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The Impact of Increased Urbanization on Urban Flooding: A Case Study of Madhyapur Thimi Municipality

Pujita Shrestha [a], Sudarshan Raj Tiwari [b]

[a,b] *Department of Architecture & Urban Planning, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
Corresponding Email: [a] pujitashrestha@gmail.com [b] srtiwari@ioe.edu.np

Abstract
Urban flooding is a serious and growing problem in the city, especially in the dense parts and in the area located along the river flood plains. Urban floods are a great disturbance to the daily life and has become a serious environmental issue which is threatening the life and health of the residents of the city as well as the environment. These urban floods are driven by a combination of natural and man-made factors. Urban areas are facing the adverse effect of urbanization and climate change, of which, urban flooding is one growing issue.The purpose of the research was to identify the impacts and contribution of urbanization on the urban flooding with the case study of Madhyapur Thimi Municipality. The research was carried out through the post positivism paradigm and was based on inductive thinking. The case study / mixed method was adopted as the primary research methodology. Also, historical data was compiled since the research deals with transformations. The paper shows that as the urbanization is implicated in, it compounds for the growth of flood risk as the natural landscape of the flood-plain is replaced by new development. The impacts of urbanization can be seen on drainage system and instant flow of run-off rivers increased during rainfall.

Keywords
Urban flood, Urbanization, land cover pattern, imperiousness, Madhyapur Thimi Municipality

1. Introduction

Urban flooding is a serious and growing development challenge in the urban areas. New flood risks are emerging in urban areas including more potential for flooding particularly for the residents of the rapidly expanding towns and cities in developing countries. Against the backdrop of demographic growth, urbanization trends and climate changes, the causes of floods are shifting and their impacts are accelerating [**?**]. Urban flooding poses a serious challenge to development and the lives of people, particularly the residents of the rapidly expanding towns and cities in the developing countries [**?**]. Urbanization has become a major trend all over the world and is a dominant phenomenon in all the developing countries. The population of urban areas are growing in a fast pace due to many reasons - the prime reasons being migration from rural areas and population growth. Migration plays a major role in urbanization. Migration is the spatial mobility of people by changing usual place of residence to a well-defined destination[1]. Some of the basic reasons for migration are the search for better education, employment, health facilities and better lifestyle to name a few. These leads mostly to the migration in established and renowned cities. However, some other reasons for people to migrate from one place to another are evacuation due to natural calamities, or political reasons. Most people migrating from these reasons tend to settle down in the cities nearest to their old residences. With the increase in population in the urban sector, the need for new and sophisticated means of living takes control and becomes the basic need of the people. This results in the fast growing road network, tall buildings, shopping malls, offices, restaurants and dwelling units with little or no consideration for the natural drainage, water supply, drainage and sewerage systems which are the life-line for the cities.

Unplanned urbanization has drastically altered the drainage characteristics of natural catchments, or drainage areas, by increasing the volume and rate of surface runoff [2]. Drainage systems are unable to cope with the increased volume of water and are often encountered with the blockage due to indiscriminate

disposal of solid wastes [2]. This results in the outflow from the drainage system to cause inundation by either breakage of drainage system or due to insufficient drainage size. Urban flooding is becoming an increasingly important challenge for the planners, policy makers and city administrators among the numerous challenges posed by rapid urbanization. Urbanization is implicated in and compounds flood risk [3]. "The study of the land cover from 1990 AD to 2010 AD showed increase in the imperviousness in Kathmandu Valley [4]. Imperviousness is considered as the sum of commercial, industrial, institutional, mixed, public utilities, residential and transportation areas which contribute to the land cover" [4]."The likelihood of flooding is closely associated with the changes in land use linked with urban development that leads to the removal of vegetation and soil. This transformation limits water infiltration and increases the speed and the amount of water run-off on the ground. Additionally, the alteration of natural drainage routes and increases in pressure on existing drainage systems due population growth in turn increases the likelihood of systems being overwhelmed" [4].

