

Vulnerability and risk mapping at the municipality level in Dailekh and Sarlahi districts of Nepal: Visualization through an online dashboard

Summary

This research assesses climate change vulnerabilities and risks to water, sanitation and hygiene (WASH) systems at the municipal level in the Dailekh and Sarlahi districts of Nepal. The study integrates over 115 socioeconomic, biophysical and climatic indicators using a six-step risk assessment methodology. Results reveal that municipalities such as Aathabis and Dullu in Dailekh and Ishworpur and Balara in Sarlahi are at very high risk due to significant vulnerabilities and low adaptive capacity. A dashboard was developed to visualize these vulnerabilities, aiding local governments in prioritizing climate adaptation and risk mitigation strategies. This tool also facilitates informed planning for future intervention activities, especially for marginalized and vulnerable communities.

Introduction

Globally, climate change and its impacts are highly visible, affecting various aspects of human society and ecosystems. In Nepal, the effects of climate change are evident across multiple sectors, including water resources, agriculture, forests and biodiversity, and energy. Despite several policies being developed at the federal level, their effective implementation at the local and community levels remains challenging. This is due to limitations such as the lack of integrated and reliable data and information on the various facets of climate change impacts at the local and community levels.

Nepal ranks as the ninth most climate-vulnerable country (Eckstein et al. 2021), with 80% of its population—particularly women, girls, persons with disabilities and marginalized groups—facing risks from climate-induced natural hazards (MoHA 2018; MoFE 2021a). Published studies and research show knowledge gaps in most of the municipalities in Karnali and Madhesh provinces in Nepal (IWMI 2021; MoFE 2021b), indicating a limited understanding of and capacity to integrate gender equality, disability and social inclusion (GEDSI) considerations into the planning and implementation of water, sanitation and hygiene (WASH) services. These knowledge gaps also hinder efforts to address climate risks in the context of climate change and anthropogenic factors.



Residents fetching domestic water and washing clothes at a public water tap for daily purposes in Dailekh District (photo: Vision360).

Climate change has severe impacts on WASH systems in Nepal. Changes in precipitation patterns, rising temperatures and extreme weather events impact water quantity and quality, adversely affecting WASH systems. Furthermore, climate-induced hazards such as floods, landslides, droughts and wildfires not only damage WASH systems but also disproportionately affect the poor, vulnerable and marginalized populations (MoHA and DpNet 2009; Dhimal et al. 2021). The WASH sector's sensitivity to climatic change means that disruptions of WASH systems can directly affect local communities in providing water-related essential services such as safe drinking water supply, sanitation infrastructure and hygiene practices. Therefore, a better understanding of hazards, vulnerabilities, risks and exposure at the municipality level is crucial for local decision-making processes.

Against this backdrop, this study aims to map the risks and vulnerabilities incurred by climate-induced hazards in municipalities and WASH systems in Dailekh District of Karnali Province and Sarlahi District of Madesh Province in Nepal and visualize them through an online dashboard.

Data and method

Understanding vulnerabilities and risks at the municipal level through socioeconomic, biophysical and climatic indicators is crucial for effective risk mitigation. To address this, we mapped

the hazards, vulnerability and exposure to assess the risk (IPCC 2014) of municipalities in Dailekh and Sarlahi districts using more than 115 indicators. The method begins with identifying the indicators, weighing the indicators and finally, assessing the risk (Figure 1). As defined by IPCC (2014), risk is a function of hazard, vulnerability and exposure (Figure 2). Dailekh District has 11 municipalities, including 4 urban municipalities (UM) and 7 rural municipalities (RM), while Sarlahi District comprises 20 municipalities, with 11 UM and 9 RM. These indicators were developed using secondary data collected from various sources such as the Central Bureau of Statistics (CBS), the Department of Hydrology and Meteorology (DHM), the National Disaster Risk Reduction Management Authority (NDRRMA) and many others (see the reference section of the Municipality and System Level Vulnerability, Risk and Resilience mapping [MULVAR] dashboard¹). These data include both climatic (e.g., landslides, floods, extreme weather events) and non-climatic data (e.g., demography, the number of male migrants, the percentage of Dalit population, the number of persons affected by various diseases).

