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Framing the Challenges of Urban Flooding on Accessibility

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Abstract
Urban flooding is a worldwide phenomenon which is witnessed more often in a growing urban city in developing countries. The insufficiency of drainage system that cannot withstand with the current precipitation due to climate change, urbanization and haphazard planning causes stormwater runoff in a city area creating inundation that lasts from few hours to even few days known as Urban Flooding. These urban floods paralyze the surface transportation of a city. Especially the daily commuters bear heavy economic and financial losses. The major objective of the paper is to assess the accessibility disruption faced by daily commuters who travel via Araniko road, Pulbazar section road and identify major cause of the flood in the study area and also explore the strategic interventions to facilitate accessibility in the region. The research is based on case study approach. A total of 243 daily commuter survey was done through stratified random sampling method. According to the research and survey, sudden flash floods inundates the highway halting transportation which occurs 10-12 days in one monsoon season. Majority of the commuters wait for the flood to settle while only few with private vehicle takes alternate route via Nala. The vast majority of commuters incurs financial loss and the commuters described commute as highly inconvenient to travel during flood/inundation. The research concludes that improvement of alternate routes as an adaptive measure and proper management of artificial drainage system as a mitigative measure should both be incorporated simultaneously to cope with the annual flooding scenario in the study area.

Keywords
Urban Flooding, Inundation, Drainage System, Urbanization, Climate Change, Daily Commuter

1. Background

Flooding disrupts transportation systems in urban areas in developing country cities. While flooding has caused immediate damage to housing and infrastructure, accessibility and transportation are also severely hindered, resulting in significant indirect economic loss. Floods reduce transportation network capacity, either directly through physical destruction rendering roads unusable or through floodwater accumulation on the road surface rendering the road impassable [1]. Due to these disruptions, which include increased travel distances and times, commuters would incur significant socioeconomic costs.

Flooding is closely linked to both climate change and the shift in how urban land is used, where porous soft surfaces have been replaced by built-up and hard surfaces. Overburdened drainage frenzied and unregulated construction, no regard to the natural topography and hydro-geomorphology all make urban floods a man-made disaster. The term urban flood is a misnomer. The problem of flooding in urban areas is not only due to overflowing rivers, but the uninformed way in which our cities are coping with urbanization also plays a large role [2].

Globally floods cause more than 40 billion dollar in damage worldwide annually [3]. In Nepal, on average, floods cause over 175 deaths each year and average annual economic losses exceeding USD 140 Million [4].

According to studies, flooding is expected to become more common in the future because of climate change and urbanization and the current drainage infrastructure will not be able to withstand future flooding scenario. The impact of flooding on transportation and accessibility has received very little attention. Further study with possible mitigative and adaptive measures have to be introduced to cope with the ongoing situation in the present and future.

2. Literature Review

Flooding in cities is caused by poor design, encroachment on water bodies and drainage, settlement in low-lying areas, watershed changes, and climate change. With climate change, urban floods are expected to be more frequent there is likely to be longer flooding season and newer areas would experience flooding [5]. According to [6] flood can be classified into two categories; according to duration: Long standing and Short standing, and according to appearance: River flood, Urban Flood, Coastal flood and Dry water flood.

Global Climate Change and Urbanization are direct factor for causing urban flood while haphazard development, inadequate drainage system, improper solid waste management are indirect factors. In developing cities flooding is becoming frequent due to both human factors and meteorological/hydrological factors, with the former factor being more predominant. Urbanization, River encroachment, Pollution, Illegal mining activities, Interference in the drainage system and absence of administrative framework are basically human factors that escalates the risk of urban flood.

Urban flooding has a wide range of repercussions, particularly in terms of both direct and indirect economic losses. Flooding in an urban area might affect more than just one sectors. Some of the impacts are; Transport and Accessibility Disruption, Infrastructure damage, Damage to public and private property, Disruption of power supply and telecommunication and Deprived of Emergency Services. The research focuses on the transport and accessibility disruption in particular. And with proper knowledge of its cause the research also intends to explore possible adaptive and mitigative ways to cope with the annual flooding scenario.

