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Fire Risk Mapping of Swayambhu Premises to prepare Disaster Mitigation Strategies

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Abstract
Among various reasons of destruction of monuments, one of the main reasons is natural or manmade hazards in our country. Henceforth, reducing the risk of these hazards is the major step to preserve the monument available. Nepal is facing lots of hazards like earthquake, fire, landslide, lightening, avalanche, epidemic etc. Among them fire is a main reason for destruction of most of monuments which is directly or indirectly caused by human. This research aim is to develop an approach to assess the possible impacts of fire on cultural heritage. It also aims to explore ways of integrating risk elements into cultural management plans.
Swayambhu is the place which is equally important historically and socially with the development of Nepal's history. In the past, Swayambhu premises had been facing from different types of hazards which destroyed it time to time requiring reconstruction and renovation of its structure. Though, hazard risk is generally not included in cultural management plan. Finally some guidelines and recommendations are given related to natural hazards and cultural heritage in the context of the study area. In this research, the risk and vulnerability mapping of the Swayambhu premises in term of fire is prepared with the help of collected secondary and primary data and analyzed and plotted. With the help of mapping, the fire risk management plan is prepared which will help to mitigate the fire risk. So that such important heritage area can be prevented for ever or can have a solid mitigation step from fire hazard. So that today's generations can handover the ancient gift to future generation.

Keywords
Cultural heritage, Hazard, Disaster, Risk, Vulnerability, Mitigation plan

1. Introduction

Nepal, like other South Asian countries, is vulnerable to a variety of natural hazard including earthquakes, floods, landslides, fires, thunderstorms and glacier lake outburst floods. Of them, floods, landslides and fires cause the severest property damage and fires claim the fourth largest hazard. In a minute, a fire can take dozens of lives and destroy hundreds of livelihoods and property. On average, fires are responsible for property losses worth 350 million rupees and the death of 77 people annually (Nepal/UNDP, p. 2013). That's why prevention from fire hazard is one of the way of preserving life and property. Fire is often one of the most threatening hazards and therefore, it is justifiable to study it in detail.

The Kathmandu Valley is popular for its traditional historical buildings and monumental structure. The rich history, importance and original peculiarity of arts and architecture of these structures have made their sites listed in the World Heritage by UNESCO. Protection of these structures has been one of the major concerns in the conservation of the cultural heritage. These cultural heritage sites need to maintain its originality but they were ruining day by day because of the lack of management of these conservation sites. They are degrading because of natural hazard and manmade hazard. Disaster risk reduction strategies are crucial for the protection of such heritage sites. So, identifying and mapping risk of hazard is the first step of mitigate the problems.

Among various reasons of destruction of monuments, one of the main reasons is natural or manmade hazard in our country. Henceforth, reducing the risk of these hazards is the major step to preserve the monument available. Nepal is facing lots of hazards like earthquake, fire, landslide, lightening, avalanche, epidemic etc.

Figure 1: Burning ghee lamp in Open Space

Swayambhu, as most of the heritage sites around the world, is exposed to enormous pressure that puts its values at risk. Natural and manmade disasters are key concerns here and mostly these disasters put the value of the site at stake. Disasters destroy the authenticity of a cultural property. Fire and landslide are two major risks that have threatened this site in recent past. And fire is a main reason for destruction of the cultural heritage area which is directly or indirectly caused by human. So, to make safe from fire, fire management plan for cultural heritage sites are necessary which must include the rules and regulations from the community level to government level. Risk management must become an integral part of conservation practices and management mechanisms.

The main objective of the research is to prepare Fire Risk Mapping and to prepare Fire Risk Reduction Plan for Swayambhu premises.

2. Methodology

This research employs qualitative method and follows action plan. It relies fundamentally on literature review which is done through study of journals, articles, postgraduate theses related to fire, and case studies of national and international fire hazard events and management. And then data were collected as the primary data and secondary data. Primary data are collected through field survey, key informant interview and hazard calendar whereas secondary data were collected from DoA, inventory data and SMFC.

To analyze the fire risk is the main aim of the thesis so, for this, first of all level of preparedness of the community, risk attributes, and community resources were identified. And weightage were given for those different attributes. So that the fire hazard risk of any corner of study site can be easily obtained. To do that, vulnerability of site from different parameter is plotted in master plan through Auto ACD and risk mapping had been prepared. And for every vulnerability parameter, weightage is given. And according to the vulnerability weightage, ranking is given to different subdivision of attributes which can be plot in master plan to show risk plan of eight different attributes. To plot on master plan, different symbols will be used according to high, medium and low risk. Rank 1 means high risk, 2 means medium risk and rank 3 means low risk.

