Seismic Vulnerability of School Buildings: A Case of Tanahun District

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***Abstract*— The research, "Seismic vulnerability of school buildings in Nepal" is carried out for the A vulnerability assessment study of the school buildings and development of risk mitigation plan for seismic hazard. Tanahun district is selected as research area for the study of the schools. A total of 15 samples school to from different part of the district for the study. All samples school which includes 57 blocks vulnerability , for seismic hazard. Hazard compliance index of school blocks are found in the range 0.35 - 0.85 and most of them are in the range 0.40- 0.60, where the safety cutoff level is 0.75. Only 6 blocks out of 57 blocks have a compliance index above 0.75. It shows that the majority of the school buildings are vulnerable to seismic hazard. The structural and nonstructural components are more responsible for making the school blocks vulnerable in the district. Four schools, namely, Shree Jal Devi Higher Secondary School, Shree Virkuti Secondary School, Shree Siddha Beni Lower Secondary School, and Shree Jamma Devi Primary School are selected for the development of seismic risk mitigation plan. In general, the assessed schools are vulnerable to seismic hazard. The school blocks with hazard safety compliance index less than 0.75 are recommended for further detail assessment and development of detail disaster risk management plan.**

Keywords*— Seismic Vulnerability, Disaster, School Building, Disaster Risk Management.

I.Introduction

Natural hazards are not rare phenomena with unfortunate consequences. Floods, wind and ice storms, earthquakes, drought, volcanic eruption, and tsunami lead to about 400 national disasters, an average of 74,000 deaths and more than 230 million people affected every single year (CRED, 2008). Floods alone affect upwards of 500 million people per year. Worldwide, 450 cities each with a population over 1 million face recurring earthquakes. Cyclones, typhoons, and hurricanes are amongst the deadliest and costliest of disasters. Droughts and desertification now affect 250 million people and threaten 1.2 billion in 110 countries [1].These disasters can be mitigated all with knowledge and planning, physical and Environmental protection measures, and response preparedness.

Nepal is one of the most disaster-prone countries in the world. It is affected by many different types of disasters each year, such as earthquake, flood, drought, landslide, forest fire, windstorm, and hailstorm, thunderstorms, GLOF, avalanche, etc. According to the National Strategy for disaster risk management, from 1971-2006, epidemics, landslide flood, and fire were principle hazard in the country. Nepal is disaster-prone because of the several factors including its terrain, excessive rainfall, climatic change, environmental degradation, and epidemics. Nepal ranked 23rd in the world in terms of total natural-Hazard related death [2], and a study by the World Bank called Nepal one of the global "hot spot" for Natural disasters. According to the disaster vulnerability and risk assessment study report by the UNDP, Nepal ranks11th in the world in terms of vulnerability to earthquake and 30th in terms of water-induced hazard such as flood and landslide. Most of the existing schools in Nepal are not disaster resilience, and when they hit by any types of disaster, many children will have lost their lives and injured due to the collapse of school buildings. Each time a disaster occurs, masses of children are excluded from school, many never to return. Therefore, building a resilient school becomes very important and essential nowadays.

Multi- hazards together with issues related to constructing a safer school is essential and essential for all school buildings nowadays. A general understanding of all hazards is necessary in order to develop an integrated approach which is crucial for locations subject to more than one hazard. Designs for two or more hazards may reinforce one another, thus reducing cost and improving a systematic analysis of these multi-hazard protection methods. The analysis takes the form of the matrices shown in this documents facilitates planner and designers faced with the challenge of multi-hazard design.

An integrated approach to designing for all hazards can help to identify potential adverse effects of specific mitigation measures and help to avoid aggravating the vulnerability of school systems and components.

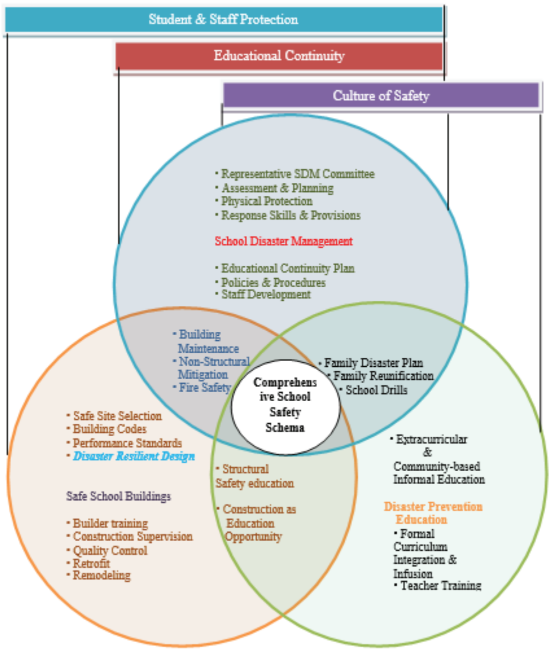

Figure 2 Integrated Safety Components

A. Rapid Visual Screening (FEMA)

In 1988, FEMA published its "Rapid Visual Screening" (RVS) procedure whose goal was to identify, inventory, and rank buildings that are potentially dangerous in case of an earthquake [3]. The RVS procedure, which was updated in 2002 [4], has been widely used throughout of identifying the structural vulnerability without considering nonstructural components or the structural peculiarities of hospitals and schools. The RVS uses a methodology based on sidewalk survey of a building and a data collection form, which the person conducting the study completes based on visual observation of the building from the exterior and if possible, the interior. The data collection form provides space for documenting building identification information, including building use and size, a photograph of the building, sketches and pertinent data related to seismic performance, including the development of a numeric and seismic hazard score.

Completion of the data collection form begins with the identification of the primary structural lateral load resisting system and materials of the building. Fundamental Structural hazard score for various building types are provided on the form, and the screener selects the appropriate one.