Two case studies were done to explore the possible ways to mitigate urban flood of similar context; Adapting to Urban Flooding: Bharatpur and The Sponge City, China. The finding from Bharatpur case study suggests that structural solutions without properly integrating effective solid waste management become almost ineffective in reducing flooding risk and if solid waste not managed properly, the area under flood risk goes back up to 7.6 percentage in Bharatpur in five years. And the sponge city concept adopted in China is a development mode that can store, infiltrate and detain urban runoff through the appropriate planning, construction and management. Study suggest that if 1% of land is allocated to water drainage, then most flooding will be stopped. In the case of biblical, 1-in-1000-year floods, 6 percentage of land allocated to water drainage would be enough to stop the damage [7].

3. Research Setting

Every year the Urban Flood inundates in the study area i.e. PulbazarBanepa, blocking the Araniko Highway. The Araniko Highway is one of the major routes that connects Kathmandu valley and Kavre District. The highway also connects to Terai Region via BP highway from Dhulikhel. Large number of people travel from Kavre district to Kathmandu Valley daily for job and study purpose via Araniko highway.

In the study area rain triggers flood at Punyamata and Chandeswori river. The flood waterlogs Pulbazar in Banepa causing blockade to section of Punayamata river bridge and approached road. Sections of the Arniko Highway between Kathmandu and Banepa are prone to chronic flash flooding every monsoon season. Water from a nearby stream overflows into the road because of insufficient drainage, and compound walls that act like dams along natural floodplains of rivers [8]. The Pulbazar area has always been inundated due to rising water levels due to the narrowing of the river.

During the monsoon sudden flash flood blocks the Araniko Highway halting the transportation causing negative impact to daily commuters and the local people which ultimately results in the social and economic loss to the people.

Figure 1: Urban Flooding in Banepa

4. Methodology

The research is based on mixed method case study design which is a type of mixed methods study in which the quantitative and qualitative data collection, results, and integration are used to provide in-depth evidence for a case(s) or develop cases for comparative analysis. Quantitative data in the form of structure of survey questionnaire, rainfall datas, land use maps. Qualitative datas are achieved by filed observation and key informant interviews.

Sample size was calculated using confidence level 95% and margin of error 10, where 243 daily commuter survey was carried out to find the quantative data done through Kobo Toolbox. Also filed survey was carried out to analyze the existing scenario and Key Informant Interview with locals and experts were done to find the actual cause for the annual flooding/inundation in the study area.

5. Data Sets and Analysis

The major part of the research focuses on identifying the impacts of flood on accessibility and the challenges faced by the daily commuter in the study area. Also, the study focuses on identifying factors that is causing flood/inundation in the study area in relation to climatic factor, urbanization and human factors.

A sample of 243 daily commuter survey was done through stratified random sampling method to find out the challenges and commute disruption faced by daily commuter. Out of the total survey, 42% respondents were female and 58% were male. Age group below 16 was not considered eligible for the survey, besides them all age group were surveyed upon. Commuters traveling through both private vehicle and public bus were surveyed to find out their inconvenient level independently. The results found that commuters had more than one purpose for the commute. 88% of the commuters responded their commute has been disturbed by Pulbazar Flood and the rest haven't yet faced the flooding scenario. The results show that commute disrupts varying from 1-2 days to more than 5 days in one monsoon season. And the commuters must either take leave, wait for the flood to settle or take alternate route via Nala. Most private vehicle users are familiar with taking alternate route. Others commute is either delayed or commute is completely disrupted for the day. Commuters responded that delay lasted more than an hour causing them different losses; financial loss, well-being disturbance, irregular attendance and deprived of emergency services deprived. A total of 35.13% respondents showed Financial loss due to Flooding Disruption ranging from Rs. 1000-3000 per day, while others showed economic losses like well-being disturbed, time delay, irregular attendance and deprived of emergency services. 5 being highly inconvenient to commute during the flooding disruption, 34.74% respondents have stated level 4 as their inconvenience level.