We used a six-step method to conduct the final risk assessment at the municipal level (Figure 1). In this assessment, risk was defined as the function of hazard, vulnerability and exposure. Vulnerability was calculated based on sensitivity and adaptive capacity, as defined by IPCC (2014), using multiple indicators (Table 1 and Figure 2).

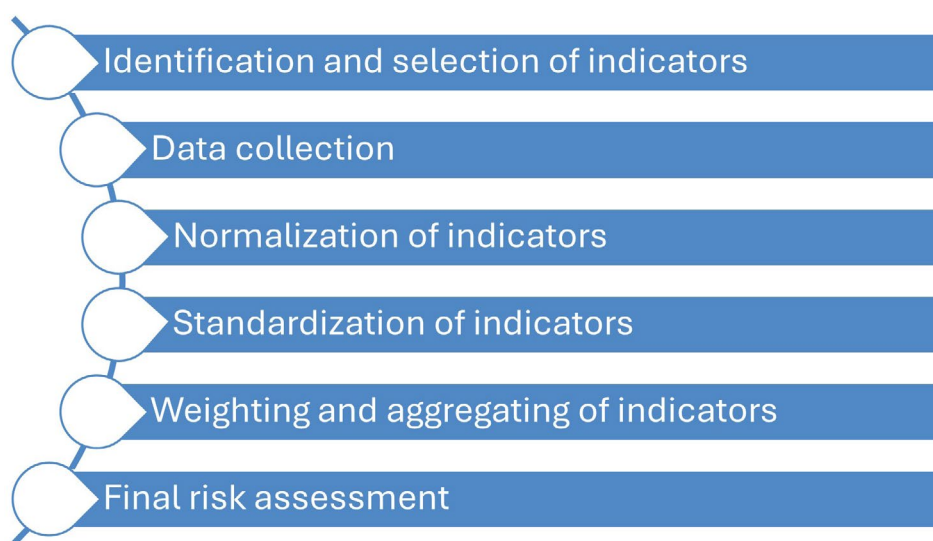


Figure 1. A six-step method to estimate risk at the municipality level in Dailekh and Sarlahi districts.

Table 1. Number of indicators within different components of vulnerability and risk.²

Components	Total number of indicators	Number of indicators used in	
		Dailekh	Sarlahi
Exposure	37	24	26
Sensitivity	55	40	40
Adaptive capacity	24	20	21
Hazard	66	34	32
Total	182	118	119

¹ Visit the dashboard: <https://thegiis.org/giis-data/mulvar>

² The list of indicators can be found in the MULVAR dashboard.

