Multi-Hazard Early Warning System (MHEWS) in Janaki Rural Municipality: A GIS Perspective

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Key words: Disaster, Early-warning, Network Analysis, Siren

SUMMARY

Addressing the increasing harshness of Climate change, disasters like floods, heat waves, fires, lightning, and storms have been common in Janaki Rural Municipality of Kailali district in the far western region of Nepal. Strong heat waves for a longer period and floods being more frequent and with high volume in a short time resulting in inundation have worsened the lives of people residing in Janaki. In the past decade, the Bipad portal has documented 23 incidents resulting in 3 casualties, 3 injuries, and 1 person reported missing. These disasters have also caused 7 million Rupees in losses, affected 24 livestock, and damaged 3 physical infrastructures. [1] Early warning system with multi-purpose sirens effective in different wards of Janaki municipality have reduced the effects of disasters. The sirens can be sounded up to 2 km radius of its place. This paper utilizes Geographic Information System (GIS) technology to create detailed hazard maps and risk assessments. GIS-based analysis of safe spaces, high shelter houses, roads, and households is performed to determine the average evacuation time based on road conditions. The integrated GIS and Early warning system significantly enhance disaster preparedness and resilience, providing a robust framework to mitigate the escalating impacts of climate change and create sustainable communities, decision-making, and infrastructure planning in Janaki Rural Municipality.

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1. INTRODUCTION

The term hazard in most cases is a dangerous phenomenon, substance, human activity, or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.[2]

The impacts of natural hazards are growing across the world because of population growth, urbanization, and changes in extreme weather. Natural hazards are becoming more dangerous as a result of anthropogenic activities-led climate change and rising population densities. As a result, the number of people vulnerable to hydro-meteorological threats, such as floods, debris flow, and storms (cyclones), has risen by 70%.[3]

Nepal is exposed to a variety of natural hazards and human induced disasters. More than 80 percent of the total population of Nepal is at risk from natural hazards, such as floods, landslides, windstorms, hailstorms, fires, earthquakes, and Glacial Lake Outburst Floods (GLOFs). The country is among the 20 most disaster-prone countries in the world. In part, this is because Nepal is in a seismically active zone with a high probability of massive earthquakes. Globally, Nepal ranks 4th and 11th in terms of its relative vulnerability to climate change and earthquakes, respectively (Maplecroft 2011, BCPR 2004 cited in MoHA 2015). [4]

Sudur Paschim Province has a high risk of multiple natural disasters where the socio-economic vulnerabilities of flood havoc are rising on due to low level of public awareness, poor infrastructure, insufficient preparedness, and a lack of institutional capacity [5]. All the river basins of the province along the Chure range the fragile Siwalik mountains are highly vulnerable to flooding during the monsoon period. Particularly, the Karnali River Basin has become a more sensitive zone of disaster and unpredictable incidents due to an increasing trend of unexpected rainfall patterns and climate extremes. The disaster risks of floods are also accelerated by unscientific construction works in the Chure range have significantly increased over the last few decades.[5]

Janaki Rural Municipality (Janaki RM) is located in Sudurpashchim province (meaning far western in Nepali) of Nepal. It lies adjacent to two big renowned places of far-western Nepal i.e. Tikapur and Lamikichuha municipality. The place lies in the Karnali basin and many other small rivers like Kulariya, Pathriya, Dhobani, and Bijuliya run through here affecting most of the areas with flood and inundation during monsoon season. Janaki being in Terai receives heatwaves during summer too. The disasters affect a large number of the population and land gets Patan and Katan affecting land rights too. Early warning system with the use of multi-purpose sirens have been very effective here. The casualties have become extremely rare and even economic losses have been reduced by a larger fraction. [6]

Early warning system is an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events. [7]

Multi-hazard early warning systems address several hazards and/or impacts of similar or different type in contexts where hazardous events may occur alone, simultaneously, cascading or cumulatively over time, and taking into account the potential interrelated effects. A multi-hazard early warning system with the ability to warn of one or more hazards increases the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines for updated and accurate hazards identification and monitoring for multiple hazards.[8]

2. DATA AND SOFTWARE

The critical infrastructure data such as spatial location of place where sirens are located, roads, and other capacity and resources like spatial and attribute data of governance, schools which are used as safe shelter during flood, nearby police stations, and location of LEOC Janaki Kailali are used in this study. One of the authors collected the data during the NYCAGG Climate Fellowship project, which the Youth Innovation Lab is implementing with the financial support of the European Union. The software used for spatial analysis is ArcGIS. The crack version of ArcGIS 10.8 is used for analysis of spatial data. The siren at wards 4 and 9 is at the ward office, and ward 6 is at Baljyoti school. There are safe shelters at ward no 4 at Munuwa and Girdharpur. At ward no 6, people take shelter at nearby school buildings during floods whereas at Ward 9 Arunodaya School and Paras Aadhurbhut School are mostly used as shelters during floods.