Recently on 12th July 2018 and 5th August 2018, Madhyapur Thimi Municipality was majorly affected by water logging of streets and seasonal river flooding. The Hanumante rivers remain out of water throughout the year expect for the monsoons when water level reaches the nearby low-lying areas. Each year more localities are being affected due to water logging. The purpose of this research is to identify the impacts and contribution of urbanization on the urban flooding – a case study of Madhyapur Thimi Municipality and to recommend the basic planning approaches to mitigate urban flooding in the towns of Kathmandu Valley.

2. Limitation

The research was only limited to one of the urban area of Kathmandu Valley i.e Madhyapur Thimi municipality. The research depended primarily on secondary data and information available through the various sources and only limited to the relationship between urban growth and urban flooding. There may be other various causes for urban flooding for example Climate change and rainfall but study on this sector was not done during this research. The research focuses on the study of flooding history and emphasizes the condition of urban growth in Madhyapur Thimi Municipality.

3. Literature Review

3.1 Urban Flooding

Urban flooding is an overflowing or irruption of a great body of water over land in a built up area which is not usually submerged. Thus, flooding in urban areas is caused by intense and/or prolonged rainfall, which overwhelms the capacity of the drainage system [5]. Our cities are densely populated, and an urban flood affects a large number of people in a very small area. In addition, an urban flood results in inundation and damage to vital infrastructure, and disruption to roads and services, thereby affecting all walks of life. It often leads to major economic losses which have both local and global implications. Outbreak of diseases is yet another hazard after a major urban flood. Urban flooding is a dangerous hazard that is increasingly causing more severe damage to metropolitan areas around the world [5].Urban floods are a serious and growing problem for both developed and developing countries. They cause damage to buildings, utility works, housing, household assets, income losses in industries, and disturbs daily city activities as it entails drainage, transportation, and electricity interruptions. Many urban areas are facing the challenge of increased urbanization with rising populations and high demands for land [3]. Urban flooding is a growing environmental concern in cities.

3.2 Urbanization

"Urbanization refers to the population shift from rural to urban residency, the gradual increase in the proportion of people living in urban areas, and the ways in which each society adapts to this change" [6]. It is predominantly the process by which towns and cities are formed and become larger as more people begin living and working in central areas. Although the two concepts are sometimes used interchangeably, urbanization should be distinguished from urban growth: urbanization is "the proportion of the total national population living in areas classed as urban," while urban growth refers to "the absolute number of people living in areas classed as urban" [6]. It can also be termed as the progressive increase of the number of people living in towns and cities. It is highly influenced by the notion that cities and towns have achieved better economic, political, and social mileages compared to the rural areas [7].

3.3 Impervious Surface

The impervious "hard" surfaces (roofs, roads, large areas of pavement, and asphalt parking lots) increase the volume and speed of storm water runoff. This swift surge of water erodes streambeds, reduces groundwater infiltration, and delivers many pollutants and sediments to downstream waters. While the pervious "soft" surfaces slowed water seeps into the ground, recharges the water table and filters out many pollutants and sediments before they arrive in downstream waters [8].

3.4 Aging and inadequate drainage system

Many older communities still rely on storm water, water supply, and wastewater systems that were designed for conditions that existed decades ago and comprise infrastructure that has significantly deteriorated or is undersized for contemporary standards [9].

3.5 Development below flood plain: Construction in low land area and flood plain

Floodplain is a vital part of the river/stream ecosystem that acts as flood buffer, water filter, nursery, major center for biological life and provide fresh water for wetlands [10]. The morphological features of floodplains which include fertile alluvial soils, flat topography and moderate gradient, make them less costly in terms of socio-economic development and thus, have encouraged encroachment [11]. Floodplain encroachment has seriously increased flood risk and damage potential, especially of urban floods due to heavy socio-economic infrastructural development on these floodplains. Urban encroachment into floodplain alters the integration of surface- runoff with the main channel, reduces surface water storage and conveyance capabilities, reduces water quality of receiving waters and adjacent lands, in addition to other secondary effects such as depletion of water resources, cumulative impact on wetlands and pollution of downstream surface waters [12]. The practice of urban encroachment on floodplains has also, exacerbated the extension of internal flooding due to reduction in floodplain's capacity to attenuate flood, thereby bringing more areas of the urban built-up under flood vulnerability [13]. The floodplain encroachment has caused rising trends in urban flooding. The problem is even more critical in developing cities where there is poor control over land use practices within floodplains and inadequate institutional mechanism to enforce floodplain ordinances [14].

