

Investigating Major Causes of Frequent Flooding in Highly Urbanized Metropolitans Using a Quali-Quantitative Approach

Saurav KC¹ and Sangam Shrestha¹

¹Asian Institute of Technology

November 25, 2022

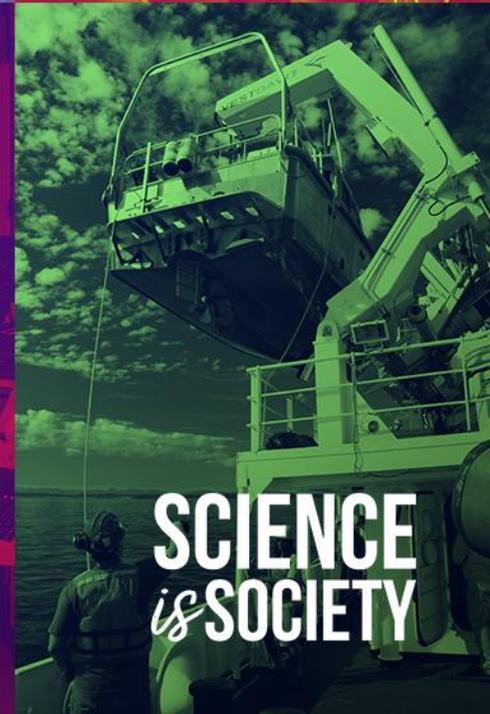
Abstract

This study investigates the key reasons for repeated pluvial flooding in highly urbanized Kathmandu Metropolitan City (KMC), using an expert' s-based questionnaire and quantitative validation through observed data and literature. The results obtained from 70 experts (onsite and offsite) showed that the majority experienced high rainfall intensities of shorter duration though the annual rainfall has declined. This result has been validated through the non-parametric Mann-Kendall test and Sen's slope estimation for rainfall trends and through the RClimDex package for the rainfall extremes using the observed rainfall at KMC (1989-2018). Furthermore, the results indicate that the three major causes of frequent pluvial flooding in KMC are (i) increased impervious cover, (ii) unplanned settlement and (iii) clogging of sewers followed by other contributors such as the undersized design of sewers, lack of coordination, climate variability etc. The land-use change analysis validates that the imperviousness of the city increased to 75% from 25% in 1990, and the census data proves the unprecedented urban settlement surged threefold in three decades, pressurizing the combined sewerage system. Additionally, the study also ranked several possible adaptation and management options and their effectiveness based on expert's perception to minimize frequent pluvial flooding in the study area. Research studies in KMC have shown that the combination of small-scale rainwater harvesting and overflow storage is likely to reduce flood volume by 20-35%. The study's approach and the findings highlight the prominence of evidence and experience-based approach in investigating causes of pluvial floods in extremely urbanized metropolitans. Besides, it also provides a common ground to policymakers, managers, planners, and technical officers in rating the multiple causes based on multi-practitioners observation and experience, understand its trend and severity quantitatively, identify the possible solutions, develop the inter and intra institutional coordination mechanism and take a call-to-action accordingly. Keywords: Urban flooding, Mixed methodology, Combined sewers, Climate Extremes, Kathmandu Metropolitan City

INVESTIGATING MAJOR CAUSES OF FREQUENT FLOODING IN HIGHLY URBANIZED METROPOLITANS USING A QUALI-QUANTITATIVE APPROACH

Saurav KC and Sangam Shrestha
December 16, 2021

AGU FALL
MEETING





SAURAV KC

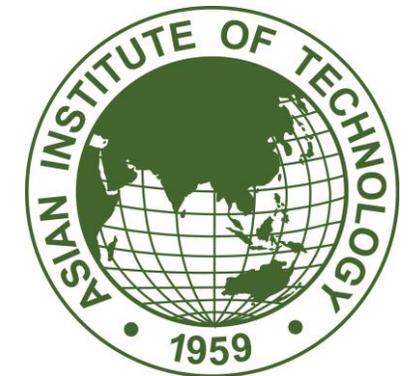
Doctoral Student

Asian Institute of Technology, Thailand

SANGAM SHRESTHA

Professor

Asian Institute of Technology, Thailand





OUTLINE

- Background
- Objective and Rationale
- Study Area
- Methodology
- Results and Discussion
- Conclusions



BACKGROUND

- Urban pluvial flooding occurs when the city's drainage capacity exceeds the volume of runoff.