3. STUDY AREA

The geographical extent of Janaki lies between 28° 31’ 17” N to 30°36’52” N latitude and 81°2’31” E to 81°15’44” E longitude. The total number of households is 11041 with a total population of 49,860 (including 23,198 males and 26,662 females) (census, 2021). This study is carried out in wards 4, 6, and 9 of Janaki rural municipality where floods and inundations are too common every year and multi-purpose sirens are available for information dissemination in near real-time.

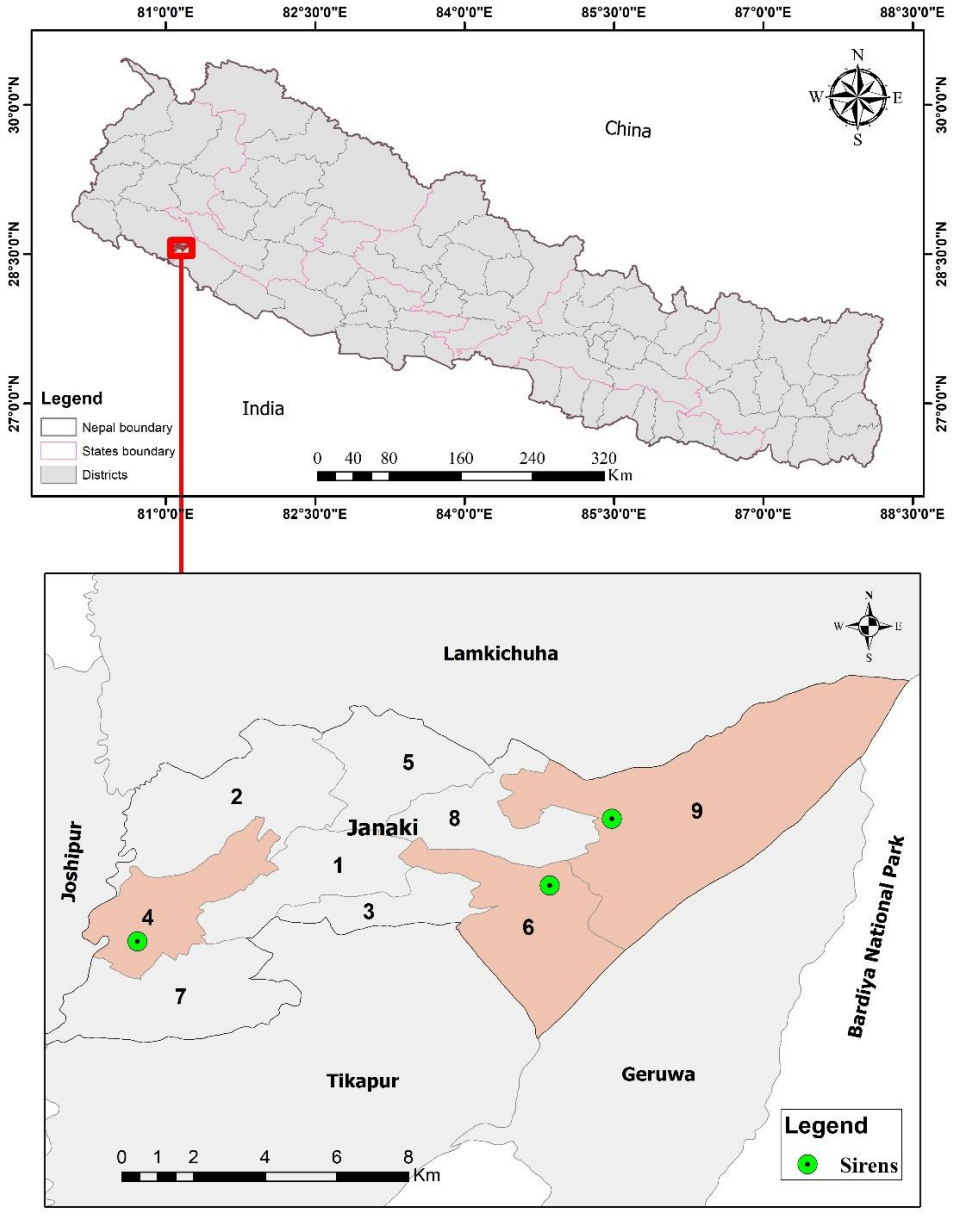

Fig. 1: Study area showing ward no 4, 6 and 9 of Janaki Rural Municipality

4. METHODOLOGY

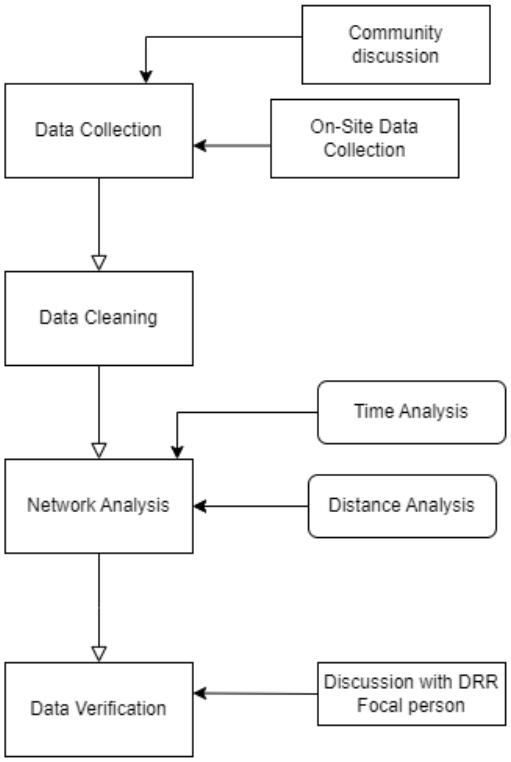

Fig. 2 : Methodology flow chart

4.1 Data Collection:

Spatial data for roads were acquired by digitizing the satellite imagery. Satellite imagery of Landsat 8 of latest date was acquired and then georeferenced. The georeferenced image was then digitized in ArcMap version 10.8. The spatial data for safe shelters, schools and government places were acquired by field visits by the authors. The attribute data such as speed was used as an average walking speed of 1.138 meters per second as per focus group discussion.

4.2 Data Preparation:

The data was cleaned in ArcMap 10.8. The road networks were slightly edited. Speed data was added using raster calculator. Using raster calculator time was calculated in ArcMap.

4.3 Network Analysis

New network dataset was created from the road network. The default parameters were used and the system created road network junctions along with road edges. The network analysis tool was used to create a new service area based on the existing road network. The analysis resulted in area around siren that the sound can reach i.e. within a 2 km radius which is working area of the siren. The area is divided into different distance breaks like 500 m, 1000m, 1500m, and 2000m. The time analysis on different breaks like 600 seconds, 1200, 1800 and 2400 seconds i.e. on breaks of 10 minutes, 20, 30 and 40 minutes is done. The analysis is discussed in result section.

5 RESULT

The areas where sirens can be sounded are mapped with network analysis. The area shows that sirens can be sounded in most of the settlements in all three wards. The areas are visualized in maps. The settlements like Katase, Baklauwa, Patavar, Dhanuwaphanta, and Murtiya which are most vulnerable in ward number 9 can clearly hear the sound of siren. In ward number 6, Jagatpur, and Jagatpur Barkapurva which are most vulnerable can also hear sirens clearly. In the case of ward number 4, the communities of Munuwa can only hear the sound of the siren.
In time analysis, it is clear that near areas will be sounded in less than 10 minutes. But for the far areas and near ward boundaries time range of 30-40 minutes is required. This means that the information should be flowed through sirens in a timely manner.