3.6 Increasing in runoff volume

There has been greater runoff generated due to two reasons, first increase in rainfall and second, land changes in the past few decades due to high urbanization. This has resulted in more built up areas and reduced permeable surfaces and open spaces. This has been evidenced from the growth rate and increase in built-up statistics [15]. This increment in impervious surface reduces rain water percolation and time of concentration, thereby accelerating the Run-off.

4. Study Area

The study area selected for the research lies in Madhyapur Thimi Municipality, Province 3, Bhaktapur District of Bagmati Zone in Nepal. It lies between 27°40'0" and 27°42'0" North Latitude, and 81°22'30" and 85°25'0" East Longitude. It occupies a total area of 11.47 square kilometers. Madhyapur Thimi municipality lies between the cities of Kathmandu, Lalitpur and Bhaktapur. The municipality is bordered by Hanumante river in the east and south, and Manohara river in the west and north side. Hanumante river flows east to west separating the municipality from Suryabinayak municipality and Lalitpur metropolitan city in the south and Bhaktapur municipality in the east.

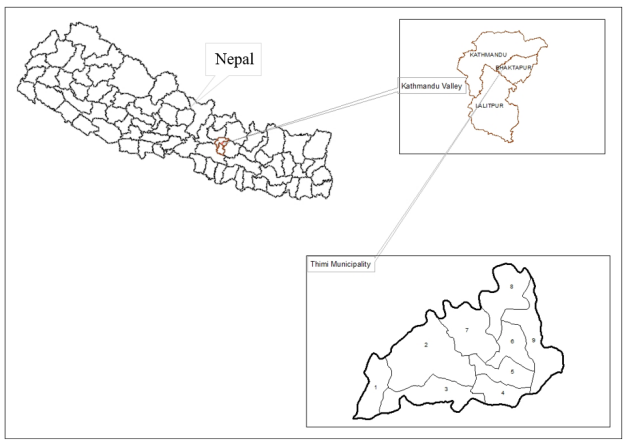

Figure 1: Map showing Location of Madhyapur Thimi municipality(source: Madhyapur Thimi Municipality)

Manohara river flows north-east to south-west separating the municipality with Kathmandu metropolitan city in the north and north-west side. Madhyapur Thimi is one of the ancient, cultural and historical places in Nepal and lies along the trade route from Bhaktapur to Kathmandu. Like other historical settlements, the city is also situated on elevated land and is located at an altitude of 1326 meters from the sea-level. The city is part of the extended form of the capital and is a city belonging to the Kathmandu valley, and hence it is one of the rapidly expanding urban areas with rapid growth in urban population in the recent years.

Figure 2: the affected area from flooding, settlements at Radhe Radhe and the Kamerotar land pooling project areas have become waterlogged on July 12th 2018 (Source: Setopati online news)

After 1950, an important educational center was established at Sanothimi and other several important education institutions like Janak Education Material Centre, Education campus of TU, Central School Examination Control Board, CTEVT and establishment of Nepal Tuberculosis Hospital, several schools and colleges, may have attracted people to municipality. After the construction of Araniko Highway linking Kathmandu to Kodari, the flood plain of Thimi became an attractive place for industries and residential growth. This expansion creates significant demand of plots to create space for the development of housing and new infrastructures. As a result, though the old settlement of the municipality is confined in the elevated terrain of the valley, the new constructions are spontaneously distributed along the river-banks and fertile agricultural low-land. Now it is seen that instant flooding has been reported yearly (flooding of 27th August 2015, 26th July 2016, 26th July 2017, 12th July 2018 and 5th August 2018 which was reported on newspaper).

For the research purpose, the catchment area was taken from the stretch extending from the bridge near the confluence of Manahara river to the bridge of Radhe Radhe to Arniko Highway. The study area was selected as it is the most affected part (in figure 2) where inundation occurred after heavy rainfall during the flood of 12th July 2018. The demarcation of catchment area as shown in figure 3 was done using QGIS software using Thiessen Polygon Method. The table no. 1 shows the total Catchment Area (Sq.Km.) of different places at Hanumante River near Confluence with Manohara.