The screeners modifies the basic structural hazard score by identifying and circling score modifiers, which are related to observed performance attributes and which are then added (or subtracted) to the basic structural hazard score to arrive at a final structural score, S. The basic structural hazard score ,score modifiers and final structural score, "S", all relate to the

READ THIS BEFORE ANSWERING THE KEY QUESTIONS									
	User will read the following key questions in this column	Against each Key Question, the User will choose the appropriate answer from the given options shown in this column	User's Input 1	Specialists can alter scale of key question specific scoring	Specialists can change key question-specific importance	DO NOT CHANGE THESE AT ALL			User's input 2: Follow the instructions in column C and type in the necessary information in this column
A	B	C	D	E	F	G	H	I	J
EXPLANATORY SKETCH	KEY QUESTIONS ON SEISMIC-SAFETY OF NEW HOSPITAL	GUIDANCE NOTES + OPTIONS FOR ANSWERS TO KEY QUESTIONS	Answer As per Guidance	Compliance Status 0 to 1	Issue Importance VI, I, LOW	Weighted Compliance C3XC4	Ideal Case	Compliance index	REFERENCES/REMARKS
	PLANNING							0.49	
P1 	Have you done (or referred to a) geological investigation report to know if there is an active major fault on or adjacent to your proposed hospital site?	If you have done/referred to geologic investigations write the source in column "REFERENCES/REMARKS" and then choose one from the following options		0.15	VI	4.05	27		
		Type 'NA' if geological investigation has been referred to , which shows that the issue of fault line is not applicable in your case							
		Type 0, if you haven't done or referred to geological investigations for your site							
	Special note: Consult local building department, State geologist, local university, or local geotechnical expert.	Type 1, if the fault line is < 500m away from the site	1						
		Type 2, if the fault line is between 500m - 1000m from the site							
		Type 3, if the fault line is >1000m away from the site							

Figure 1 sample worksheet for the seismic hazard

II. VULNERABILITY ASSESSMENT

The vulnerability assessment of the schools and disaster risk reduction plan had been carried out worldwide using well-developed methodologies and guiding principal, respectively.

probability of building collapse, should severe ground shaking occur ;that is ,a ground-shaking level equivalent to that currently used in the seismic design of new buildings. Final "S" scores typically range from 0 to 7 with higher S scores corresponding to better seismic performance.

B. Assessment of school safety for multi-hazards in South Asia (UNHABITAT & UNISDR).

With an extensively large stock of school buildings that are present today, adequate mitigation measures need to be looked depending on their levels of vulnerability. Out of many methods and techniques that can be used to determine the vulnerability of a structure, the visual assessment method is one of the cost-effective and efficient techniques when dealing with a large number of building stock.

Assessment of selected building is done using the standard tool, a tool developed by UNHABITAT (2012) for the evaluation of school safety for multi-hazards in South Asia. Though there is a wide range of tools designed for assessment, this tool assumes that disaster safety is not only the technical issues but needs proactive participation of both the owner and end-user for the endeavor of safe schools and hospitals.

This tool views top-level management and end-users as the two most important key role players. Through this tool top-level management can keep track of the retrofitting requirement of the schools. The Compliance Index for each category (planning, architecture, structural and non-structural) for each school is calculated which will enable us to screen out school facilities which are safe and investigate those where compliance level is below acceptable safety level (say 0.75).

1) Toolkit Summary

Table 1 Hazard Safety Compliance

Is this hazard → applicable at your site?	Applicable	Applicable	Applicable	Applicable	NA
	HAZARD COMPLIANCE				
	Seismic	Wind	Flood	Landslide	Fire
Planning	0.41	0.38	0.47	0.77	NA
Architectural	1.28	0.48	0.40	0.10	NA
Structural	0.32	0.47	0.57	0.62	NA
Nonstructural	1.00	0.75	0.53	1.00	NA
Overall CI	0.76	0.51	0.49	0.68	0.00

C. The legal provision in Nepal: Disaster risk reduction framework

The current institutional framework of the Government of Nepal is more oriented towards disaster response and relief. The government organization responsible for disaster management is the Disaster Management section within the Ministry of Home Affairs. The Ministry collaborates with Nepal Police and the Royal Nepalese Army. Through Chief District Officers, the Ministry has a network throughout the country that extends to the district level. Although the Ministry of Home Affairs holds the overall responsibility of emergency preparedness and disaster management, it is still primarily concerned with the provision and distribution of emergency relief to disaster victims.

The Central Disaster Relief Committee (CDRC) is the apex body of the disaster response system in Nepal. The Central Disaster Relief Committee is headed by the Minister of Home Affairs, consists of the Minister of Health, the Minister of Physical Planning & Works, Secretaries of other ministries, representatives from the Royal Nepalese Army and the Nepal Police, the Director Generals from the Department of Mines & Geology and from the Department of Hydrology & Meteorology, as well as representatives from the Social Welfare Council, the Nepal Red Cross Society and the Nepal Scouts. Following a disaster, the CDRC meets as required to address the needs of the affected population. The committee controls a Central Disaster Relief Fund (CDRF), which is occasionally supplemented by the Prime Minister's fund.

At the district level, the District Disaster Relief Committee (DDRC) is the nodal body for coordinating relief efforts. The District Disaster Relief Committee is chaired by the Chief District Officer, consists of representatives from public sector organizations such as the District Health, r, and the Nepal Red Cross Society. The Natural Calamity (Relief) Act, 1982 also accommodates the provision for the establishment of regional and local disaster relief committees as required. NSET, 2008

D. Disaster and Emergency Preparedness: Guidance for Schools

This is a handbook published by IFC international finance corporation World Bank group. IFC, a member of the World Bank Group, creates the opportunity for people to escape poverty and improve their lives. Guidance for schools is useful for administrations, teachers, support staff, and other individuals involved in emergency and disaster preparedness at school. Its purposes are:

- To guide administrators and staff in assessing risks and planning and carrying out Physical protection measures;
- To develop skills and provisions for disaster and emergency preparedness, response, and rapid recovery;
- To support schools in developing disaster and emergency plans specific to their local needs and reflecting good practices internationally and nationally.

