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TRANSFORMATION TOWARDS SUSTAINABLE
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Mapping and analysis of the disaster risk of water supply schemes by using mobile application

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After the earthquake of Nepal in 2015, a study was conducted the risk mapping and carried out analysis of the selected water supply scheme (WSS) at all links in the water supply chain from source to consumers and also determined the functionality status of WSS in the post-earth quake scenario by developing a standardized user guidebook and methodologies. A mobile based tool KOBO was used to collect the data and information and findings were linked with Google Earth. The assessment was conducted in 1504 WSS in 7 severely earth quake affected districts. Different 16 risks were identified and the assessment was conducted by developing the score in different 5 parameters. The overall risk has been classified in to three categories. It was found that 21.4% of the total schemes have high risk, 21.7% of the schemes have medium risk and 56.9% of the schemes have low risk.

Background

The Government of Nepal aims to achieve universal access to improved water supplies and sanitation systems by 2017. The national census of 2011 reported access to improved water supplies at 85 per cent and improved sanitation systems at 62 per cent. The 2011 census also reported that the rural open defecation rate stood at 45 per cent. These figures are further reconfirmed by Multi Indicator Cluster Survey (MICS) 2014 which reports improved water supply coverage at 93% and improved sanitation at 60%. However, the report states significant risk in drinking water quality with 82% of households has e-coli risk at household level and 71% household having e-coli risk at source.

The quality of water at source could have further deteriorated due the massive earthquake of 7.8 magnitude that occurred in Nepal on 25 April 2015 as WASH facilities have also been greatly affected in the country. The Government of Nepal has categorized 14 districts as the most affected and other 17 districts moderately affected also for the Water, Sanitation and Hygiene (WASH) sector beside other sectors. The Post Disaster Need Assessment (PDNA) has reported that there has been damage and losses equivalent of USD 114 million in the WASH sector. The summary findings of WASH PDNA shows that out of a total of 11,288 water supply systems in 14 severely affected districts, 1570 sustained major damages and 3,663 were partially damaged and that 220,000 toilets were partially or totally destroyed.

It was also reported that the total needs for recovery and reconstruction using the principle of building back better is estimated at NRS 18.1 billion (177.4 Million US$). In order to address sector needs, it is very important to ensure that WASH interventions are based on a robust assessment of and analysis of disaster risks.

In this regards this study was conducted to access the information and creating the data base of the users committee and water supply schemes by using the mobile application and Google earth.

Objectives of the study

The risk mapping of water supply services aims to identify the risks associated in the smooth operation and management of water supply services particularly in the post-earthquake scenario where more than 1,570

schemes have sustained major damage as per the PDNA report. This has increased the disaster risks and vulnerability of the schemes in terms of water production, distribution and functionality. The mapping and analysis of disaster risks of water supply schemes will provide insight that will help the District/Municipal and Village WASH Coordination Committees, Water Supply and Sanitation Division/Subdivision Offices and Water Users and Sanitation Committees to prioritize the recovery and reconstruction of water supply schemes and sanitation services to ensure access to safe and adequate WASH services to the people.

The specific objectives of the study are as follows:

- To conduct risk mapping and analysis of 1,500 water supply schemes at all links in the water supply chain from source to consumers from the perspective of Significant, Medium, Insignificant and Uncertain risks;
- To identify whether Water and Sanitation Users Committees (WSUCs) of water supply schemes in 7 most affected districts have implemented Water Safety Plan and thereby carried out risk mapping of water supply schemes prior to the earthquake;
- To determine the functionality status of water supply schemes (WSS) in the post-earthquake scenario in terms of minor, major, rehabilitation and reconstruction support needs.

Methodology

The study included both qualitative and quantitative methods of data collection, and both secondary and primary data was used to carry out this study. The secondary data was in the form of study teams visiting each water supply scheme as well as the Water Supply and Sanitation Division Offices (WSSDO) at each of the seven districts to collect a list of the water supply schemes. A standardized user guide book was prepared to collect data from each of the scheme. The research team collected data on risks and vulnerabilities using the following method.