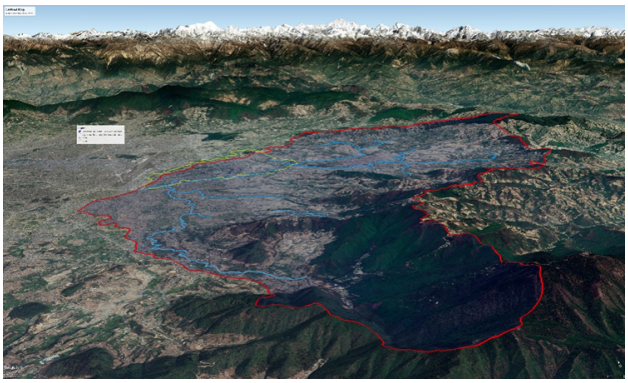

Figure 3: The red boundary showing catchment area at Hanumante River near confluence with Manohara River @ 27°40'04"North Latitude, and 85°21'11" East Longitude.

5. Methodology

The research was carried out through the 'post positivism paradigm' where it is believed that the objective reality, look at truth knowable within probability, raises practical issues and have limited observations. The degree of co-relation of different variables is analyzed. However, the study was also validated by the interpretation of the spatial

Table 1: Catchment Area (Sq.Km.) at Hanumante River near Confluence with Manohara

Location	District	Easting	Northing	Elevation	Area in sq km.
Nankhel	Bhaktapur	85.47	27.65	1428	27.996
Tikathali	Lalitpur	85.35	27.65	1341	22.75
Chapa Gaun	Lalitpur	85.33	27.6	1448	2.747
Changunarayan	Bhaktapur	85.417	27.7	1543	18.981
Bhaktapur	Bhaktapur	85.42	27.66	1330	34.111
Nagarkot	Bhaktapur	85.52	27.7	2163	14.865
Kathmandu Airport	Kathmandu	85.37	27.7	1337	4.238
Khumaltar	Lalitpur	85.33	27.66	1350	0.385
Godavari	Lalitpur	85.4	27.58	1400	21.72
Sankhu	Kathmandu	85.48	27.75	1449	0.204
Total					148

observations and literature study. The research was based on inductive thinking approach. In this research, case study (mixed method) is adopted as the primary research strategy. The mixed approach has been adopted to collect data and includes the mixture of both qualitative and quantitative data collections. The quantitative research begins with the ideas, theories and concepts that are defined as they are used in the study for the variables of interest. Different variables and their relationship are studied to obtain, verify and confirm the results. The qualitative research approach consists of individual interviews and observations through set of questionnaire. The qualitative research gives the opinion, reasons and might be useful to find the impacts and alternative solutions. Both primary and secondary data were collected during the research. The primary data was collected through visual inspection and interviews with local community and various stakeholders. The secondary data was collected through different sources from the internet, news articles, and published / unpublished reports. Time Series Analysis is used to record the transformation in certain period of time and show the trends and changes throughout the research interval. The collected information is analysed and prepared in form of graphs and charts. Maps and photographs are also prepared to present the visual condition of the study area.

6. Data Set and Analysis

6.1 Land Cover Change Trend In Catchment Area Of Hanumante River

The decadal maps of varied periods were analyzed by using QGIS to assess the land cover changes. The land cover maps were prepared based on acquired aerial and satellite images of four time slices-1990, 1998, 2008 and 2018 which were geo-referenced in the national coordinate system.