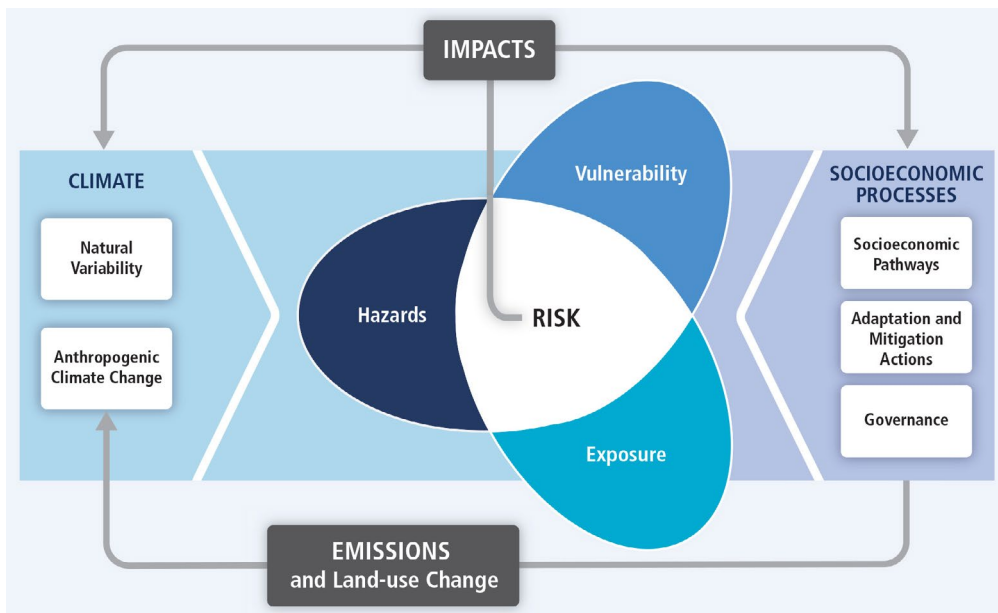


Figure 2. Core concepts of risk assessment where risk is a function of hazards, vulnerability and exposure.

Source: IPCC (2014)

Notes: Risk = Hazards * Vulnerability * Exposure

Here, Vulnerability = Sensitivity * Adaptive capacity

First, the indicators were developed using secondary data collected from various sources. These indicators were normalized based on the max-min approach, transforming raw values to a range between 0 and 1. Before normalization, multicollinearity tests were conducted among the indicators.

The normalized data were then standardized across indicators, and the final aggregation of indicators was completed. A composite map of each component—exposure, sensitivity, adaptive capacity and hazard—was subsequently developed, and finally, a risk map was produced.



A small drum being used for water storage in a household of Dailekh District, Nepal, in the absence of a piped water supply in their premises (photo: Vision360).

Outcomes

Vulnerability and risk in municipalities of Dailekh

Our assessment suggests that Mahabu rural municipality falls into the very high hazard category, while Aathabis UM, Thantikandh UM and Bhairabi RM can be classified in the very low hazard category (Figure 3). Similarly, Aathabis UM exhibits very high sensitivity compared to the very low sensitivity observed in Bhairabi RM, Narayan UM, Dungeshwor RM and Bhagawatimai RM. Particularly, the adaptive capacity of Narayan municipality is very high compared to the very low adaptive capacities of Thantikandh UM, Naumule RM and Chamunda Bindrasaini UM. The overall assessment suggests that Aathabis and Dullu UMs are very high-risk municipalities due to high

vulnerability (characterized by high sensitivity and low adaptive capacity) and high exposure (to various diseases). Aathabis UM has a high percentage of the Dalit population, and Dullu UM has a high number of girls and women who are directly exposed to risks related to WASH systems. In contrast, Dungeshwor, Bhagawatimai and Bhairabi RMs are very low-risk municipalities as they are less vulnerable, have medium hazards and have very low exposure to multiple hazards. For example, these three rural municipalities have a very low number of girls and women who are primarily responsible for fetching water for domestic use, reducing their sensitivity. Similarly, Dungeshwor and Bhairabi RMs have a low to very low number of landslide incidents and Bhagawatimai RM has a very low number of flood incidents responsible for impacting WASH systems.