The following process was adopted while conducting the assessment:

- A mobile-based application was designed using the KOBO tool to collect data through a questionnaire.
- A team of engineers (field officers) were trained and deployed for the data collection. Two engineers were deployed per each district to collect data. The data collection in the field took almost three months per district (Jan 2016 – March 2016).
- A focus group discussion was conducted with users and members of water supply scheme management committees to understand and document the risks at the scheme level and with users of the water supply to understand risks.
- Observation and transect walk of the scheme and its catchment area was carried out for sanitary inspection of the scheme and the community.
- The real time data was uploaded and checked by the research coordinator along with the data management specialist and IT specialists within the same day and feedback provided, if needed.
- A water quality test (existence of Coliforms) using P/A vial was carried out at one tap per scheme to determine the water quality. It is considered as a proxy indicator to determine water quality.
- The GPS coordinates of each scheme was taken to locate the scheme for future reference and linked with Google Earth along with a database summary.
- All the raw data was analyzed and processed using ArcView GIS, SPSS and MS Excel.

Methods

The following methods were used for this study.

Desk review: A review of policy was the first and foremost task of the team to finalize tools and instruments. Policies, reports and databases were assessed and analyzed to finalize parameters and tools.

Development of tools and pre-test: A mobile-based application was designed using KOBO to collect data along with a questionnaire.

Stakeholder consultation: The software was pretested and approved in consultation with the Department of Water Supply and Sewerage (DWSS) /UNICEF/Federation of Drinking Water and Sanitation Users' Nepal (EDWASUN).

Mobilization of engineers: 15 civil engineers were first trained and then mobilized in seven districts undertake a risk assessment of water supply schemes and collect data as per the designed tool.

Checks and updates: All the data was checked and updated on a regular basis immediately after it was entered into the system.
Risk assessment: Both quantitative and qualitative data was used to determine the level of risk. Both component level and overall risks were identified using standard criteria.
Risk classification: All 1,504 schemes were classified by the level of risk adopting a holistic approach that referred to international practice.

Approach

The assessment used a participatory approach to collect data. Members of water users groups and other stakeholders were consulted to understand the situation. The field engineer also visited and observed the situation to confirm the risk level. Altogether 16 risks indicators were examined during the assessment. The list of indicators were: Risk due to - contamination by floods, contamination/disruption by landslides, drought, human activities, cattle grazing, cleaning, contamination from waste collection sites, sedimentation, filtration, chlorination, lack of backwashing facilities, status of water quality as per test, quality of pipes used, leakage from main pipeline/joints, drainage near pipelines are the identified.

All of the risk indicators other than the drought and governance risk indicators have been considered to calculate the overall risk of the schemes. Schemes with river/stream source having no treatment (sedimentation, filtration and chlorination) at all accounts for a high scheme risk. Further assessment is done based on a weighted risk score. A total weighted risk score greater than 24 accounts for a high scheme risk, a total weighted risk score between 12 and 24 accounts for a medium scheme risk, and a total weighted risk score of less than/equal to 12 accounts for a low scheme risk.

Table 1. Risk assessment category and score

Risk Category	Score
High	>19
Medium	10 -19
Low	<10

Risk Matrix:
Risk can be defined as a function of likelihood and the severity of the impact.
RISK = LIKELIHOOD × SEVERITY
Risk matrix had been used to assess the risk imposed by any hazardous events; first the team assessed the likelihood of occurrence of hazardous events. Then, the team assessed the severity of impact of these events.

The following Risk Matrix has been used to determine the risk level.

Table 2. Risk matrix and scoring

Risk	Significant	Medium	Insignificant	Uncertain
Range of Matrix	16-25	10-15	5-9	1-4

Table 3. Risk matrix and scoring

		Severity				
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Likelihood	Almost certain	5	10	15	20	25
	Likely	4	8	12	16	20
	Possible	3	6	9	12	15
	Unlikely	2	4	6	8	10
	Rare	1	2	3	4	5

Major findings

This study includes a total of 1,504 WUSCs from the 7 districts (put the name of districts) most affected by EQ where the selection was carried out in consultation with DWSS, DWASHCC, District chapter of FEDWASUN and VWASHCC. Among the 1,504 schemes, while majority of the schemes were gravity flow type (92.2%), the most prevalent source of water is recorded as spring (75.6%) followed by stream (17.9%). Similarly, majority of the schemes were considered to be safe since 1,173 scheme has the safe source; 36 from boring and 1,137 from spring source. Further, there were only 5% (83 cases) of wards (where the water source is located) that were ODF after EQ and districts such as Kavre and Ramechhap were poor in terms of ODF attainment. Despite the severe impact of the aftershock in Dolakha, the district recorded only 6 schemes as nonfunctional and that might be related to the quick recovery of the system.

A total of 777 schemes out of 1,504 were not fully functional that is either non-functional (158) or partially functional (619). For the non-functionality, the major reason is recorded as EQ (68.2%) followed by drought either due to EQ or climate change (12.6%). For the recovery, majority of the schemes require major repair (41.1%) followed by minor repair (27.7%), rehabilitation (20.6%) and reconstruction (10.7%). Almost all non/partially functional schemes (753 schemes out of 777, 96.9%) are re-habitable.