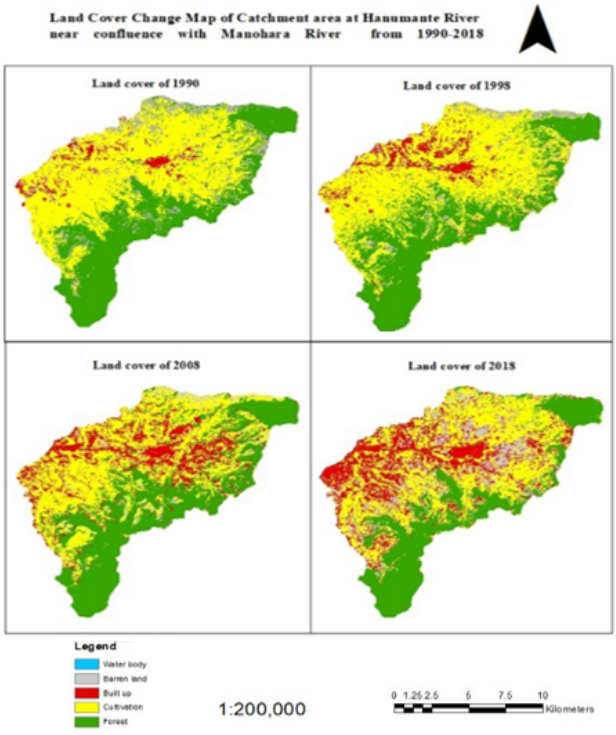

Figure 4: Land cover of 1990, 1998, 2008, 2018 of catchment area of Hanumnate river near the confluence with Manohara River

The land cover maps of 1990, 1998, 2008 and 2018 were prepared through interpretation of (1990, 1998 and 2008) Landsat 5 TM images and 2018 Landsat 8 OLI-TIRS images of 30m resolution respectively. The prepared land cover maps were overlaid in QGIS to analyze the change trend of land cover using Maximum likelihood classification.

Table 2: Magnitude of Land Cover change (1990-2018) of Catchment Area at Hanumante River near confluence with Manohara River

Land Cover	Available land in sq. km				Change in area (sq.km)			Total Change	Change in %			Total change in %
	1990	1998	2008	2018	1990-1998	1998-2008	2008-2018	1990-2018	1990-1998	1998-2008	2008-2018	1990-2018
Forest	85.64	71.24	64.55	40.8	-14.4	-6.68	-23.75	-44.83	-16.82	-9.38	-36.79	-52.35
Built up	1.29	3.9	14.63	54.78	2.61	10.73	40.15	53.49	202.58	275.21	274.37	4150.35
Barren land	3.14	21.73	35.33	31.17	18.59	13.6	-4.16	28.03	591.35	62.61	-11.78	891.84
Cultivation	57.7	50.95	33.42	21.21	-6.74	-17.53	-12.21	-36.48	-11.69	-34.41	-36.53	-63.24
Water body	0.23	0.18	0.06	0.03	-0.05	-0.12	-0.03	-0.2	-22.78	-67	-45.45	-86.1
Total area (sq. km)	148	148	148	148								

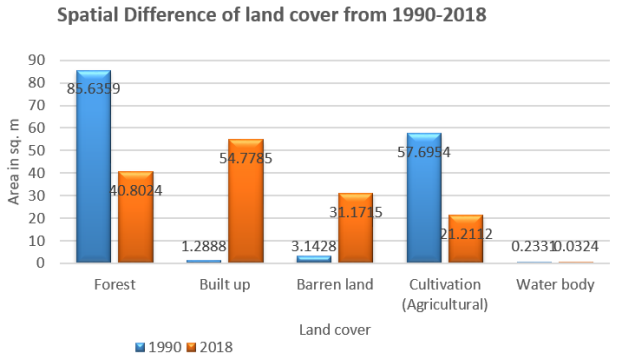

Figure 5: 4 Spatial Difference of land cover change in the catchment area of Hanumante river since 1990-2018

Figure 4, shows the land cover change trend of the catchment area (sq.km.) at Hanumante River near the confluence with Manohara River from 1990 to 2018. These maps clearly illustrates that the trend of land cover has been changed significantly over the past last two decades. The area has undergone rapid change in land cover during the period of 1990-2018 as explained by figure no 5. From table 2, the land cover of 2008 presents significant urban growth. The magnitude of land cover changes were related to conversion of agricultural land into other land cover. Much of the agricultural land has been converted into built-up areas to cater the increasing population. The conversion of cultivational land into built-up spaces are attributes to urbanization and to create space for growing population. The analysis shows that the built-up area was seen to be increased by 53.49 sq. km area during the period of 1990-2018 and however at the same time the agricultural land was seen to be decreased by 36.48 sq. km area which is a decrease by 63.24 during the period of 1990-2018. The forest area also decreased by 44.83 sq. km area during the period of 1990-2018. This clearly shows that the conversion of the agricultural land and forest area was essential to create the land for the growth of urban area. The barren land was also seen to be increased which shows ready plot for urban growth which are the result of conversion of agricultural land into new development process of urban growth. The study of land cover from 1990AD to 2018 AD showed increaseness in the imperviousness and thus the runoff generated during rainfall also increases. Hence we can say urban expansion causes the increase in urban flood vulnerability.