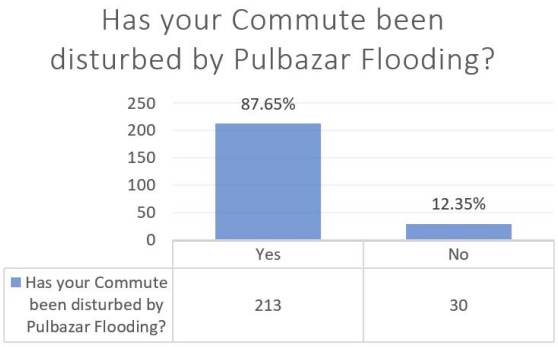

Figure 2: Commute Disturbed by Pulbazar Flooding

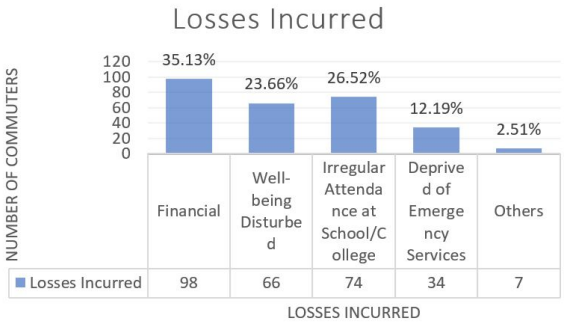

Figure 3: Loss Incurred to Daily Commuter

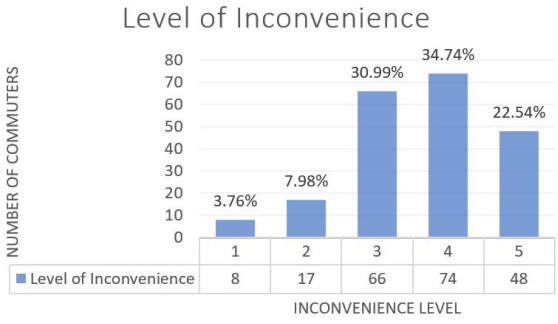

Figure 4: Level of Inconvenience during Flooding

The study from field observation shows that the catchment area extends from Nagarkot on the northern

side to Kashivanjhyang on East and Nala Tukucha on the eastern side, with area around 23sq.km and perimeter 20.9km. All the water from these area outlets from pulbazar bridge. Even heavy rainfall in Nagarkot basin might affect in Banepa Municipality.

"Flooding in banepa is not only associated to rainfall in Banepa but heavy rainfall in Nala, Bhaktapur and Nagarkot area will have adverse effect on the area, since water from all those area finally discharges through Punyamata River. And during massive flow, the river cant bear such volume which causes flooding in the Punyamata river" -KII, Nabin Thapa, Banepa Residency

The data from overview of study area shows that there has been massive growth of population between year 2011 and 2021. Between the year 2010 and 2020, built-up has increased by 400%, which indicates the expansion of imperious surface causing utmost stormwater runoff overburdening the existing drainage system.

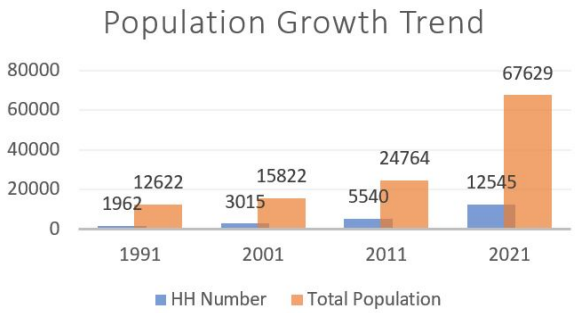

Figure 5: Population Growth Trend in Banepa Municipality

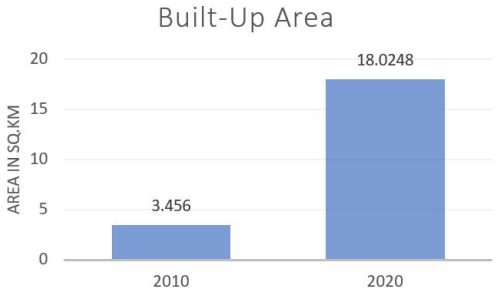

Figure 6: Built-Up Expansion between year 2010 and 2020

From a KII with Rajaram Palanchoke, who is a 63 year old permanent residence of Banepa, there used to be a Rajkulo to east side of the river, where inundation happens at present. Water from north side of the area used to accumulate and then drains out from Rajkulo. Also, after the construction of driving center, which is raised 2 feet above the road level stormwater drainage has been obstructed and waterlogs in study area causing inundation which lasts from 1-2 hours to 4-5hours causing traffic disruption.