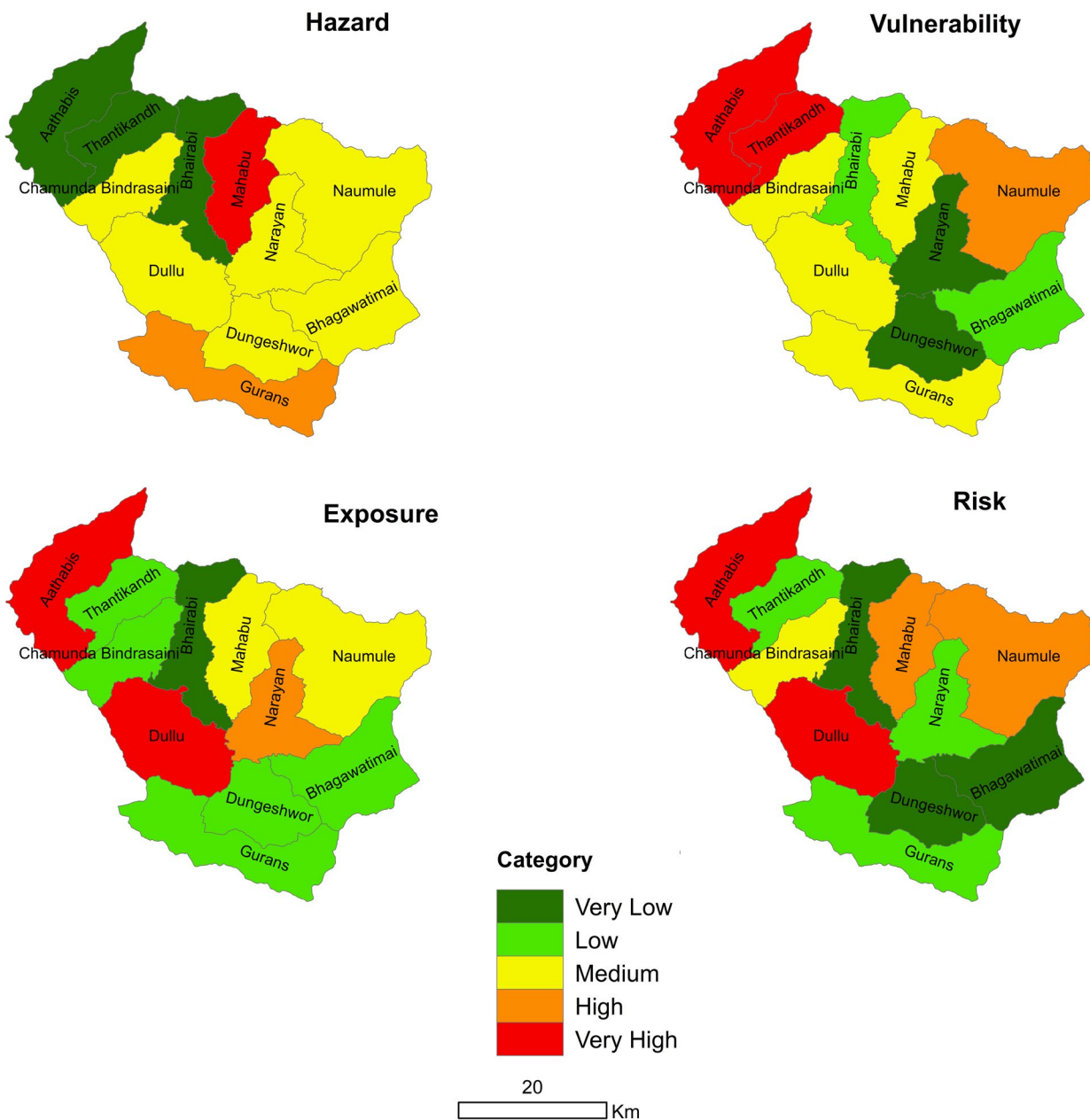


Figure 3. Hazard, vulnerability, exposure and risk mapping of the municipalities in Dailekh District.

Vulnerability and risk in municipalities of Sarlahi

The vulnerability and risk assessment of Sarlahi District suggests that Haripur UM falls under the very high hazard category, while municipalities such as Chandranagar RM, Bishnu RM and Basbariya UM are in the very low hazard category (Figure 4). Similarly, the eastern municipalities are highly sensitive to external hazards compared to municipalities such as Malangwa and Lalbandi, which display very low sensitivity. The adaptive capacity of Malangwa municipality is very high compared to the very low adaptive capacities in Parsa, Dhankaul and Chandranagar RMs and Basbariya and Haripurwa municipalities, which reflects a low risk to multiple hazards in the municipality. The assessment suggests that Ishworpur and Balara are very high-risk municipalities. Balara UM experiences a high frequency of consecutive dry days and maximum temperatures, which significantly reduces water availability. Ishworpur municipality

and its vicinity are highly sensitive due to the large indigenous populations, which makes it a high-risk municipality. Further, these municipalities lack sufficient adaptive capacity in terms of high-quality domestic water supply as their systems do not have proper covers for their wells and ponds.