6.2 Population Data and Population Growth Rate of Madhyapur Thimi Municipality

According to the Census data of 1991, the population of Madhyapur Thimi was 31,970 and as per the Census data of 2001 the population of Madhyapur Thimi was 47,751 (male 24,747 & female 23,004) with households number 9,551 and population density of 4,298 per sq. km) taking annual growth rate of 4.11 percent. As per the Census of 2011 the population of Madhyapur Thimi is 84,142 (male 43,510 & female 40,632) residing 20,337 households (CBS, 2011) and population density of 7,573.54 per sq. km. . The table 3, shows the population data of Madhyapur Thimi Municipality from 2001 to the projected population data of 2018 which shows the population difference from 2011-2018 is 42050 by using annual exponential growth rate method. According to Central Bureau of Statistics (CBS) data from 2001-2011, the records shows that the Madhyapur Thimi Municipality has higher population growth rate against the national population growth rate and population of Nepal's Urban Centres.

6.2.1 Migration To Urban Areas

The population growth in Madhyapur Thimi is the result of both natural population growth and internal migration. The 2011 population census provides data on internal migration for 58 designated urban localities and it is necessary to analyze them to understand migration flow to the urban localities. The data shows that the urban-ward migration data of Madhyapur Thimi Municipality is 45 percent which constitutes nearly half of the native born population.

Table 3: Projected Population Data for 2018

	Population (Year 2001)	Population (Year 2011)	Annual Exponential Growth_Rate	Projected Population (Year 2018)	Population Difference
Madhyapur Thimi Municipality	47751	84,142	5.79%	126192	42050

The important part of development is accessibility and connectivity. The construction of 8-lane Araniko Highway which is the through road through the valley is both problematic and also an opportunity. The development of highway resulted the economic development and is also responsible for the growth of urbanization in the highway side of Madhyapur Thimi Municipality in rapid way. Due to the location of institutional zones in Thimi area and upgrading of linkages with other adjoining cities, the number of in-migrants increased, which resulted in population growth and hence rapid increase in the area of built-up spaces at the cost of reduction of cultivable land in the low-lying area and flood-plain of Hanumante river.

6.3 Effects Of Urbanization On Drainage System

With the increase in urbanization, there is a proportional increase in the water consumption and volume of sewerage. According to Madhyapur Thimi Municipality, municipal sewerage system is only available near the highway and main market area, totalling to approximately 54 kilometres of sewerage pipeline. The RCC Hume pipes of 45km length with drain sizes varying from 150mm to 700mm are mostly used and is used as combined sewer. There is no maintenance of the drains allocated. Most of the sewerage system dates back to decades which is insufficient and undersized to serve the present population. There is continuous demand for addition of drainage system as the city is expanding to new areas in a fast pace. The recently expanded uplands like Gatthaghar, Laukanthali, Kausaltar, etc. were built without proper planning and thus initially had severe drainage problems. In several of these settlements drains are constructed but have faced problems of inadequate size and slope[16]. The high flow in the sewer system in the rainy season exceeds the capacity of the pipes and thus damages the pipeline. The sewer pipes are released to the open fields, which later joins the gutters, small canals and ultimately is mixed in the Hanumante river. Also, the improper disposal of solid wastes finds its way to the drainage system and thus creates water-logged spaces in the sewerage system.

6.4 Impacts of Highway Construction

The important part of the development is the accessibility and connectivity. The construction of 8 lane Araniko Highway which was completed in 2011 is the through road through the valley is both problematical and also an opportunity. The development of highway resulted in the economic development and is also responsible for the growth of urbanization in the highway side of Madhyapur Thimi Municipality in rapid way. Due to the location of institutional zones in Thimi area and linkage of valley with outside the migration has increased in the area. This resulted in population growth through in-migration and which leads to the rapid increase in the area of built up spaces in cost of reducing the area of pervious ground represented by cultivable land. Also, the construction of road affects the natural drainage system in its vicinity. The infiltration rate is decreased due to reduction in the area of open ground surface and thus ground water recharge is obstructed resulting in instant and quick run-off during rainfall which increases the risk of flash-flooding of the river.