This handbook has been prepared with a primary focus on 'school safety,' and thus the language used throughout refers to 'schools' versus 'universities.' However, the underlying tenets in terms of the development of policy, planning, and implementation are equally relevant regardless of the type of institution.

E. School Disaster Management

School safety and educational continuity require a dynamic, continuous process initiated by management and involving workers, students, parents, and the local community. School disaster management involves the familiar cycle of steps found in all project management: assess hazards, vulnerabilities, capacities and resources; plan and implement for physical risk reduction, maintenance of safe facilities, standard operating procedures and training for disaster response; test mitigation and preparedness plans and skills regularly, with realistic simulation drills; and revise your plan based on your experience.

School disaster management mirrors individual and family disaster prevention and wider community disaster prevention efforts. This guidance document is organized to help remember and observe the parallel processes for disaster prevention that are taken up at every level of society. The full scope of activities is included as follows:

1) *Assessment and planning*
establishing or empowering your school disaster management committee; assessing your risks, hazards, vulnerabilities, and capacities; making contingency plans for educational continuity; communicating your plan.

2) *Physical and environmental protection*
structural safety maintenance, nonstructural mitigation; local infrastructure and environmental mitigation; fire safety.

3) *Response capacity development*
standard operating procedures; response skills and organization; response provisions.

4) *Practicing, monitoring, and improving*
holding simulation drills to practice, reflect upon, and update your plan; monitoring indicators for school disaster management.

F. Guide to School Vulnerability assessment

This report was produced under U.S. Department of Education Contract with EMT Associates, Inc., and Macro International Inc. Tara Hill served as the contracting officer's technical representative. This report outlined the comprehensive vulnerability assessment guidelines for school building. The report is focused only on the qualitative process of vulnerability assessment of the school's interference by different natural hazards like Earthquake, Wind storms, climate change, and some technological and biological hazards.

Vulnerability assessment is the ongoing process for identifying and prioritizing risks to the individual schools and school districts. It also includes designing a system of accountability with measurable activities and timelines to address risks. As schools continue to plan and prepare for critical events that could have severe consequences, identifying the appropriate vulnerability assessment tool(s) is an important step for helping schools to understand what they are at risk from and just how seriously they could be affected. Schools need to use appropriate tools to capture the relevant data needed to inform the development and maintenance of customized plans.

This report is intended to be a companion piece to Practical Information on Crisis Planning: A Guide for Schools and Communities, originally published by the U.S. Department of Education in 2003 as a guide for schools and districts to prepare for a variety of crises. This guide emphasizes a valuable part of emergency management planning—ongoing vulnerability assessment—and is intended to assist schools with the implementation of an effective vulnerability assessment process, to include choosing an appropriate vulnerability assessment tool.

Vulnerability assessment tools may vary from one school site to another, depending on variables such as location, environment, size, and structure, and even student population and school culture. For example, schools may be located in urban or rural environments, may have limited or greater resources, or may have specific populations with their own unique needs. As a result, vulnerability assessments must be customized on an individual district and school basis, taking all of these factors into consideration.

This report is not intended to be prescriptive or to give step-by-step instructions for conducting assessments; rather it is intended to describe the key elements to be considered when selecting an assessment tool appropriate for school environments and provide guidance for conducting an assessment that will inform school emergency management activities.

G. Disaster Prevention for Schools-Guidance for Education Sector Decision-Makers

This report was published by UNISDR, Geneva in November 2009 with the slogan "The rights of all children to both education and safety must be safeguarded simultaneously."

Natural hazards are not occasional phenomena with unfortunate consequences. Floods, wind and ice storms, earthquakes, drought, volcanic eruption, and tsunami lead to about 400 national disasters, an average of 74,000 deaths and more than 230 million people affected every single year [5]. Local disasters and pandemics more than double these numbers. Three-quarters of the world's population was affected by these phenomena at least once between 1980 and 2000. Floods alone affect upwards of 500 million people per year. Worldwide, 450 cities each with a population over 1 million face recurring earthquakes. Cyclones, typhoons, and hurricanes are amongst the deadliest and costliest of disasters. Droughts and desertification now affect 250 million people and threaten 1.2 billion in 110 countries [1]. These disasters can all be mitigated with knowledge and planning, physical and environmental protection measures, and response preparedness.

The World Education Forum's Dakar Framework for Action: Education for All (EFA) (UNESCO, 2000) acknowledged that natural hazards pose significant challenges to countries in meeting their EFA goals, and would require international level support. Worldwide 875 million school children live in high seismic risk zones, with 32 million of these children newly enrolled in primary education (Wisner et al. 2004). As this threat has continued to grow, neither national nor international commitments have kept pace with the huge numbers of children affected.

A partial list of the physical impacts of disasters on schools, school-children, and teachers provides compelling evidence that cannot be ignored. School buildings destroyed must be rebuilt at a much greater cost than the 4-8% average incremental cost of disaster-resistant construction. Some of these events will continue to strike during the school day when vulnerable school buildings will collapse and may cost tens of thousands of children their lives if no action is taken.

III. IMPACT OF DISASTER IN SCHOOL

Table 2 Impact of Disaster in School

List of Recent Impacts of Disaster on Schools (deaths in school shown in bold)		
2008	Myanmar	2,250 schools completely collapsed in Cyclone Nargis. Another 750 were severely damaged.
2008	NW China	**An estimated 10,000+children died in their school.** An estimated 7,000 classrooms were destroyed.
2007	Bangladesh	The cyclone destroyed 496 school building and damaged 2,110 more.

