncertain risk due to piping.

Table 4.13 Risk due to Leakage from Transmission/distribution Pipe line/joints

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| Expected to occur in most circumstances; observed frequently | 5 | Major impact for large % of beneficiaries, litigation by beneficiaries | 5 | Risk=25=risk score 4=significant risk |

The risk due to leakage from transmission/distribution pipeline/joints was found significant. There seemed a leakage in some of the joint and it was expected to occur in most circumstances; the community people suffered from this problem frequently. The severity of this impact was high and it affect large % of beneficiaries.

Table 4.14 Risk due to Drainage near Main Pipeline (if pipe exposed)

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| May occur only in exceptional circumstances; has not been observed on the field | 1 | Major quality impact for large % of beneficiaries | 5 | Risk=5=risk score 2= Insignificant risk |

Since the source and transmission line were laid in jungle and hill rock there might occur of drainage in exceptional circumstances and had not been observed on the field by community people. But if the drainage passed from the main pipeline it would have major quality impact for large % of beneficiaries. So, there was insignificant risk due to drainage near main pipeline.

Table 4.15 Risk Related to Governance

| Scheme Governing Activities | Risk score |
|---|---|
| No timely GA, no public/social audit, no tariff collection, no trained community technician (none for these four activities) | 4 (Significant risk) |
| Only one-two of four activities done | 3 (Medium risk) |
| Up to three of four activities done | 2 (Insignificant risk) |
| Timely GA, no public/social audits, regular tariff collection, trained CT (all four activities done) | 1 (uncertain) |

To find the risk related to governance only four parameters named timely general assembly, public social audit, tariff collection and trained community technician were taken. It was found that there is no timely general assembly and no public/social audit. There was provision of water tariff collection but not proper and there were two community technicians but not well trained. So there was medium risk related to governance.

- Salyankot Water Supply Project is presently functioning with current Functionality index of 58.4%. For the condition before earthquake it is found that this project was running properly with the functionality index of 71%.
- From the risk assessment it is found that there is significant risk from landslide, risk associated with filtration, water quality testing and leakage in transmission and distribution pipelines. There is medium risk from governance. From the risk related to drought, and due to drainage near pipeline there is insignificant risk and from contamination by flood, human activities and piping there is uncertain risk.
- To overcome the risk due to leakage in transmission and distribution pipeline, fittings should be replaced and high density polythene pipe (HDP) should be grounded properly.
- The foundation of all major structures should be treated sufficiently earthquake resilience design.

## 5.1 Recommendation for Further Study

- Geological study of landslide should be conducted to avoid landslide risk

## REFERENCES

Black, 1998. Harvesting Intensity Versus Sustainability in Indonesia

CBS, 2011. National Population Survey of Nepal. Central Bureau of Statistics (CBS).

Davinson.ct.al, 2002. Water Safety Plans. Geneva: WHO

DDRC, 2015. Household Statistics of Dhading District, Dhading: District Disaster Relief Committee

Devi and Bostoen, 2009. Functionality Status of Water Supply and sanitation in South Africa

DWSS/WHO, 2000. Drinking water Quality Surveillance and Monitoring Program

DWSS, 2010. Nationwide Coverage and Functionality Status of Water Supply and sanitation in Nepal

Egesa, p, 2006. Water Quality Standards Review and Revision

FEDWASUN,2015. Mapping and Analysis of Disaster Risks of Water Supply Schemes in Severely Affected Districts: Federation of Water and Sanitation Users nepal

GoN, 2014. National Water Supply and Sanitation Sector Policy, Kathmandu: Government of Nepal

GoN, 2015. Post Disaster Need Assessment, National Planning Commission: Government of Nepal

IEC, 1995. Dependability Management part 3: Application guide-Section 9: Risk Analysis of technological Systems: International Electrotechnical Commission

IRC (Schouten.et.al), 2003. Predicting Sustainable Performance and Household Satisfaction of Community-oriented Rural Water Supply Project.

Jagals, 2006. Effective Water Surveillance for Rural Water Supply in South Africa

Jimnez and Perez-Foguet, 2008. Accessibility Condition of Rural Water Supply in Kenya.