In contrast, Bagmati UM, Parsa RM, Ramnagar RM, Bishnu RM, Basbariya RM, Kaudena RM and Malangwa UM are very low-risk municipalities in Sarlahi District. These municipalities are highly adaptive in terms of daily water availability for WASH services. With high adaptive capacity, Malangwa UM falls under the low vulnerability category even though it experiences high hazard and exposure levels. For instance, they have a higher percentage of households with tube wells and hand pumps. Further, these municipalities are also less sensitive as they have fewer girls and women aged above 15 who are directly involved in fetching water for domestic use.

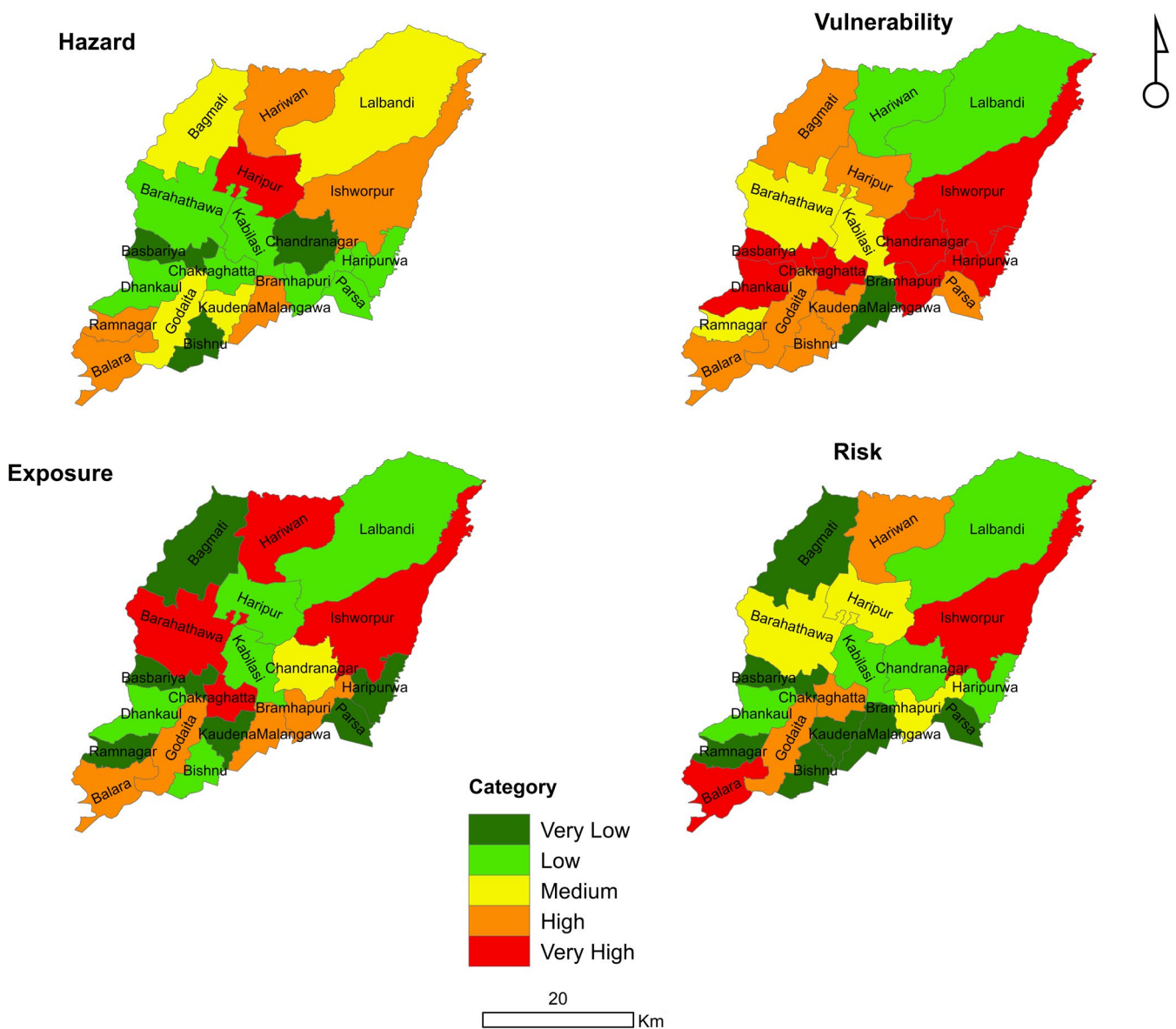


Figure 4. Hazard, vulnerability, exposure and risk mapping of the municipalities in Sarlahi District.

The dashboard

We created a [dashboard](#) to visualize the municipality and system-level vulnerability and risk assessments for Dailekh and Sarlahi districts (Figure 5). The dashboard presents different components of vulnerability and risk, as well as cumulative risk and vulnerability. Users can select provinces, districts, individual indicators, components and composite values of vulnerability and risk to produce interactive maps. The maps display five categories (very low to very high) for each indicator, component and overall vulnerability and risk, enabling users to quickly identify the status of municipalities in terms of individual indicators and components of vulnerability and risk. Normalized values are used for visualization in the dashboard. However, users can also download the raw data (secondary). Municipalities can

use this raw data for planning related to climate adaptation, disaster risk mitigation, development activities and service delivery strategies in the WASH sector.

The overall risk assessment shows that Dullu and Aathabis municipalities fall under the very high-risk category in Dailekh District, while Ishworpur and Balara municipalities fall under the very high-risk category in Sarlahi District. In contrast, Dungeshwor, Bhagwatimai and Bhairabi rural municipalities in Dailekh, along with Bagmati, Parsa, Ramnagar, Bishnu and Basbariya municipalities in Sarlahi, are categorized as very low-risk areas. These results suggest that the high-risk municipalities are exposed to multiple threats of hazards, while the low-risk municipalities either experience fewer hazards or have high adaptive capacity compared to others.