2006	Leyte Island, Philippines	**245 children and their teachers died** in a mudslide that buried the village elementary school after schools' days of rain had ceased.
2006	Uganda	**13 children died in a school dormitory fire where children were using candles for lighting.**
2005	North Pakistan, Kashmir	**17,000 students died at school,** and 50,000 were seriously injured, many disabled. 10,000 school buildings destroyed. 300,000 children affected. In some districts, 80% of schools were destroyed.
2005	Gulf State, USA	56 schools were destroyed, and 1,162 were damaged. 700 schools were closed and 372,000 children displaced. 73,000 college students displaced. $2.8billion was spent to educate displaced students for a year.
2004	Indian Ocean	A tsunami destroyed 750 schools in Indonesia and damaged 2,135 more. 150,000 students without schools. 51 schools were destroyed in Sri Lanka, 44 in the Maldives, and 30 in Thailand.
2004	Cambodia	Severe floods directly affected between 500,000 and 1m.students in 1,000 – 2,000 schools in 8 provinces.
2004	Bangladesh	1,259 school buildings were lost to floods, and 24,236 were damaged.
2004	Tamil Nadu, India	**93 children died in a fire due to explosion of a cooking gas cylinder**
2003	Bingol, Turkey	**84 children and teachers die in a collapsed school building in a moderate earthquake.** 4 schools collapsed. 90% of schools were impacted, and education disrupted.
2003	Xinjing, China	900 classrooms in dozens of schools collapsed in earthquake 27 minutes before thousands of children returned to their classrooms. **The middle school collapsed killing at least 20 students.**
2003	Dominican Republic	18,000 students lost their classrooms.
2003	Boumerdes, Algeria	103 schools destroyed, 753 severely damaged. Cost of rehabilitation $79 million.
2002	AbGarm	16,500 students education disrupted when 8 schools collapsed, and 137 were damaged.
2002	Molise, Italy	**26 children and 1 teacher died in a school earthquake collapse.**
2001	Cariaco,Venezuela	2 schools collapsed in an earthquake. **46 students died.**
2001	EI Salvador	85 schools were damaged beyond repair. Replacement and repair cost $114m. **22 preschoolers and their teacher were killed in an aftershock a month later.**
2001	Arequipa, Peru	98 school buildings seriously damaged by the earthquake
2001	Taiwan	A three-story school collapsed in the middle of the night.
2001	Bhuj, India	**971 students and 31 teachers were killed by this earthquake, though most children were outside for Republic Day celebrations.** 1,884 schools collapsed, destroying 5,950 classrooms, including 78% of public secondary schools.
		11,761 school buildings suffered major damaged with 36,584 classrooms unusable.
1999	Pereira, Colombia	74% of schools in 2 cities , (22 in one city alone .'). Children were outside for lunch.
1999	Chi-Chi, Taiwan	51 schools collapsed, and 786 were damaged. Cost of school reconstruction and repair was $1.3 billion
1999	Kocaeli, Turkey	43 schools were damaged beyond repair and hundreds more damaged. The school was suspended for hundreds of thousands of children for 4 months.
1998	Bangladesh	Flooding destroyed 1,718 school buildings, and 12,000 were damaged.
1998	Eastern Nepal	1,200 schools destroyed or heavily damaged.
1997	Ardakul, Iran	**Primary school collapse killed 110 students (earthquake).**
1997	Cariaco, Venezuela	**2 schools collapsed in an earthquake, killing 46 students.**
1993	Maharashtra, India	48% of the 8,311 killed were under the age of 14. Many schools were destroyed by the earthquake.
1992	Erzincan, Turkey	**A 6 story medical school collapsed in a moderate earthquake, burying 62 students**
1989	EI Asnam, Algeria	70-85 schools collapsed or severely damaged in an earthquake.
1988	Udaypur, Nepal	6,000 schools destroyed in an earthquake.
1988	Yunan, China	1,300 schools destroyed in the earthquake
1988	Spitak, Armenia	**2/3 of the 25,000 earthquake deaths were school children killed in their schools. 400 children died in 1 school alone. 32,000 children were evacuated**
1985	Mexico City, Mexico	Several schools collapsed in the early morning before school started.
1964	Anchorage, Alaska	Half of the city's schools were severely damaged by an earthquake during school hours; however the school was unoccupied due to the Good Friday holiday.
1963	Skopje, Macedonia	44 schools (57% of the urban stock) were damaged by earthquake, affecting 50,000 children.
1958	Chicago, USA	**92 students and adults died in a fire** at Our Lady of the Angels School
1952	Sapporo, Japan	400 schools collapsed in the earthquake.

IV. ANALYSIS OF LEGISLATION RELATED TO DISASTER RISK REDUCTION IN NEPAL

This report was published by the International Federation of Red Cross and Red Crescent Societies with the support of Australian Government (AusAID). It is one of several case studies the IFRC is undertaking to learn about how legislation can support (or impede) disaster risk reduction, particularly at the community level.

The IFRC's "International Disaster Response Laws, Rules and Principles" (IDRL) Programme seeks to reduce human vulnerability by promoting legal preparedness for disasters. It works in three areas: (1) collaborating with National Red

Cross and Red Crescent Societies and other partners to offer technical assistance to governments on disaster law issues; (2) building the capacity of National Societies and other stakeholders on disaster law; and (3) dissemination, advocacy and research.

The geology, topography and tropical location of Nepal mean that the country is faced with frequent natural hazards or risks that can lead to disasters causing displacement, loss of life, property, and livelihoods. These include the annual monsoonal rains, frequent forest fires and a level of seismic activity that could lead to a major earthquake at any time. These natural occurrences and risks are in turn exacerbated by environmental degradation, deforestation and soil erosion, leading to the likelihood of devastating flash floods and landslides, while glacial melt associated with climate change has increased the risk of glacial lake outburst floods.

Nepal has adopted a National Strategy for Disaster Risk Management (NSDRM) in 2009. It is important to take a wide view of DRR law and regulation in Nepal so that many elements of what may be termed 'good governance' towards planned and sustainable development are an integral part of the legal framework for DRR. Effective law and regulation to support DRR in Nepal need to address some of the regulatory factors that cause or fail to prevent natural events becoming human disasters, using long term planning and public regulation to help prevent loss of life and livelihoods which currently have a major impact on the country's human development. This necessary integration of DRR and development goals have been recognized at national Government level in Nepal in its national development planning, it's National Policy on Environmental Adaptation to Climate Change, and it is National Strategy for Disaster Risk Management. The principal challenges in this regard are carrying such integration into district and local government priority setting and implementation, and empowering communities to take an integrated approach.