Table 4. Overall risk of schemes

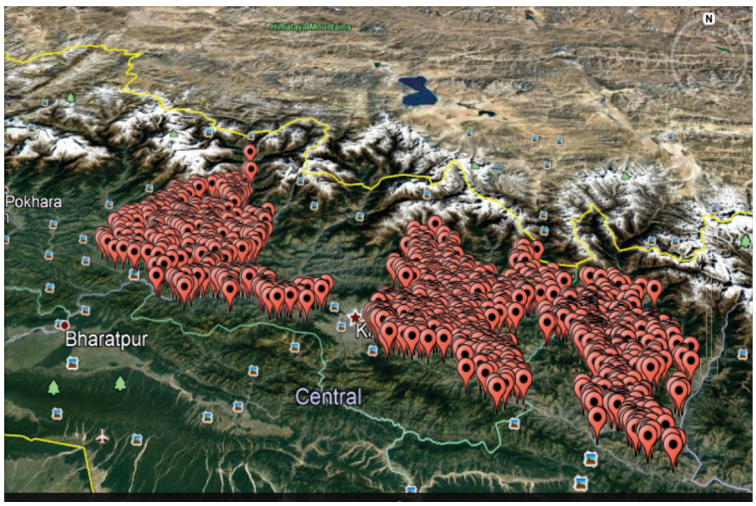
District	**Overall risk class**						
	High		Medium		Low		
	No.	%	No	%	No.	%	Grand Total
Bhaktapur	18	21.2	32	37.6	35	41.2	85
Dhading	92	38.2	105	43.6	44	18.3	241
Dolakha	32	10.6	22	7.3	248	82.1	302
Gorkha	90	34.6	85	32.7	85	32.7	260
Kavre	20	9.5	33	15.6	158	74.9	211
Ramechhap	57	39.3	21	14.5	67	46.2	145
Sindhupalchok	13	5.0	28	10.8	219	84.2	260
Grand Total	322	21.4	326	21.7	856	56.9	1504

Majority of schemes fall under the category of uncertain (55.5%) and significant risk (16.1%) due to flood. The rest fall under the medium and significant risk mostly due to seasonal flash floods, with severe impacts in Dhading and Ramechhap. Similarly, majority of schemes fall under the category of "Uncertain (53.3%) /Insignificant (24.1%)" risk due to landslides. Only 7.4% of scheme possesses significant drought risk and 13.2% possess medium risk. Majority of schemes with significant drought risk (34) was recorded for Dhading followed by, 28 for Gorkh a. Furthermore, 11.2% of the schemes had poor cleaning practices (once in > a year or never) while 45.7% schemes had very good cleaning practice (monthly). In addition, human activities contributing to "Significant" risk was found very low i.e. 3.6%. Similarly, cattle grazing near the source are contributing less to have significant (2.4%) and Medium (7.8%) risk. Likewise, the contamination from waste collection site imposes very little risk; 2% medium risk and 0.6% significant risk.

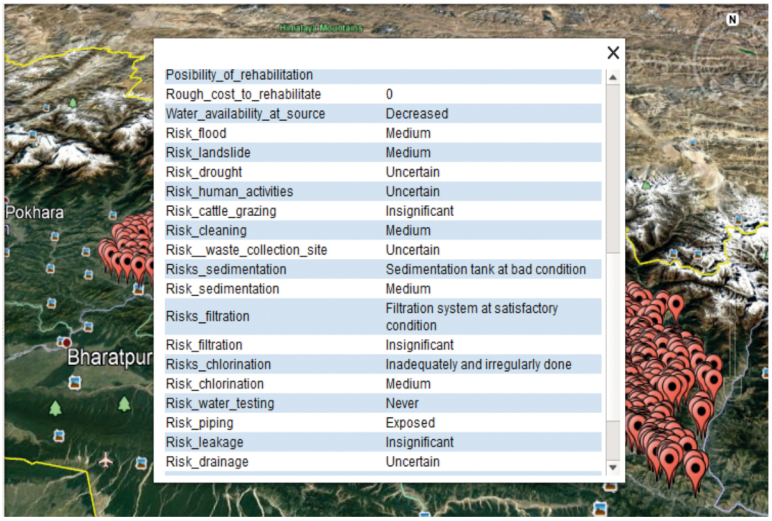
In terms of water safety, 84% of the schemes did not have a sedimentation tank imposing significant risk while 10.6% were identified to have sedimentation tank but in a very bad condition (imposing the medium risk). Moreover, some cases were identified where the source is river/stream and were not facilitated with the sedimentation tank, contributing higher overall risk. Similarly, a total of 83.4% had no filtration system at all (imposing significant risk) while only 4.1%, have fully functioning filtration systems (imposing the uncertain risk). Further, 11.2% had filtration systems in a very bad condition (imposing medium risk). Similarly, there were only 57 schemes that carried out regular and adequate chlorination whereas 77.8% of schemes were not chlorinated at all (imposing significant risk). A significant number of schemes, i.e. 201 (13.4%) were found to have been chlorinated inadequately or irregularly or with very little knowledge of chlorination (imposing medium risk). 76 WUSCs did chlorination only during risky periods such as during the monsoon season. This could be as dangerous as not undertaking chlorination. In addition, there are only a few cases, 10.7%, that carry out water quality testing.