Mishra,A.K., & Mallik,K. (2017),Factors and Impact of Risk Management Practice on success of Construction Projects of Housing Developers, Kathmandu, Nepal International Journal of Sciences: Basic and Applied Research (IJSBAR) Volume 36, No 7, pp 206-232

Mishra, A.K.,and Shrestha. M., (2017)." Health and Safety Status of Casual Workers in Road Improvement Project Kathmandu Valley, Nepal." International Journal Engineering Technology Science and Research, Vol.4,pp.1187-1199

Majuru, 2010. Community Managed Rural Water Supply System in the Dominican Republic.

MICS, 2014. National Population Survey of Nepal: Multiple Indicator Cluster Survey.

Module 18, 2012. Risk Assessment of Small Scale Water Supply System: A WECF Publication.

MoPPW, 2005. National Drinking Water Quality Standards (NDWQS) and its Implementation Directives, Kathmandu :Ministry of Physical Planning and Work

Muller, 2008. A Study of the Factors Affecting Sustainability of Rural Water Supplies in Tanzania.

NMIP/DWSS, 2014. National Coverage and Functionality Status of Water Supply and sanitation in Nepal: Department of Water Supply and Sewerage

SWUSC, 2016. Record File: Salyankot Water Users and sanitation committee

UNICEF and WHO, 2013. Joint Monitoring Programme for Water and Sanitation.

UNICEF, 2016. Post Disaster Assessment of Water Supply: United Nations International Childrens Fund

Unit, G., 2011. LGCDP/MLD [Online].

WHO, 1993. WHO Water Quality Guideline

WHO, 1999. Guideline for Drinking Water Quality (Volume 3, second edition)

WHO, 1999. Water Risk Assessment Quideline

WHO, 2000. Guideline for Drinking Water Quality, Volume 1: UNEP.

WHO, 2000. WHO Guidelines for Drinking Water Quality, Third Edition

WHO, 2011. Guideline for Drinking Water Quality, 4$^{th}$ Edition

WHO and UNICEF, 2000. Global Water Supply and Sanitation Assessment Report

WHO and UNICEF, 2014. Global Water Supply and Sanitation Assessement Report,Volume II.

www.quakerelief.com, 2015. www.quakerelief.com.[online]

# ANNEX 1:

## POSSIBLE RISK AT SOURCE, TRANSMISSION AND DISTRIBUTION SYSTEM

### Possible Risk at Source and Transmission system:

### Risk 1: Risk due to Contamination by Floods

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| Once or more in a year | 5 | Heavy contamination causing major quality and quantity damage | 5 | Risk=16-25=risk score 4=significant risk |
| Once in 2 year | 4 | Medium contamination causing major quality/quantity damage | 4 | Risk=10-15=risk score 3=Medium risk |
| Once in last 3 year | 3 | Medium contamination causing medium quality/quantity damage | 3 | Risk=5-9=risk score 2= Insignificant risk |
| Once in last 5 years | 2 | Minor contamination causing minor quality/quantity damage | 2 | |
| Once in more than 5 year | 1 | Minor/no contamination | 1 | Risk=1-4=risk score 1= uncertain risk |

### Risk 2: Risk due to Disruption by Landslides

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| Once or more in a year | 5 | Major damage which affects large % of beneficiaries | 5 | Risk=16-25=risk score 4=significant risk |
| Once in 2 year | 4 | Major damage which affects small % of beneficiaries | 4 | Risk=10-15=risk score 3=Medium risk |
| Once in last 3 year | 3 | Minor damage which affects large % of beneficiaries, significant but manageable | 3 | Risk=5-9=risk score 2= Insignificant risk |
| Once in last 5 years | 2 | Minor damage which affects small % of beneficiaries | 2 | |
| Once in more than 5 year | 1 | Negligible damage on water quality | 1 | Risk=1-4=risk score 1= uncertain risk |

**Risk 3: Risk due to Drought**

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| Once or more in a year | 5 | Water source completely dried up | 5 | Risk=16-25=risk score 4=significant risk<br><br>Risk=10-15=risk score 3=Medium risk<br><br>Risk=5-9=risk score 2= Insignificant risk<br><br>Risk=1-4=risk score 1= uncertain risk |
| Once in 2 year | 4 | Water source up to 80% dried up | 4 | |
| Once in last 3 year | 3 | Water source up to 60% dried up | 3 | |
| Once in last 5 years | 2 | Water source up to 40% dried up | 2 | |
| Once in more than 5 year | 1 | Water source less than 20% dried up | 1 | |

(Source: FEDWASUN, 2015)