6.5 Development Below Flood Plain, Construction In Low Land Area and Flood Plain

According to Madhyapur Thimi Municipality, there is "Developed Guidelines and Building Regulations 2001". The regulations mandate the municipality to prevent the development of any kind of urban infrastructure or utilities within the preserved zone. The intent behind the zoning was to support continued farming practices for both environmental considerations while curbing the loss of prime farmland to unplanned urban sprawl. Green zone has been created at river banks and forest area. In area of river banks it is prohibited to build any structures within 20 m from the river bank and that area is separated as green belt area. However, the implementation of the land use regulation has not taken effectively resulting the uncontrolled unplanned and haphazard construction of residential buildings and the plotting of land for housing in the area at the Hanumante river belt, Gatthaghar, Lokanthali, Kaushaltar area. The agriculture land is being converted into urban areas to shelter the massive

population growth.

6.6 River Encroachment

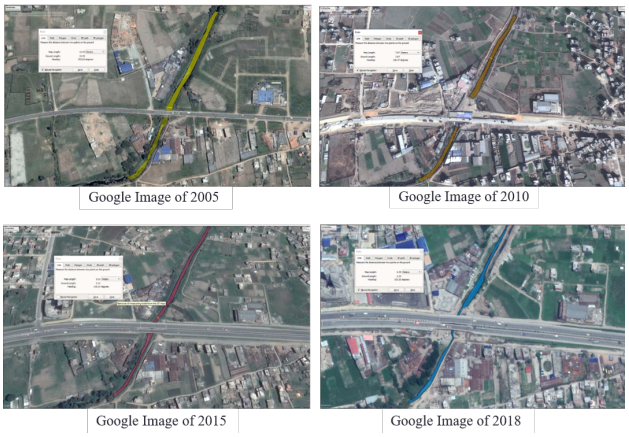

Figure 6: Map showing Change in width and flow path of Hanumante River, near Radhe Radhe in 2005, 2010, 2015 & 2018(source: Google Earth)

The encroachment of river for land leads to obstruction in the natural flow path of water, which causes flood. The width of Hanumante stream used to be six to ten meters in 1964, and now it has shrunk and narrow down to two meters only [17]. In figure 6, river flow path and width of Hanumante River in 2005, 2010, 2015 and 2018 near Radhe Radhe prepared by using google earth are shown. The width of river in the selected section are 12.53m in 2005, 7.67m in 2010, 5.31m in 2015 and 2.33m in 2018 respectively. Thus the result of measurement in google earth also shows the encroachment of river. Hence the run-off area of river also reduces which causes the generating of the flooding during rainfall.

6.7 Impact of Occupational Shift

Madhyapur Thimi Municipality was known for its agricultural productions like paddy, wheat, rice and vegetables which was the major source of income of the local municipal residents until a date back. Owing to the change lifestyle, new occupation opportunities having more economical benefit than agriculture and urbanization the agricultural land owned by the farmers are decreasing. Hence the rice farming also decreases which is the best water management for monsoon period as the rainwater will be hold by the cultivation field. Terrace irrigation is widely provided in the areas where cultivation depends upon rainfall. Previously, there was the provision of Pre monsoon management of water body. The farmers of newar community celebrates the ”Sithinakha” at the end of May or the beginning of June at Kathmandu Valley which is the day for cleaning and repairing the household and surrounding grounds, especially the wells. The water from the wells are taken out for cleaning process and to manage water in the agriculture field to grow the seeds for rice at that time which is dry season time. The well will be empty and which is useful to recharge the aquifers during the monsoon period. If the monsoon balances the recharge, then the source could be utilized and the ground water can be recharged again which is useful to hold the water of monsoon period. But now as the occupation is shifting and there is decline in cultivable land, the previously used monsoon management and flood mitigation measures is not followed which creates impact on the recharge function during dry season and water cannot be balanced during monsoon. The preservation of agricultural land is vital for the sustainability of urban development in the Kathmandu Valley.