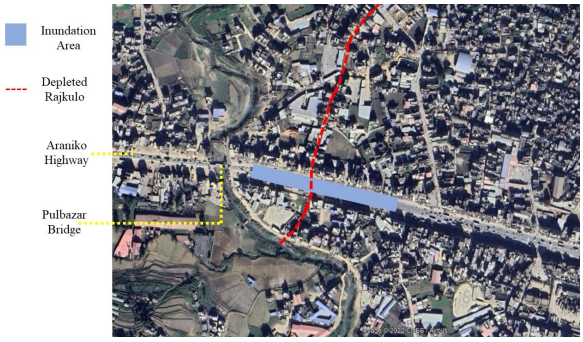

Figure 7: Depleted Rajkulo in the study area

Besides the land cover change factor, climatic factor also plays an important role in Urban flooding in the developing regions. Climate change has resulted in the heavy precipitation/ heavy rainfall globally. Although floods are not always caused by heavy rainfall, but their likelihood does increase. In areas where urban flooding is on the rise, even moderate amounts of rainfall can result in significant damage.

6. Findings

6.1 Findings from Daily Commuter Survey

Findings from daily commuter survey suggest that both adaptive and mitigative measure should go together to cope with flooding scenario.

Adaptive measures: From the survey it is found that 29% of the commuters take alternate route. Among them maximum i.e.; 40% of the commuters are private vehicle user. Also, 38% of alternate road user are Public vehicle. Since the alternate route is narrow and there is chance of landslide, proper maintenance should be done so that such routes can be used efficiently in flooding scenarios. Also early warning system would alert the commuters beforehand guiding them to use alternate route.

Mitigative Measures: River widening and Drainage system improvement are the mitigative measures that needs to be implemented to lessen the flood consequence. The Local government should be more responsible and participate actively in flood management taking necessary actions.

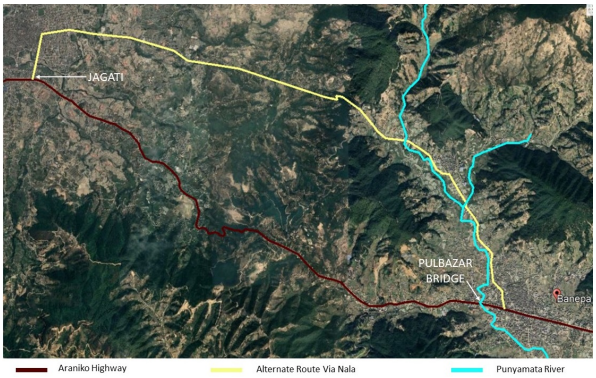

Figure 8: Alternate route in the area

6.2 Findings from Site Overview, Literature & Case Study

The findings suggest Short-term, Mid-term and Long-term solution to mitigate the flooding and make ease for accessibility in the particular route. Short-term solution includes; Inspection, Repair and Maintenance before Monsoon and Rainwater Harvesting. Mid-term solution includes; Pervious Pavements and Proper Drainage System to cater present and future water runoff. Long-term solution includes; River Widening and Detention Basin in the depression area.

Figure 9: Detention Basin in Depression Area

7. Conclusion and Recommendation

One of the major impact of flood is on accessibility which is being overlooked as the data shows that almost 90% of the surveyed respondents has experienced flooding disruption. In addition to that, significant financial and economic loss is being incurred. The challenge to mitigate the effect of flooding on accessibility in the study area is spread across policy interventions of various improper urban practices.

Looking at the site condition and scenario, it is recommended that both Adaptive measure as a short-term solution and Mitigative measures as a long-term solution may be implemented simultaneously to abate the flood risk and ease the accessibility during flooding.

Proper management and maintenance of the alternate routes, in addition to that Early Warning System should be developed. Width of the bridge should be increased so as to cater the peak volume flow of water. Identification of Recharge Ponds with proper Hydrology Analysis. The Municipality vision should be to increase the Riverine and Lakes area from 0.28% to 1% as suggested from the studies. Drainage system to be effectively designed considering the Urbanization, climate change and its return period. Flood vulnerability mapping should be the primary step involved in risk reduction and Strict control on the land use with respect to vulnerability mapping should be implemented to reduce the tangible and intangible losses. River-front water development plans and allocation of floodplain areas to manage flood control plans.

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