- Climate change and rapid urbanization are stressing metropolitans in public service delivery.



OBJECTIVE

- To investigate the major causes of urban pluvial flooding in a highly urbanized metropolitan using a mixed approach.

RATIONALE

- Provides common ground for an evidence-based understanding of the issues and possible solutions, taking a joint call to action.



STUDY AREA

Country

Nepal

Location

Kathmandu Metropolitan City

Area

51.94 sq km

Population (2019)

1,000,000

Population Density

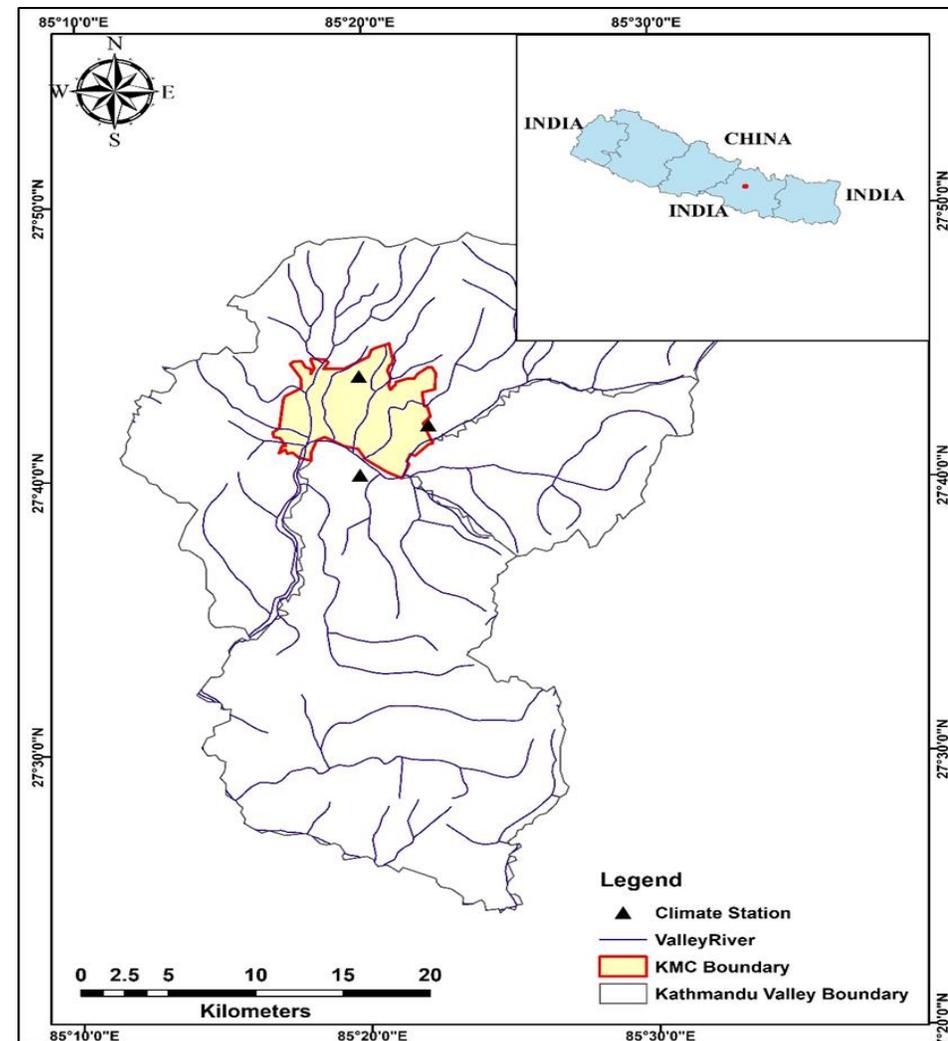
≈19250 Person/sq.km

Average Rainfall

≈1407 mm

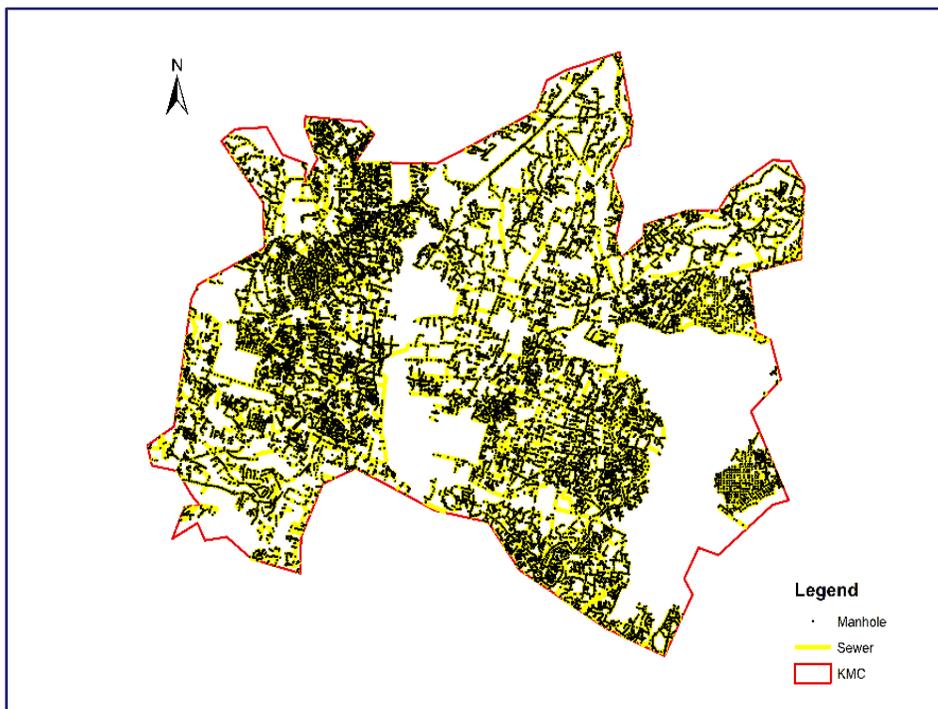
Drainage System

Combined Sewerage





STUDY AREA



**30,450
Manholes**

**30,144
Conduits**

**650 Km
Length**

Lack of proper drainage management bothering locals of Kathmandu

30 May 2016 | 19:40pm | SHRADDHA AMATYA | Comments

Share Tweet Google+ Pin Email

KATHMANDU, May 31: Sampada Koirala, a local of Maitidevi, recently got late for her medical preparation class as she had to walk carefully along the muddy road in her locality.

Ad closed by Google

Stop seeing this ad Why this ad?

PRINT EDITION - 2011-03-11 | METRO

'Drainage system a major problem'

Drainage system a major problem' Mar 10, 2011-

What are the ongoing development works in the ward?

There is no development work as such at present. Recently, the ward office paved roads with stones in a few places while the development budget of the ward is over now. We were given only Rs 200,000 for development and construction this year.