V. Methodology

The study is carried out mainly in three phases: Deskwork, Fieldwork, and Data analysis and preparation disaster risk reduction (DRR) plan. The literature review is done as part of the deskwork which is briefly described in chapter two of this report. The kinds of literature related to the seismic hazard, Flood hazard, Landslide hazard, and wind hazard have been reviewed in detail in that section.

The second phase of the study is data collection, which includes both primary and secondary data. Secondary data includes the hazard profile of the country and study area. The secondary data is collected from the desInventor, Center Bureau of Statistics, other relevant publications, and web sites.

The primary data includes the schools' general information and hazard information, which is collected directly for the field. A tool for data collection is prepared with the help of FEMA, UNHABITAT and several other related kinds of literature. The data collection tool is developed basically with the help of information articulated in section FEMA424 and UNHABITAT toolkit for school safety. The UNHABITAT toolkit is developed especially for school safety in South Asian countries including Nepal. Some information which is not applicable in our context is omitted, and some issues which are failed to address are included.

The method for primary data is collection includes questionnaire survey, focus group discussion with school community, conduction meeting with expert at the local level. It also includes the investigation of the construction methodology of the school buildings in this area. Total numbers of sample for this study are 15 schools situated at different parts of Tanahu District. The information about different hazard for a school is collected in order to identify the vulnerability of the school buildings for a particular hazard.

the phase of this study includes Data analysis and Disaster risk management plan. Data analysis is with the help of toolkit developed by UNHABITAT and FEMA. The vulnerability index of each school building is calculated against four categories namely: Site/planning issue, Architecture issue, structural issues, and Non-structural issues with the help of EXCEL based tool which gives the score for each hazards ranging from zero (0) to one (1). The indicator zero (0) indicates that the facility does not comply with standards required to make a system disaster resilient and indicator one (1) indicates that the facility fully complies with the standards. That means higher the value of compliance index represents the system is more disaster resilient.

Disaster risk management plan for the existing school is the concept of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property wise management of land and the environment, and improved preparedness for adverse events.

A. Study Area

The research area is Tanahun district. Tanahun lies in Gandaki zone, western Development Region of Nepal. It is 62.5 km east to west and 43.7 km north to south. Topographical location of the district is 83° 57′ to 84° 34′ east and 27° 36′ to 28° 05′ north. The district is surrounded by Chitawan and Gorkha in the East, Kaski, and Syangja in the West, Kaski, and Lamjung in the North and Palpa and Nawalparasi in the South. The major disasters in the district are Flood, Fire, Earthquake, Landslide, and Wind, etc.

There are large numbers of government and a few private schools including primary to higher secondary level. Most of the government school buildings in the district are traditional type, and no precaution has been adopted for disaster safety. The materials and construction technique used for building had been identified very poorly and also constructed without any proper planning.

School is one major area where large numbers of peoples gather to perform an intended task (learning, teaching) so disaster may lead to collapse human generation when it occurs not any time but at running time. When a disaster occurs in Tanahun District, an immediate response is very difficult due to un-comfort geography which may lead large fatality along with huge economic losses.