According to weightage, total point is 100 so, 75 to 100 falls on high risk, 50 to 74 falls on medium risk and below 50 falls on low risk. This process is based on the case study of risk assessment of Vientaine, Lao PDR.

3. Limitations

- Only fire hazard is studied though many more hazards are present on the study area.
- Since the information about all fire hazards may not have been collected to central data of GON or may be from out of heritage area, so some fire data may be missing.
- The interviews were targeted to all level of responders thus the respondents may not have sufficient knowledge of the hazard identification, system assessment and respective planning.
- Attributes taken for risk assessment are limited, but more than taken attributes may be present in site.

4. Literature Review

4.1 Cultural Heritage

The culture, values and traditions that is passed down from previous generations to present, is known as cultural heritage. Cultural heritage implies a shared bond, our belonging to a community. It represents our history and our identity; our bond to the past, to our present, and the future. Cultural heritage includes both tangible and intangible heritage things.

4.2 Hazard

A hazard is a situation that poses a level of threat to life, health, property or environment. Most hazards

are dormant or potential, with only a theoretical risk of harm; however, once a hazard becomes ”active”, it can create an emergency situation. There are lots of hazards in the world but Nepal is facing hazards like; epidemic, landslide, flood, earthquake, fire, avalanche etc. Among them fire becomes fourth biggest hazard in Nepal which become a cause for big loss of life and property every year. Most of cultural heritage sites are also moving towards destruction because of the hazards. Hazards differ in severity, scale, and frequency.

4.3 Disaster

A hazard is a natural process or phenomenon with potentially adverse effects on life or property. If any of the hazards affect to disrupt the normal life of people, then the event becomes disaster which may lead to loss of a lot of lives and property within just a small time interval. Disasters are the damages that result from human vulnerability to hazards.

4.4 Vulnerability

The concept of vulnerability encompasses a variety of definitions. In general, vulnerability means the potential to be harmed. Vulnerability to fire hazards is thus the potential to be harmed by fire hazards. Vulnerability has to be quantified in terms of a probability of success, expressed as a percent likelihood while assessing. Vulnerability is the first thing to address for assessing the risk of any place. Vulnerability is determined by a number of economic, social, physical and environmental factors. The vulnerability of heritage sites to both natural and human-made disasters can be reduced by lowering the overall risk threatening generating attributes of the area.

4.5 Risk

Risk is defined as the probability that a certain kind of damage will be realized (Ball and Watt, 2001). Risks are the result of natural or human-made threats. Natural risks include both the catastrophic and sudden and continuous, cumulative and slow processes. Risks to heritage sites are also dependent on the specific characteristics of each site and its inherent vulnerability. We know that risk depends upon hazard, vulnerability, exposure, and coping capacity of the proper area. Hazard, vulnerability and exposure is directly proportional to risk where as coping capacity is inversely proportional to risk. Risk = Hazard x Vulnerability x Exposure /Coping capacity

4.6 Risk mapping

Risk mapping system is not only as a tool for collecting information but also for synthesizing it. Risk maps help identify, locate, and rescue threatened property in addition to recording the existing state of the site or object. At a larger context scale, maps can be an effective tool in communicating with emergency managers and planning officials.

5. Case Study

5.1 Ban Hatsady, Lao PDR

In the late afternoon of August 1, 2000, fire raged across Ban Hatsady village of Vientiane, Lao PDR. About 26 single and multi-family structures, including a small market, were totally destroyed or irreparably damaged.

Although fire suppression actions attempted to save homes, the high ignitability of most of the structures caused numerous simultaneous house fires that quickly overwhelmed the suppression forces. The damage was relatively high. This distressful experience left deep scars in the minds of the villagers as they helplessly witnessed their properties being burned down slowly to the ground. The incident is only one among the recurring fire events in Vientiane, Lao PDR.