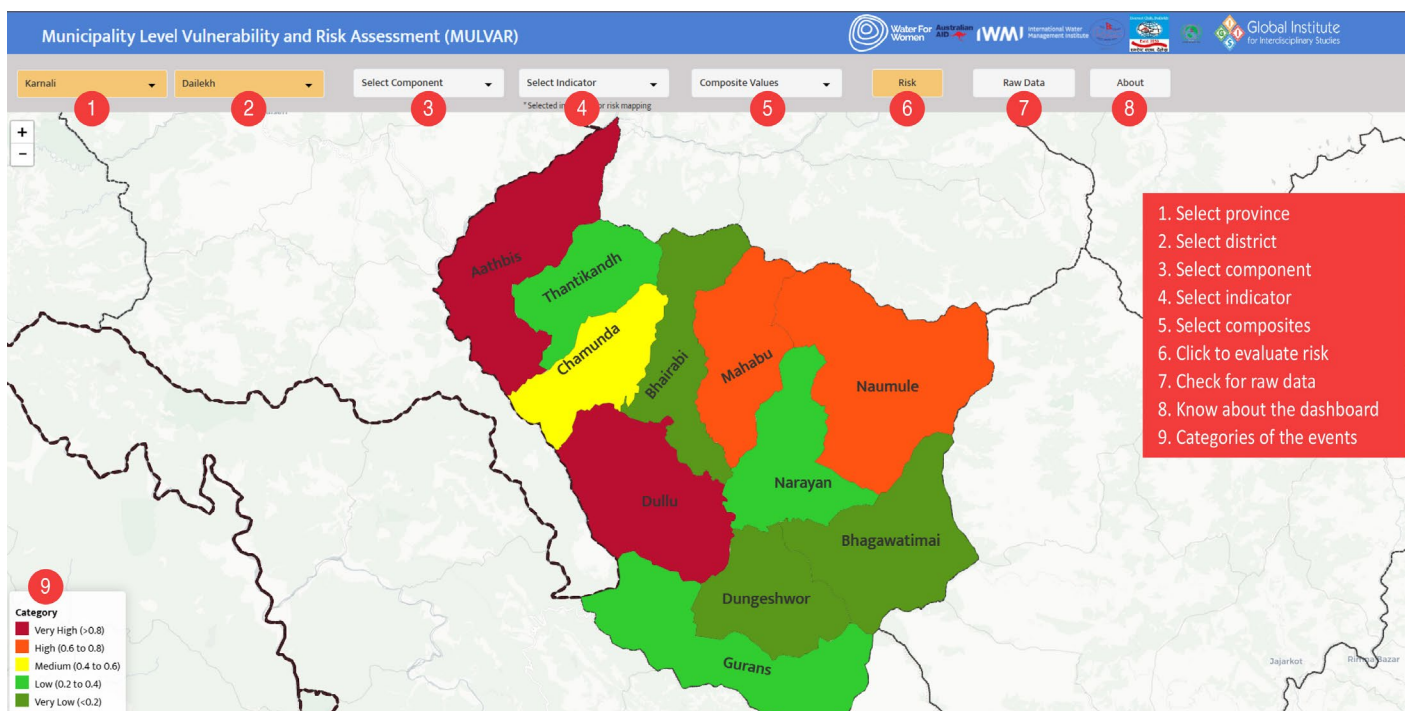


Figure 5. An overview of the dashboard (presenting Dailekh as an example) used for visualization and informed decision-making.

Notes: The numbers from 1 to 9 show the steps used for effective visualization.

Visit the dashboard at <http://thegiis.org/giis-data/mulvar>

Recommendations

- Municipalities with high-risk scores (for example, Ishworpur UM in Sarlahi and Aathabis UM in Dailekh) across various indicators can use this information in planning future activities to improve and reach lower risk categories.
- Historical records indicate that the two municipalities, Mahabu RM in Dailekh District and Haripur UM in Sarlahi District, face multiple hazards with high severity. These municipalities should prioritize hazard mitigation and adaptation in their upcoming plans and activities.
- Climate change risk-based WASH planning should be incorporated into WASH policies and plans to enhance resilience against climate-related risks.
- The dashboard provides municipalities with status updates at the district level, facilitating informed decision-making. This can be further extended with new indicators and more specific information related to the system level, which can then be fed into the local planning process.



A participant explores the MULVAR dashboard during a knowledge-sharing workshop in Kathmandu, Nepal (photo: Vision360).