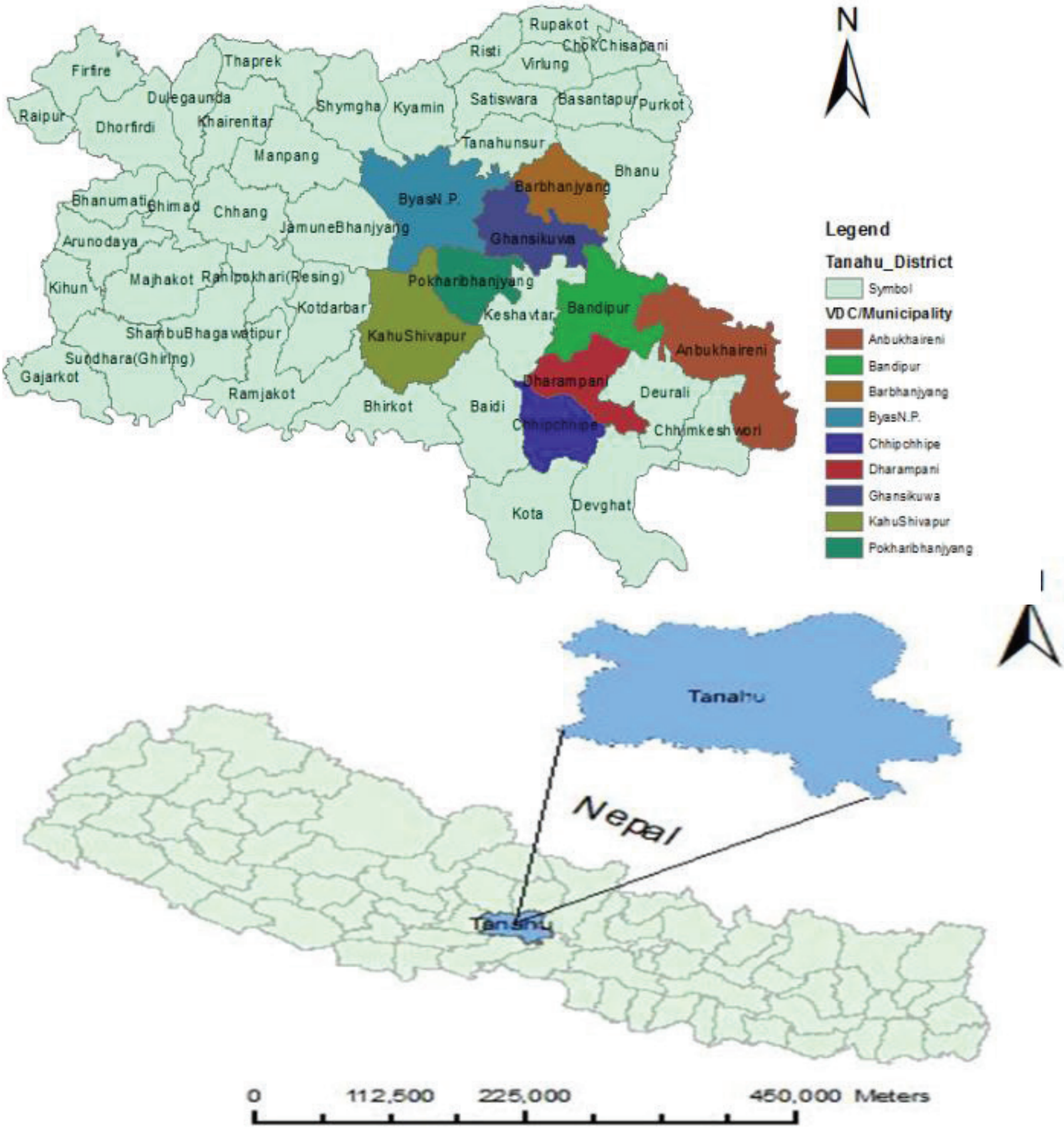

Figure 3 Study Area in Map of Nepal

B. *Disaster Scenario of Tanahu District* [6]

Table 3 Disaster Scenario of Tanahu District

S.N.	Hazard	Number				House	
		Event	Death	Injured	Population	Destroyed	Damaged
1	Fire	68	13	18	1512	484	9
2	Flood	43	55	29	52061	142	55
3	Landslide	59	101	45	3563	171	29
4	Strong Wind	13	0	0	1733	11	89
5	Earthquake	0	0	0	0	0	0
6	Others	151	141	308	30558	44	577

The data in the table shows the disaster scenario from 1971 till 2017 of Tanahun district.

C. *Studied School*

Table 4 Table showing school of the study area with its location

S. N.	School Name	Address	Resource Centre	VDC/ Municipality
1	Shree Jal Devi Higher Secondary School	Vyas 1, Bahdgaun	Damauli Resource Centre	Vyas Municipality
2	Shree Bal Mandir Lower Secondary School	Vyas 3, Damauli	Damauli Resource Centre	Vyas Municipality
3	Shree Sindhu Primary School	Vyas 7,Sanghee	Damauli Resource Centre	Vyas Municipality
4	Shree Sukla Secondary School	Kahusinghapur 1, Jhaputar	Kahusinghapur Resource Centre	Kahusinghapur VDC
5	Shree Dipak Lower Secondary School	Kahusinghapur 2, Bhirkot	Kahusinghapur Resource Centre	Kahusinghapur VDC
6	Shree Laligurans h Primary School	Kahusinghapur 3,Bhirkot	Kahusinghapur Resource Centre	Kahusinghapur VDC
7	Shree Sahidganga Higher Secondary School	Kahusinghapur 6, Bhirkot	Kahusinghapur Resource Centre	Kahusinghapur VDC
8	Shree Sideshwori Secondary School	Ghanshikuwa 3, Kamalbari	Kamalbari Resource Centre	Ghanshikuwa VDC
9	Shree Jal Devi Primary School	Bandipur 8, Kalchowk	Kamalbari Resource Centre	Bandipur VDC
10	Shree Adarsha Saraswati Secondary School	Barbhanjyang8,	Chudi Resouce Centre	Barbhanjyang VDC
11	Shree Siddha Beni Lower Secondary School	Pokharibhanjyang1, Bachyandi	Keshavtar Resource Centre	PokhariBhanjyang VDC
12	Shree Buddha Primary School	Pokharibhanjyang1, Kaidim	Keshavtar Resource Centre	PokhariBhanjyang VDC
13	Shree Seti Ganga Primary School	Dharampani 1, Baidee	Keshavtar Resource Centre	Dharampani VDC
14	Shree Bhirkuti Secondary School	ChippChipee 5, Sarangghat	Devghat Resource Centre	Chippchipee VDC
15	Shree Jamma Devi Lower Secondary School	Aanbukhairani 8, Muglin	Satryasaya Resource Centre	Aanbukhairani VDC

D. *Compliance Index Calculation Technique*

Calculation technique for Single and Multi-Hazard compliance is described by considering the following parameters:

1) *Issue importance*

Each key question in a category is classified in three-level based on their importance (Very Important issue (VI), Important issue (I), and Less Important issue (LI)). Generally." this is determined by the specialist to suit country-specific context. Type VI/I or LI against each key question is assigned as an ideal value of the question and based on the status at site weight compliance for each question is calculated.

Issue Importance (Specialist can modify these)	
Very Important (VI)	3
Important (I)	2
Less Important (LI)	1

on of

scoring against each issue: Each issue in the field may or may not be addressed or partially addressed. In this situation, the status of field is identified against each issue and degree that each , is maintained in the field is determined as the percentage of the maximum value as following: Not addressed (0.5%), Low (25%), medium (50%), high (75%) and completely addressed (100). This can be modified depending upon situation.

2) Why it is necessary?

Each issue under same category is seeking different answer. Some issue is seeking the answer in crucial part and some not in crucial part of the existing system at site. Addressing any , an issue at the site plays important role in managing disaster than others but can't ignore any issues. Therefore each issue is necessary to classify in any one of three categories mentioned above.

3) Category weight

Each category for a single hazard is assigned a value in a proportion, so that summation of each category for a hazard is equal to 1 (100%). In this report, the category weight is assigned as in the table.

Category Weight (Specialist can modify these)	
Planning	30%
Architecture	30%
Structure	30%
Non-Structure	10%

4) Hazard weight:

Hazard weight basically depends upon the magnitude and the frequency of occurrence in a particular location. This may vary from place to place in a country or country to county in a world. It also determined by the socio-economic status, living standards of peoples and their education level. All-natural events are random in nature and level of severity is also varying, so it is very difficult to calculate the hazard weight in reality. However from the past evidence we can be qualitatively categorized into different level. If we assume the severity of all hazards is equal then the hazard weight for each is equal to 1.