The fire risk map was prepared through integrating seven layers of hazard attributes as building materials, availability of fire sources, fire fighting scenario, fire history, electrical wiring, building density and road accessibility. Mostly data is collected through field surveys and integration was done manually. The zonation was prepared through identification of areas having relatively uniform characteristics from the fire hazard attribute viewpoints through clustering according to the total fire hazard rating. The overall rating showed that more than half of the communities covered in the zonation process were identified as “high risk”, while six of them were labeled “very high risk” to hazards. The Vientiane Fire Risk Mao served as the basis for formulation of fire risk reduction strategies at the city and national levels (Ms. Charina May Blanco, 2004).

6. Water requirement for firefighting

The minimum amount of water shooting through B-3 class firefighting pump equipped with fire engine is 498lits/min. It means minimum standard discharge rate of water is 500lits/min. (Indian Practical Civil Engineerings' Handbook) But it may vary on context based and may also vary according to climate, sanitation facility available, people's habit, religion, culture, food, clothes, present materials etc.

According to Code of Practice for Installation and Maintenance of Internal Fire Hydrants and Hose Reels on Premises, for 450l/m. terrace pump, it needs 2"dia. Suction pipe and delivery pipe.

6.1 The National Strategy for Disaster Risk Management in Nepal (NSDRMN)

Priority Action 1: Ensure that disaster risk reduction is a national and local priority with a strong institutional basis for implementation. Priority Action 2: Identify, assess and monitor disaster risks and enhance early warning. Priority Action 3: Better knowledge management for building a culture of safety. Priority Action 4: Reducing the underlying risk factors. Priority Action 5: Enhance preparedness for effective response. Staying within these strategies, fire risk management plan for Swayambhu premises will be prepared.

7. Study Area

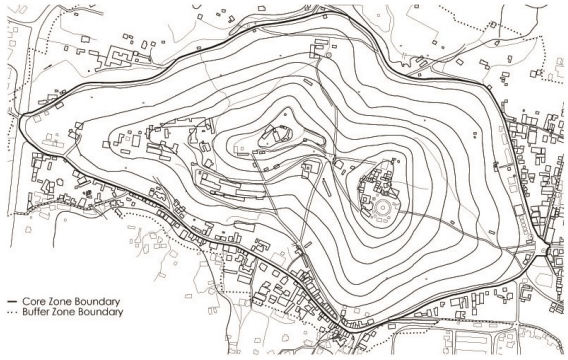

Figure 2: Master plan of area covered by Swayambhu premise according to FSMC

The study is conducted in the Swayambhu premises, which is one of the protected heritage sites of the Kathmandu Valley. This premise includes varieties of shrines and temples. The main monument is Swayambhu mahachaitya itself. It is difficult to say exactly who and when had founded this mahachaitya but certain repairs and perhaps enlargements of this Swayambhu Mahachaitya is believed to have been carried out in Licchavi time. The first authentic historical evidence of such restoration occurred in 1129 A.D. recorded in an inscription adjacent to the Mahachaitya.

It is situated on top of a hill lying 4 kilometers west of Kathmandu. More than 2,500 years old, it is an important pilgrimage center as well as the center of art, architecture, religion and culture of Buddhism. So, Swayambhu is the place which has very significant importance in both history and society. With the past of Nepal's history, importance of Swayambhu is also increasing. Therefore preserving the Swayambhu is preserving Nepal from losing its history and identity. As the time passed, Swayambhu premises had been facing different types of hazard which had been destructing the premises multiple times and its structure reconstructed and renovated then after.

The pilgrim's progress to Swayambhu holy premises is actually through a sylvan path of 365 steps.

According to the FSMC it has covered 24.3 hectors of land as core area of Swayambhu Premises, which includes Swayambhu cultural heritage area, school, museums, and monasteries. Among them only 17.3 hectares of land is covered by forest and remaining 7 hectares by other structures.

7.1 Inventory List of monuments at Swayambhu monumental zone

Table 1: Inventory List of monuments at Swayambhu monumental zone

Monument Name	Construction Period	Owner
Swayambhu Mahachaitya	12th c., 13th c., 1654	GoN/Guthi
Shantipur Building		Guthi
Sengu Bahi	18th c.	Guthi
Pratappur	1654	Guthi
Anantapur	1654	Guthi
Harati Temple	17th c.	Guthi
Manjushree Shrine	16th-17th c.	GoN/Guthi
Devdharma Gumba	1908	Guthi
Karmaraj Gumba		Guthi
Dharmachakra Vihar	1947	Guthi
Maitri Gumba		Guthi
Pulan Sengu Stupa		Guthi

7.2 Fire in Swayambhu Premises

According to the key person informant, there are lots of evidences of bush fire in the holy forest. Most of

the fire takes place in dry seasons i.e., the months of Chaitra and Falgun. Almost every year, fire takes place but luckily, it didn't spread in large area, it was controlled in growing period with the help of community and SMC.