Nevertheless, approximately half of the schemes; 51.8%, had grounded pipes laid properly through the layout. In relation to the risks due to leakage from main pipelines, majority of scheme possesses insignificant risk (43.8%) followed by uncertain risk (32.9%). Further, majority of the schemes had "Uncertain (88%)/Insignificant (6.4%)" drainage risks. In regard to governance structures, majority of the schemes show the uncertain risk (492 cases) followed by medium (420) and significant (323). The water schemes at Ramechhap and Dolakha did not contain coliform during testing. There was only 9.7% of schemes that contain coliform. The few cases of coliform presence of might be related to spring source (which are mostly considered safe) in most of the scheme, the dry season (with limited flooding of source and contamination) or may be low ambient temperature as the test was carried out during the winter season.

The overall risk of the schemes show that majority of schemes have low risk (856 cases out of 1,504 accounting to 56.9%), followed by medium risk (326 cases out of 1,504 accounting to 21.7%) and high risk (322 cases out of 1,504 accounting to 21.4%). Finally, the risk assessment of each individual scheme has been mapped in ArcGIS and linked to Google Earth with its coordinates and database summary to trace its location. This can be updated in timely manner to monitor the progress.



Photograph 1. View of Google Earth mapping



Photograph 2. View of information of scheme in Google Earth

Conclusion

Since this study assessed the risks at 1,504 individual schemes, the databases itself is a tool for the planning and improvement the efficiency of schemes and minimize the risks. The database will be useful for the future endeavours and to prepare action plan to address institutional and programmatic issues.

- The existing database and its sharing mechanism at district look very weak. There is almost no existence of such database at district. An arrangement and ownership of this kind of data should be in place and duplication of similar activities should be avoided. This should be owned by DWASHCC, MWASHCC and VWASHCC along as well as WSSDO, FEDWASUN and local governments.
- This database should be used for the planning process where the high-risk project should provide the first priority. Micro-level assessment will be useful at project level while preparing water safety and other micro-planning of the project.
- All the agencies in the district should use this data and provide support to update it periodically. DWASHCC, MWASHCC and VWASHCC along with WSSDO and FEDWASUN and other stakeholders in all of the districts should use this information as a baseline. This is real time data of individual projects and not generated from the sample.
- The tools like overall database with level of risk, Google link with GPS coordinates, summary data and the colour code are very useful to track the projects and see the progress in the future.
- The district level institutions' capacity should be enhanced to update data periodically and sharing through WSSDO and FEWASUN as public information. The "Co-ordination Committees" at different levels should not allow any institution to work in the area without referring this database.
- This database should be shared widely and used for the planning process from district to villages. The new project information as well as interventions on these projects (existed in database) should be periodically updated using simplified MS Excel based format provided along with this report.

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References

GON 2015 *Post Disaster Need Assessment.* Government of Nepal. Kathmandu: Nepal

AWWA 1990 *Water Quality and Treatment: A Handbook of Community Water Supplies*. American

CENTRE FOR HOUSING RIGHTS AND EVICTIONS *2008 Legal Resources for The Right to Water, International and National Standards – 2nd extended diction, Right to Water Programme*. Centre on Housing Rights and Evictions. Geneva: Switzerland

GON/NPC 2013, *Nepal Millennium Development Goals, Progress Report 2013*. Kathmandu: Nepal

GON 2014 *Second Joint Sector Review (Technical Report), Ministry of Urban Development*, Sector Efficiency Improvement Unit: Nepal

FEDWASUN 2012 *The Right of Children, Women and Socially Excluded people in drinking water and sanitation. FEDWASUN* . Kathmandu: Nepal

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