References

- Dhimal, M.; Bhandari, D.; Dhimal, M.L.; Kafle, N.; Pyakurel, P.; Mahotra, N.;...Müller, R. 2021. Impact of climate change on health and well-being of people in Hindu Kush Himalayan Region: A narrative review. *Frontiers in Physiology* 12: 651189. <https://doi.org/10.3389/fphys.2021.651189>
- Eckstein, D.; Künnel, V.; Schäfer, L. 2021. *Global climate risk index 2021: Who suffers most from extreme weather events? Weather-related loss events in 2019 and 2000-2019*. Bonn, Germany: Germanwatch. 52p.
- IPCC (Intergovernmental Panel on Climate Change). 2014. Summary for policymakers. In: Field, C.B.; Barros, V.R.; Dokken, D.J.; Mach, K.J.; Mastrandrea, M.D.; Bilir, T.E.; Chatterjee, M.; Ebi, K.L.; Estrada, Y.O.; Genova, R.C.; Girma, B.; Kissel, E.S.; Levy, A.N.; MacCracken, S.; Mastrandrea, P.R.; White, L.L. (eds.) *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, USA: Cambridge University Press. pp.1–32.
- IWMI (International Water Management Institute). 2021. *A gender perspective to understanding and enhancing the functionality of water supply systems in Nepal*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 8p. <https://hdl.handle.net/10568/111794>
- MoFE (Ministry of Forests and Environment). 2021a. *Vulnerability and risk assessment and identifying adaptation options: Summary for policy makers*. Kathmandu, Nepal: Ministry of Forests and Environment, Government of Nepal. 184p. Available at https://reliefweb.int/attachments/df975b3-a953-3eb3-8e03-ff8772854cf8/Vulnerability_Report_1622809902_compressed.pdf (accessed on November 18, 2024).
- MoFE. 2021b. *Vulnerability and risk assessment and identifying adaptation options in the water, sanitation and hygiene (WASH) sector in Nepal*. Kathmandu, Nepal: Ministry of Forests and Environment, Government of Nepal.
- MoHA (Ministry of Home Affairs). 2018. *Nepal Disaster Report 2017: The road to Sendai*. Kathmandu, Nepal: Ministry of Home Affairs, Government of Nepal. 92p. Available at https://www.undp.org/sites/g/files/zskgke326/files/migration/np/Nepal_Disaster_Report_2017.pdf (accessed on November 18, 2024).
- MoHA; DPNet (Disaster Preparedness Network-Nepal). 2009. *Nepal Disaster Report 2009: The hazardscape and vulnerability*. Kathmandu, Nepal: Ministry of Home Affairs (MoHA), Government of Nepal; Kathmandu, Nepal: Disaster Preparedness Network-Nepal (DPNet). 208p. Available at https://www.undp.org/sites/g/files/zskgke326/files/migration/np/UNDP_NP_Nepal-Disaster-Report-2009_The-Hazardscape-and-Vulnerability.pdf (accessed on November 18, 2024).



A woman carrying water in a bucket from a tube well in Sarlahi District. Untreated water drawn directly from the tube well poses health risks to local communities in the Terai Region of Nepal (photo: Vision360).

Authors

Santosh Nepal, Researcher - Water Resources and Climate Change, International Water Management Institute (IWMI), Kathmandu, Nepal (s.nepal@cgiar.org)

Anil Aryal, National Researcher - Water Resources Management, International Water Management Institute (IWMI), Kathmandu, Nepal (a.aryal@cgiar.org)

Uttam Babu Shrestha, Executive Director - The Global Institute for Interdisciplinary Studies (GIIS), Kathmandu, Nepal (ubshrestha@yahoo.com)

The project

This two-year (2023–2024) research project titled *Addressing climate vulnerability in Nepal through resilient inclusive WASH systems (RES-WASH)* is implemented by the International Water Management Institute (IWMI) office in Nepal in collaboration with Bagmati Welfare Society Nepal (BWSN), the Global Institute for Interdisciplinary Studies (GIIS), Everest Club, Dailekh (EC) and the National Association of Rural Municipalities in Nepal (NARMIN). The project is funded by the Water for Women Fund, a key initiative of the Department of Foreign Affairs and Trade (DFAT) as part of the Australian Aid program.

Contacts

Dr Santosh Nepal, IWMI, Kathmandu, Nepal (s.nepal@cgiar.org)

Dr Uttam Babu Shrestha, GIIS, Kathmandu, Nepal (info@thegiis.org)

IWMI
International Water
Management Institute



IWMI is a CGIAR Research Center

The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, civil society and the private sector to solve water problems in developing countries and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services and products with capacity strengthening, dialogue and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a CGIAR Research Center with offices in 15 countries and a global network of scientists operating in more than 55 countries.

**International Water
Management Institute (IWMI)**

Headquarters

127 Sunil Mawatha, Pelawatte,
Battaramulla, Sri Lanka

Mailing address:

P. O. Box 2075, Colombo, Sri Lanka

Tel: +94 11 2880000

Fax: +94 11 2786854

Email: iwmi@cgiar.org

www.iwmi.org