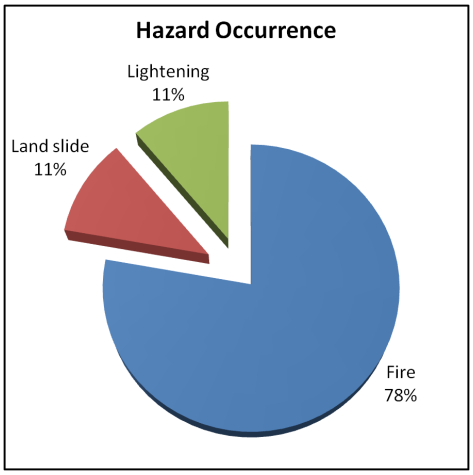

Figure 3: Hazard occurrence Chart of Swayambhu

To control the forest fire, now-a-days, SMC and Conservation Trust had managed pipelines, pumping machine and generator as fire extinguisher. It manages water in water pond and tank located below the Santipur temple so that it can use as fire extinguisher for fire. There are two generators with backup of limited fuel for pump up the water to required area.

7.2.1 Fire in Swayambhu Mahachaitya

In 1349, Sultan Samsuddin of Bengal destroyed the Swayambhu mahachaitya and put fire on it after long time at 1372, the Swayambhu mahachaitya was reconstructed (Shakya, 1098 N.S.). But there is no any legal document of destruction and reconstruction of the Mahachaitya.

7.2.2 Fire in Pratappur

In August 2003, Pratappur temple caught by fire, possibly due to wick lamp offered, and it was completely gutted.

The temple itself collapsed possibly aggravated by the water jet fire fighting that was used. The fire of 5th August 2003 that smoldered for more than 24 hours and gutted the granthakuta Shikhara of Pratappur completely, charring even the embedded timber uprights encased in brick work in mud mortar also highlighted how unclean conditions inside the temples can be key cause of disasters due to fire in heritage buildings (CARD, July, 2014). However, there has been no concerted effort or study to quantify and qualify fire risks to other key monuments at Swayambhu Monument Zone.

Figure 4: At the phase on reconstruction after fire on Pratappur

7.3 Available Capacity for firefighting for Swayambhu Premises

The risk of fire in any place is directly depends upon the capacity of fire fighting of that area. For this, the main responsible groups are the community itself, SMC and National fire brigade.

7.4 Federation of Swayambhu Management and Conservation (FMSC)

FSMC is the only one institutional committee which is working actively for management of Swayambhu premises from ruining than previous time. The fund for the committee is generated by the ticket sold for international tourists. On the way of management of conservation, to tackle risk of fire hazard, it manages nos. of water collections as ponds, tanks in different area of the premises. It manages ponds and tanks having capacity as shown in table 2.

Table 2: Water Storage in Swayambhu Premises

Description	Capacity in liters	Location
Santi Pond	80,000	In front of staircase above parking
Monkey pool	50,000	Behind santi pond
Underground Tank	30,000	East of monkey pool
Underground Tank	10,000	Behind building of FSMC
Plastic overhead Tank	$4 \times 5{,}000 = 20{,}000$	Above FSMC terrace and near Manjushree temple
Plastic overhead Tank	$3 \times 5{,}000 = 15{,}000$	Above a building of terrace in front of Santipur
Plastic Tank	5,000	As drinking water storage, infront of Santi pond
Total	210,000	

As whole it has capacity of 210,000 liters. of water storage within the premises. And it arranges almost 300,000 liters. capacity tank over muslim dip as backfill. So that it seems that storage of water (in case of fire) as fire extinguisher is enough though it is not only for fire fighting the water storage is used for daily supply to the community as drinking water. It is said that most of the time water storage are fully filled.

FSMC manages two nos. of generators and 2 nos. of water pumps so that they can control the small fire on the premises. According to the management policy, in case of fire, there are no chance of reaching brigade up to the hill so that the water will pour in the pond and from pond, water can lift up to the hill by using multiple pumps in between wherever necessary. But they do not have any preparation for fire extinguisher.