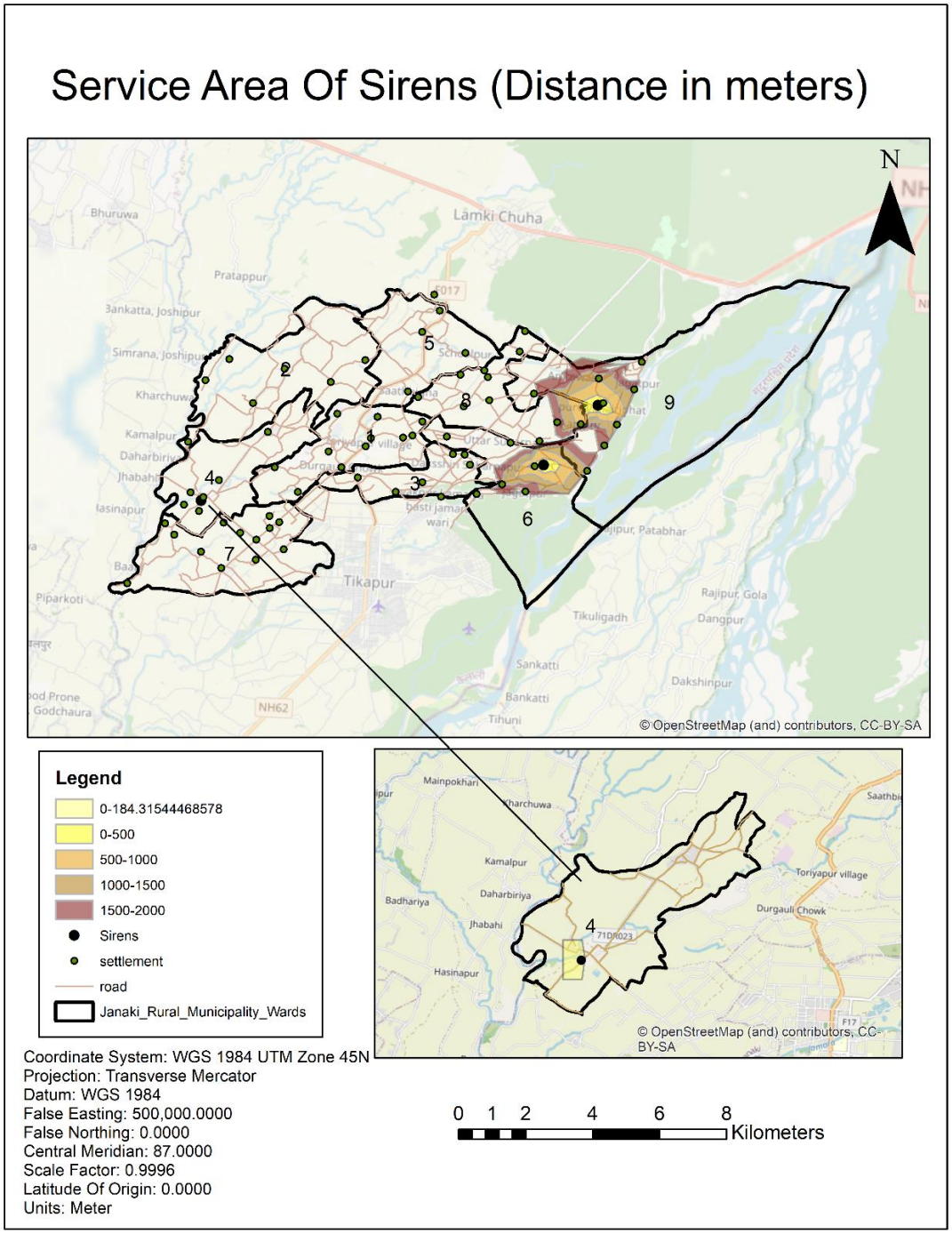

Fig. 3 : Distance analysis of siren location

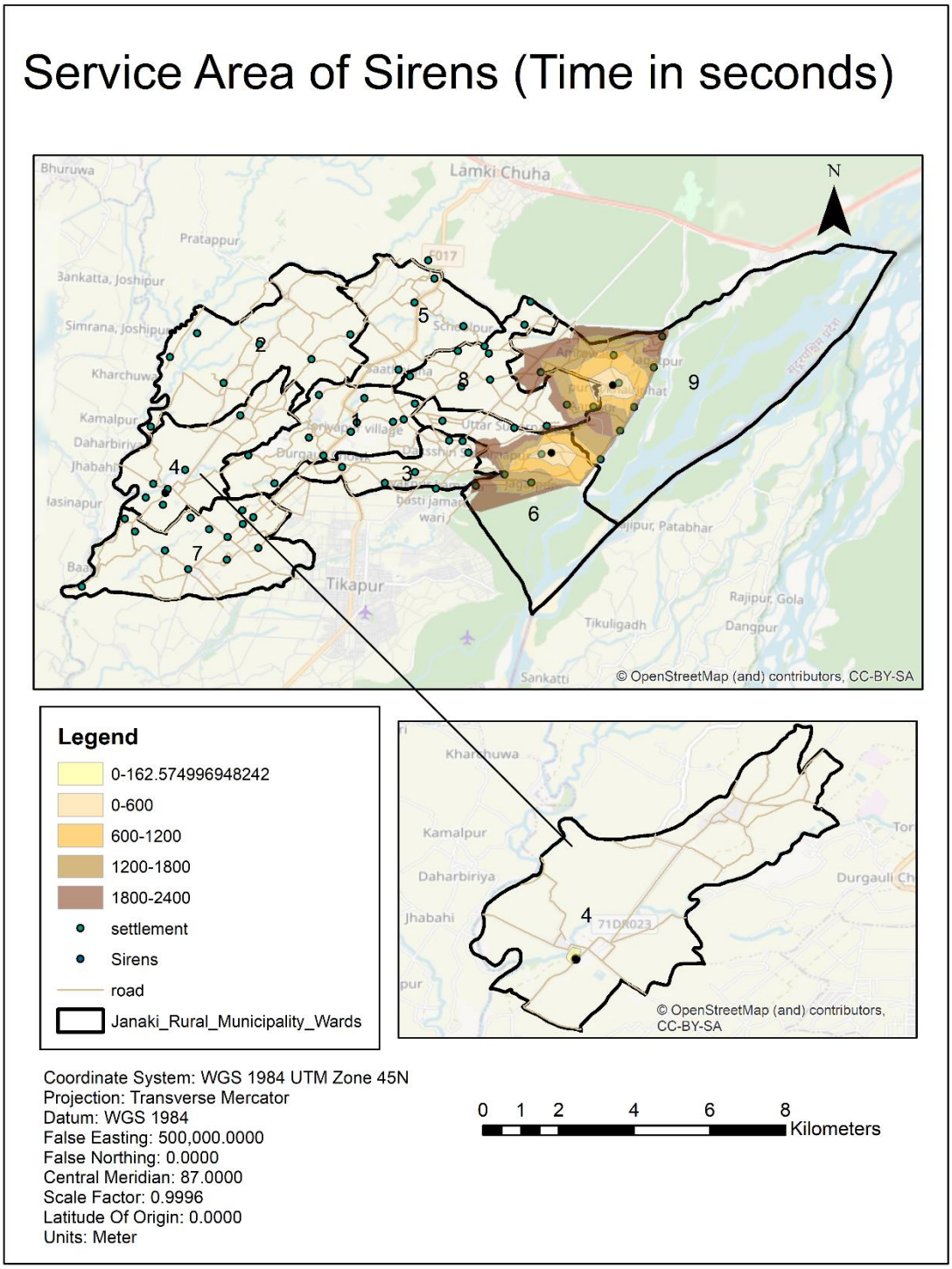

Fig. 4 : Time analysis

6 VERIFICATION

The area that was generated using ArcMap that stated the possibility of reaching to safe space within the required time was tested in field and with discussions with the Disaster Risk Reduction (DRR) focal person and field test, the analysis was verified.

7 CONCLUSION

Most of the settlements lie in the zone where the sirens are sounded. These areas can get information about disasters like floods and heatwaves. The minimum time that the information should be relied on through the siren is 40 minutes. So, if sufficient information is relied on through the multi-purpose sirens before 40 minutes of heavy catastrophe, the people can reach the safe space. As a result, most of the human lives can be saved before disasters. For this, an accurate at least half-hourly forecast is required from the Department of Hydrology and Meteorology (DHM).

8 RECOMMENDATION

The sirens are located only in three wards of Janaki RM whereas all other wards are also affected by floods every-year. The people of other wards are not able to get timely and reliable information with such sirens making them vulnerable to the effects of disasters. So, it is recommended to install such multi-purpose sirens in other wards of Janaki RM. Also, the location of sirens should be near more vulnerable groups and where settlement is high.

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10 BIOGRAPHICAL NOTES

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