**Risk 4: Risk due to Human Activities**

| Likelihood | Score | Severity | Score | Risk (Likelihood*severity) |
|---|---|---|---|---|
| Is expected to occur in most circumstances; observed regularly in the field | 5 | Defecation and other major activity | 5 | Risk=16-25=risk score 4=significant risk<br><br>Risk=10-15=risk score 3=Medium risk<br><br>Risk=5-9=risk score 2= Insignificant risk<br><br>Risk=1-4=risk score 1= uncertain risk |
| Will probably occur in most circumstances; observed occasionally on the field | 4 | Washing/bathing and other activities, no defecation | 4 | |
| Might occur at some time; observed occasionally on the field | 3 | Agricultural practices, use of pesticides etc. | 3 | |
| Could occur at some time; has not been observed in the field | 2 | Rare human activities | 2 | |
| May occur only in exceptional circumstances; has not been observed in the field | 1 | Source prohibited | 1 | |

**Risk 5: Risk Related to Cleaning (including area near source and other structures)**

| Cleaning frequency | Risk score |
|---|---|
| More than year/Never | 4 (significant risk) |
| Six month to one Year | 3 (Medium risk) |
| Three to six month | 2 (Insignificant risk) |
| Less than three month/Monthly | 1 (Uncertain) |

## Possible Risk at Distribution System :

### Risk 6: Risk due to Water Quality Testing at Tap Level

| **Testing done** | **Risk score** |
|---|---|
| Testing on regular basis | 1 (uncertain risk) |
| Never | 4 (Significant risk) |

### Risk 7: Risk due to Piping

| **Types of pipe** | **Risk score** |
|---|---|
| Grounded | 1 (uncertain risk) |
| Exposed | 4 (Significant risk) |

### Risk 8: Risk due to Leakage from Transmission/Distribution Pipe line/joints

| **Likelihood** | **Score** | **Severity** | **Score** | **Risk** |
|---|---|---|---|---|
| Expected to occur in most circumstances; observed frequently | 5 | Major impact for large % of beneficiaries, litigation by beneficiaries | 5 | Risk=16-25=risk score 4=significant risk |
| probably occur in most circumstances; observed occasionally on the field | 4 | Major impact for small % of beneficiaries, large number of complaints | 4 | Risk=10-15=risk score 3=Medium risk |
| Might occur at some time; observed occasionally on the field | 3 | Minor impact for large % of beneficiaries, clear rise in complaints | 3 | Risk=5-9=risk score 2= Insignificant risk |
| Could occur at some time; has not been observed on the field | 2 | Minor impact for small % of beneficiaries | 2 | Risk=1-4=risk score 1= uncertain risk |
| May occur only in exceptional circumstances; has not been observed in the field | 1 | Negligible impact on water quality/quantity, service delivery or normal operations | 1 | |

**Risk 9: Risk due to Drainage near Main Pipeline (if pipe exposed)**

| Likelihood | Score | Severity | Score | Risk |
|---|---|---|---|---|
| Expected to occur in most circumstances; observed frequently | 5 | Major quality impact for large % of beneficiaries, litigation by beneficiaries | 5 | Risk=16-25=risk score 4=significant risk |
| probably occur in most circumstances; observed occasionally on the field | 4 | Major quality impact for small % of beneficiaries, large number of complaints | 4 | Risk=10-15=risk score 3=Medium risk |
| Might occur at some time; observed occasionally on the field | 3 | Minor quality impact for large % of beneficiaries, clear rise in complaints | 3 | Risk=5-9=risk score 2= Insignificant risk |
| Could occur at some time; has not been observed on the field | 2 | Minor quality impact for small % of beneficiaries | 2 | Risk=1-4=risk score 1= uncertain risk |
| May occur only in exceptional circumstances; has not been observed in the field | 1 | Negligible impact on water quality, service delivery or normal operations | 1 | |

(Source: FEDWASUN, 2015)

**Risk 13: Risk Related to Governance**

| Scheme Governing Activities | Risk score |
|---|---|
| No timely GA, no public/social audits, no tariff collection, no trained CT (none for these four activities) | 4 (Significant risk) |
| Only one-two of four activities done | 3 (Medium risk) |
| Up to three of four activities done | 2 (Insignificant risk) |
| Timely GA, no public/social audits, regular tariff collection, trained CT (all four activities done) | 1 (uncertain) |