Hazard Weight (Specialist can modify these)	
Seismic	1
Flood	1
Wind	1
Landslide	1

VI.DATA ANALYSIS AND INTERPRETATION

The analysis of the existing schools of Tanahun district is done using toolkit developed by UN-HABITAT. It uses a checklist to calculate the safety compliance level of Schools. Safety compliance of an existing building ; rather by evaluating a list of questions for different hazards namely- 1) Seismic, 2) Wind 3) Flood 4) Landslide.

The vulnerability of existing schools due to each hazard was against four aspects (hereinafter referred as category); 1) Planning/site 2) Architecture 3) Structural 4) Non-Structural. The vulnerability referred here is an only physical vulnerability. An excel spreadsheet is used to answer different questions for those four categories, and the answers are obtained while visiting the schools physically. A Compliance Index (CI) of each category is obtained after answering the questions, and a combined Index is obtained as single hazard compliance index.

Is this hazard → applicable at your site?	**Applicable**	**Applica ble**	**Applica ble**	**NA**	**Applica ble**
HAZARD COMPLIANCE					
	Seismic	***Wind***	***Flood***	***Fire***	***Landslid e***
Planning	0.52	0.38	0.47	NA	0.77
Architectural	0.37	0.48	0.40	NA	0.10
Structural	0.31	0.47	0.57	NA	0.62
Non structural	0.78	0.75	0.53	NA	1.00
Overall CI	0.46	0.51	0.49	0.00	0.68

Common information in all school buildings	
Accessibility for disable student	None of the school is designed for disabled people. However one block in Shree Siddha Beni Lower Secondary School is designed for physically disabled people.
Lighting arrester facility in a school	There is no lighting arrester facility provided in the school or its surrounding
Location of emergency facilities	Emergency facilities such as batteries, inverter, generator, and other types of equipment are not provided in the school
Early warning system	No, an early warning system is provided in the school
Awareness program/training conducted for mitigating disaster in school	Neither any training conducted in the school nor any training attained by staff/students for mitigating disaster in school.
Signage for emergency exit	No special signs in school for emergency exit.
Door openings	Doors in all block opens inside.

Table 5 Seismic hazard analysis for Field

School Name	Block	Hazard	Category Compliance				
			Hazard Safety				
			Planning	*Architecture*	*Structure*	*Non-Structure*	Compliance
Shree Jal Devi Higher Secondary School	B1	Seismic	0.88	0.83	0.79	0.72	0.81
	B2	Seismic	0.88	0.83	0.79	0.67	0.8
	B3	Seismic	0.88	0.59	0.49	0.37	0.57
	B4	Seismic	0.88	0.86	0.59	0.55	0.72
	B5	Seismic	0.9	0.67	0.59	0.55	0.72
	B6	Seismic	0.88	0.85	0.59	0.55	0.64
Shree Bal Secondary School	B1	Seismic	0.82	0.86	0.95	0.72	0.85
	B2	Seismic	0.82	0.73	0.5	0.5	0.63
	B3	Seismic	0.82	0.72	0.32	0.33	0.54
Shree Primary School	B1	Seismic	0.57	0.38	0.18	0.25	0.37
	B2	Seismic	0.57	0.6	0.36	0.31	0.46
	B3	Seismic	0.57	0.6	0.41	0.44	0.51
Shree Sukla Secondary School	B1	Seismic	0.67	0.89	0.8	0.82	0.8
	B2	Seismic	0.67	0.74	0.44	0.72	0.63
	B3	Seismic	0.67	0.65	0.8	0.72	0.74
	B4	Seismic	0.67	0.74	0.44	0.72	0.63
Shree Secondary School	B1	Seismic	0.67	0.78	0.95	0.3	0.71
	B2	Seismic	0.67	0.66	0.55	0.3	0.55
	B3	Seismic	0.67	0.6	0.49	0.18	0.5
Shree Lali School	B1	Seismic	0.56	0.6	0.29	0.18	0.41
	B2	Seismic	0.56	0.6	0.4	0.18	0.45
Shree Sahid Ganga Higher Secondary School	B1	Seismic	0.66	0.58	0.4	0.3	0.49
	B2	Seismic	0.66	0.69	0.46	0.55	0.58
	B3	Seismic	0.66	0.58	0.4	0.3	0.49
	B4	Seismic	0.66	0.62	0.4	0.3	0.5
	B5	Seismic	0.66	0.62	0.49	0.55	0.58
	B6	Seismic	0.66	0.62	0.23	0.18	0.42
	B7	Seismic	0.66	0.85	0.49	0.3	0.59
Sideshwori Secondary School	B1	Seismic	0.56	0.53	0.46	0.3	0.47
	B2	Seismic	0.56	0.53	0.46	0.3	0.47
	B3	Seismic	0.56	0.53	0.46	0.3	0.47
	B4	Seismic	0.56	0.53	0.46	0.3	0.47
	B5	Seismic	0.56	0.79	0.79	0.75	0.74
	B6	Seismic	0.56	0.57	0.57	0.75	0.6
Shree Jal Devi Primary School	B1	Seismic	0.61	0.68	0.55	0.3	0.55
	B2	Seismic	0.61	0.41	0.34	0.18	0.38
	B3	Seismic	0.61	0.59	0.34	0.18	0.43
Shree Adarsha Saraswati Secondary	B1	Seismic	0.56	0.93	0.79	0.75	0.78
	B2	Seismic	0.56	0.62	0.37	0.18	0.44
	B3	Seismic	0.56	0.64	0.47	0.3	0.5
	B4	Seismic	0.56	0.64	0.37	0.3	0.47