7. Findings and Discussion

Urban flooding is mostly created by man-made structures. The growth in urbanization replaces the natural grounds of flood-plain with new development. Over the past few decades, rapid urbanization with changing land-use pattern has resulted in the loss of recharge area and increased surface run-off. Due to rapid increase of population in most of the urban areas, the existing sewerage system has become inadequate. Unplanned urbanization has drastically altered the drainage characteristics of natural catchments, or drainage areas, by increasing the volume and rate of surface run-off. It is found that the existing sewerage system was not designed to cater this need and hence surface flow in municipal area as well as run-off water in the Hanumante River increased. Also, the improper disposal of solid wastes finds its way to the drainage system and creates blockage in the sewerage system thus creating water-logged areas during the monsoon.

Traditionally settlements of Kathmandu valley were not impacted by flooding as the settlements were located in high lands (tar) and, ’dola’ or the ’tala’ which is low land areas and are often the flood-plains are used for agriculture. Thus during monsoon also, the human settlement didn’t get affected by flood and the agricultural field got water from rainfall which is necessary for the crops. This traditional planning was

continued up-to the time when planning was done in the late 1990s. But in present context, the low lying areas is being converted into residential areas and it is the main place where new infrastructures are developing. The agricultural hinterland is converted to built-up areas with the increase in population and demand for new residential areas. The impact of development in low-land and urban sprawl have resulted in the encroachment upon what is still primarily agricultural land, now it is seen that instant flooding has been reported yearly (flooding of 27th August 2015, 26th July 2016, 26th July 2017, 12th July 2018 and 5th August 2018 which was reported on newspaper). The past generations had means to sustainable approach. But now as the occupation is shifting and decline in agriculture field, the previously used pre and post monsoon management is not followed which creates impact on the recharge function during dry season and water cannot be balanced during monsoon. The agricultural hinterland is converted to built-up areas with the increase in population and demand for new residential areas. The lowland area which was previously used for cultivation purposes are observed to be major urban expansion areas in the present context. This has increased the vulnerability of people residing in the flood plains and along with it, decreased the original width of the river due to river encroachments. The natural drainage system is also greatly affected by increment in built-up area which results in the reduction of percolation area and subsequently obstructs the ground-water recharge and increases the surface run-off thus increasing the risk of flash flooding in the rivers. Furthermore, the construction of Araniko Highway in the vicinity of the low-lands in Madhyapur Thimi has resulted in the urban growth in that area, causing more people to reside in the flood risk plains increasing in urban flood vulnerability.

8. Conclusion and Recommendation

The research concludes that the major causes for urban flooding in Madhyapur Thimi municipality are change in land use and land cover pattern covering the previous rice field and other cultivable areas into urban area for addressing the rapid urban expansion and population growth, encroachment in low-lying flood plains, river encroachment, inefficient and inadequate drainage system, poor solid waste disposal system that cause blockages, and the impact and obstruction of natural drainage system due to construction of infrastructures which are the impact of urbanization. Urban expansion causes the increase in urban flood vulnerability. It is common scene in most of the core city area which are expanding in rapid and haphazard manner. The encroachment along seasonal rivers and drains are being common in urban areas. Urbanization changes the natural drainage regime, thus increasing the risk of flooding in depressions and other areas where surface water run-off naturally collects. One of the concerns relates to rapid conversion of agricultural land in the study area to meet the human settlement needs. The agricultural land is being converted into urban areas to shelter the massive population growth. If this unregulated trend continues, then there will be no land left for agriculture in future.

The haphazard and illegal growth of urban area without considering the land-use patterns authorized by municipality is one of the basic reasons of flooding. The residential development on low-lying area and flood-plain should be restricted. Hence, it is recommended that effective regulatory measures should be taken to restrict haphazard and illegal urban growth. While planning for development of infrastructures, whole of the catchment planning for drainage needs to be considered. With the solid wastes blockading the sewerage system, it is recommended that the solid wastes should be well managed by the municipalities. The effective flood risk management needs should be considered including the mapping of vulnerable area which should be restricted for development. Thus planning needs to be considered for future urbanization and sustainable approach needs to be considered to save the agricultural land.

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