8. Parameter Analysis

Swayambhu premises are divided into eight different parameters and all parameters are given weightage. As the importance of selected parameters, weightage were given to each parameter which is finalized after the discussion with heritage expert (Dr. Prof. Prem Nath Maskey), supervisors, culture expert (Mr. Pushpa Raj Bajracharya) and reference of postgraduate theses related to fire. According to discussion and solution, weightage were given as;

Table 3: Parameter Weightage

S.N.	Parameters	Weightage
1.	Building construction materials	15
2.	Firefighting scenario	15
3.	Availability of Fire Source	15
4.	Fire History	10
5.	Building Density	10
6.	Road accessibility	15
7.	Forest Typology	15
8.	Electrical wiring	5
Total weightage		100

This weightage becomes 100 points as total. And these all parameters are again further divided into three levels as site condition and directed by case studies and discussion with expertise. As levels have to be differentiated, values were also minimized from full to lowermost in each parameters. According to the weightage given, the level is ranked as 1,2, or 3 i.e; high medium and low risk level.

Table 4: Weightage Table according to parameter

SN	Parameter	Total Weightage	Contents	Rank	Weight
1	Building Construction Materials	15	Thatched roof with Sun Dried Brick	1	15
			G.I. Sheet roof with Burn Brick	2	9
			R.C.C. slab with Framed/load bearing structure	3	4
2	Fire Fighting Scenario	15	No Water or Fire Fighting Equipment	1	15
			Insufficient Water or Fire Fighting Equipment	2	10
			Sufficient Water or Fire Fighting Equipment	3	3
3	Availability of Fire Source	15	Open Fire Source near combustible storage	1	15
			Fire Source in safe zone	2	10
			Very small Quantity of Fire Source	3	5
4	Fire History	10	3 incident in last 5 years	1	10
			2 incident in last 5 years	2	5
			1 incident in last 5 years	3	2
5	Building Density	10	Greater than 50% up to 70%	1	10
			Greater than 40% up to 50%	2	6
			Greater than 20% up to 40%	3	2
6	Road Accessibility	15	Less than 4' wide Road	1	15
			One way up to 8' wide road	2	10
			Wide greater than 8' wide well access	3	2
7	Forest Typology	15	Highly Inflammable trees (Seasonal)	1	15
			Having Inflammable Waste Disposal	2	9
			Ever Green Trees Area	3	4
8	Electrical Wire	5	Open High Voltage Cabling	1	5
			Partially managed Wiring	2	3
			Well planned Wiring	3	1
		100			

8.1 Fire Risk Assessment by Mapping

Figure 5: Fire Risk Mapping according to Building Materials

Figure 6: Fire Risk Mapping according to Firefighting Scenario

Figure 7: Fire Risk Mapping according to availability of Fire Source

Figure 8: Fire Risk Mapping according to Fire History

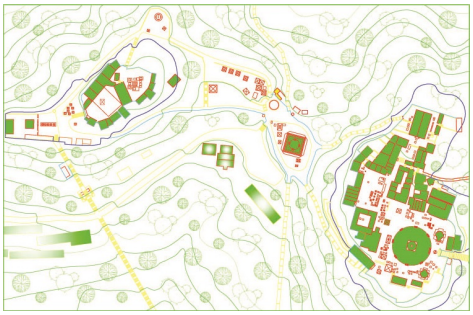

Figure 9: Fire Risk Mapping according toBuilding Density

Figure 10: Fire Risk Mapping according to Road Accessibility

Figure 11: Fire Risk Mapping according to Forest Typology

Figure 12: Fire Risk Mapping according to Electrical Wiring

The risk mapping and plotted graph shows that the Swayambhu premises have moderate type of fire risk which is now facing in present condition.

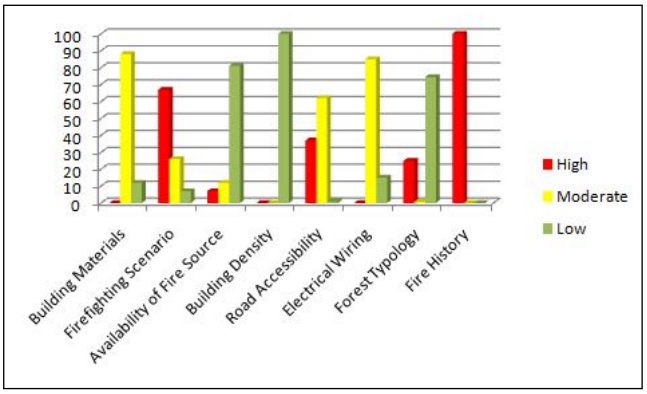

Figure 13: Bar Chart of Fire Risk Level

All together there are 99 structures which are in high risk level, 243 nos. of structures are in moderate level and 192 nos. of structures are in low risk. So, in general it can be said that the study area has moderate level of fire risk.