School	B5	Seismic	0.56	0.53	0.29	0.18	0.39
Shree	B1	Seismic	0.77	0.82	0.74	0.55	0.73
Lower	B2	Seismic	0.77	0.82	0.59	0.55	0.69
Secondary	B3	Seismic	0.77	0.91	0.74	0.55	0.76
School	B4	Seismic	0.77	0.81	0.74	0.55	0.73
Shree	B1	Seismic	0.56	0.91	0.37	0.3	0.55
School	B2	Seismic	0.56	0.81	0.23	0.55	0.53
Shree Seti	B1	Seismic	0.66	0.9	0.38	0.75	0.66
School	B2	Seismic	0.66	0.72	0.21	0.75	0.56
Shree	B1	Seismic	0.62	0.55	0.29	0.3	0.43
Virkuti	B2	Seismic	0.62	0.45	0.23	0.3	0.39
Secondary	B3	Seismic	0.62	0.55	0.29	0.34	0.43
School	B4	Seismic	0.62	0.66	0.46	0.75	0.61
	B5	Seismic	0.62	0.8	0.46	0.3	0.56
Shree	B1	Seismic	0.53	0.79	0.4	0.3	0.52
School	B2	Seismic	0.53	0.79	0.4	0.3	0.52

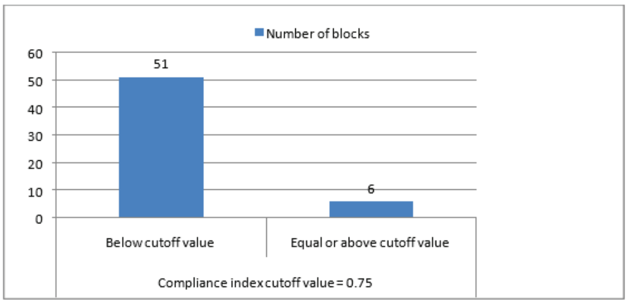

Figure 4 Rank of school blocks as per CI cutoff value

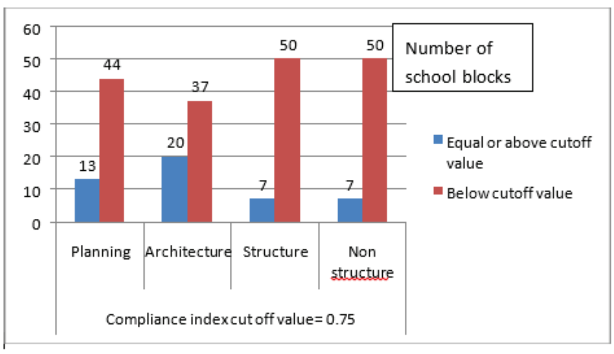

Figure 5 Category wise ranks of school blocks as per CI cutoff value

Figure 5 shows that, out of a total 57 sample blocks, 51 blocks have hazard compliance index below cutoff level. It means majority of sample school blocks in the district are vulnerable in seismic hazard.

Figure 4 The cyclone that all categories are responsible for making school block vulnerable. However, the structural and nonstructural components are more responsible than others. Sinc, only 7 blocks have CI above cutoff level in structure and non-structure category.

VII. Conclusion

The research is focused on the school area in Nepal. The research study is divided into two parts; first vulnerability study of school building in natural hazards and second development of seismic mitigation plan for selected schools.

In this research a total sample of 15 public schools which includes 57 blocks is selected for the vulnerability study. The schools are selected on stratified random basis from eight VDCs and one municipality in Tahanun district. The sample data includes all the school grades practices in Nepal. All hazards are not equally likely to occur at the site as it depends upon the location, topographic condition, and other factors. The majority of the school buildings are found vulnerable to seismic hazard at site.

In Tanahun district, the structural system of the school blocks is one-story masonry structure and RCC structure. The principal materials used in the school buildings are stone, brick, reinforcement, cement, aggregate, timber and CGI sheet. The structural configuration of many school blocks are rectangular with few of them are found irregular in plan and section. Also, the school blocks are not disable friendly except block B2 of Shree Siddha Beni Lower Secondary school.

In this research, literature published by different institutions, agencies, organizations, NGOs and INGOs from Nepal and other countries have been reviewed. Some useful information from the literature is used in this report. Data collection and analysis is done by using standard tool developed by the UNHABITAT and UNISDR for South Asian countries including Nepal. The tool kit is modified later using FEMA guidelines for the school safety (FEMA p- 424) and other relevant documents. UNHABITAT and UNISDR toolkit give hazard safety compliance index for each school block based on their degree of resiliency. In this toolkit the risk associated with hazard is examined against four categories al.i.e. site condition/planning, architecture, structure, and non-structure. The value of hazard safety compliance index ranges within 0-1. The indicator zero (0) indicates the facility is not resilient at all an indicator one (1) indicates the facility is completely resilient. The cutoff value 0.75 is taken in this study and those blocks whose compliance index equal or above 0.75 is categorized under safe and below 0.75 is categorized under vulnerable. In this study, most of the assessed school blocks are found below the compliance index cutoff value.

Seismic risk mitigation plan for four schools: namely, Shree Jal Devi Higher Secondary School, Shree Virkuti Secondary School, Shree Siddha Beni Lower Secondary School, and Shree Jamma Devi Primary School are developed based on the information available for site-condition/planning, architecture, structure, and non-structure. In general, most of the school blocks are found vulnerable in seismic hazards applicable at site.

A. Major conclusion of the study

The major conclusions of this research study are found as follows:

- All school buildings in Tanahun district are found vulnerable in seismic hazard.
- Hazard compliance index of the school blocks is found in the range of 0.35-0.85. Only 6 blocks have found compliance index above cut off level (i.e. 0.75).
- Majority of blocks have found compliance index between 0.40 -0.60
- The structural and nonstructural components are more responsible for making the school vulnerable in seismic hazard in the district.

VIII. REFERENCE

[1] T. Hazardscape, "Nepal Disaster Report 2009," 2009.
[2] T. Aging and D. Resource, "Aging and Disability Resource Center 2007 Annual Report," pp. 1–14, 2007.
[3] T. D. Drive, "EVALUATION OF EARTHQUAKE DAMAGED Applied Technology Council (ATC-43 Project) The Partnership for Response and Recovery," *Management*, 1998.
[4] F. 543, "Design Guide for Improving Critical Facility Safety from Flooding and High Winds," *Design*, no. Decemberthe 2010.
[5] I. No, "Cred crunch," no. 13, 2008.
[6] Ministry of Home Affairs, *Nepal Disaster Report 2017: The Road to Sendai*, no. December. 2017.