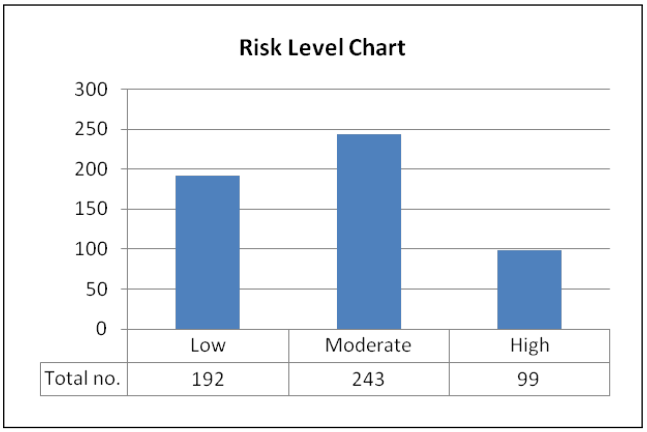

Figure 14: Bar Chart of Fire Risk Level

8.2 Fire Risk Assessment by Weightage Calculation

The calculated weightage table is shown in table 5 to know the fire risk level.

Table 5: Data Analysis according to weightage

S.N	Parameters	Total weightage	Contents	Rank	Given Weight	Gained weightage	Total gained	Remarks
1	Building Construction Materials	15	Thatched roof with Sunburned brick	1	15		9.1	
			Metal Roof with Burned brick	2	10	8.76		78nos. out of 89=87.6%
			R.C.C. Slab with cement mortar	3	4	0.34		11nos. out of 89= 3.7%
2	Firefighting Scenario	15	No Water or firefighting Equipment	1	15	10.11	12.89	60 nos.
			Insufficient Firefighting Equipment	2	10	2.58		23 nos.
			Sufficient firefighting Equipment	3	3	0.2		6 no.
3	Availability of Fire Source	15	Large storage of inflammable materials in Open Fire Source	1	6	1.01	6.28	3 nos.
			Storage of inflammable materials in Safe Area	2	11	1.23		5 nos.
			Small Quantity of Fire Source	3	72	4.04		53 nos.
4	Fire History	10	3 incident in last 5 years	1	10	10	10	
			2 incident in last 5 years	2	5			
			1 incident in last 5 years	3	2			
5	Building Density	10	Greater than 75%	1	10		2	39.5% density
			Greater than 50% up to 75%	2	6			
			Up to 50%	3	2	2		
6	Road Accessibility	15	Up to 4' or less than 4' wide access	1	33	5.56	11.76	33 nos.
			One way up to 8'wide way	2	55	6.18		55 nos.
			Well access for vehicle	3	1	0.02		1 no.
7	Forest Typology	15	Highly inflammable seasonal trees	1	15	15	15	
			Inflammable Disposal in forest	2	10			
			Evergreen trees	3	4			
8	Electrical wiring	5	Open high Voltage Wiring	1	5		2.7	
			Partially Managed Wiring	2	3	2.56		76 nos.
			Well Managed Wiring	3	1	0.14		13 nos.
			Total weightage		69.73			

As the result is 69.73 which lies in the range of 45 to 75, that's why it can be said that the report shows the area has the moderate risk of fire hazard.

9. Conclusion

From the research of the Swayambhu premises and its analysis it can be concluded in to three different topics such as:

- Different parameter has different level of fire risk. But while summarized all parameter, the level of risk lies on moderate level. And from weightage calculation, it is also known that, the premise is facing moderate level of risk of fire hazard.
- People of that community do not have any preparedness about fire hazard. They don't want to be aware from fire even there was a huge fire hazard in 2011 on Pratappur.
- From all above research, it is concluded that there are risk form fire hazard which seems to be controlled and the hypothesis of the thesis has been accepted and Disaster Reduction plan is necessary for the Swayambhu premises and Fire risk reduction plan is recommended.

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