National News

ค้นพบประสิทธิภาพ
ที่ทำให้สิ่งก่อสร้างขึ้น คงอยู่ตลอดไป



PRINT EDITION - 2014-05-05 | MAIN NEWS

waterlogging: First rains expose city's poor drainage

- POST REPORT, Kathmandu

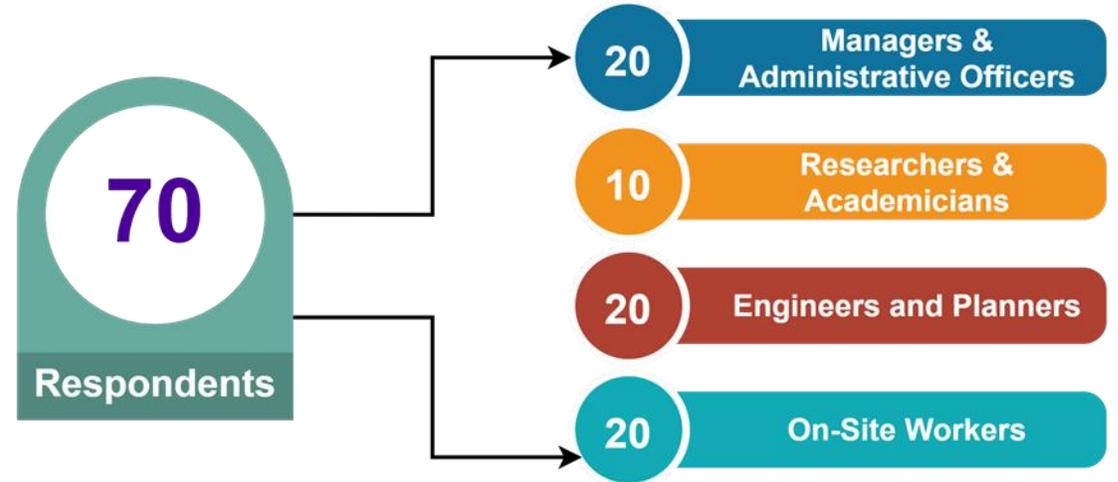
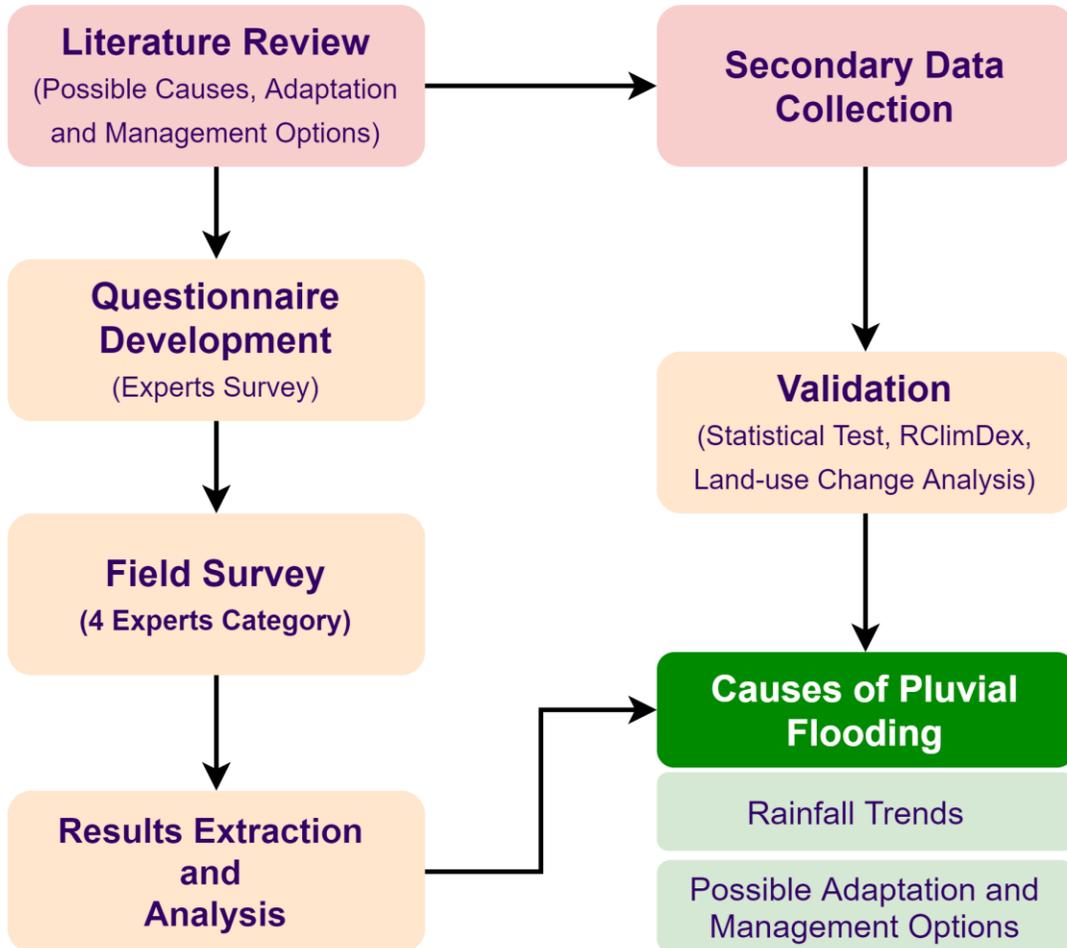
waterlogging: First rains expose city's poor drainage May 4, 2014-

The sudden downpour on Sunday revealed the cracks on the newly-expanded roads in the Capital. Pedestrians and drivers had to navigate through waterlogged streets—an unpleasant introduction to times ahead. Authorities have once again failed to install a drainage system capable of flushing away the monsoon rain.

The authorities lament that most of the major roads are grappling with this problem due to lack of connectivity to the drainage system. According to them, in roads like Maitighar-Tinkune and Lainchaur



METHODOLOGY



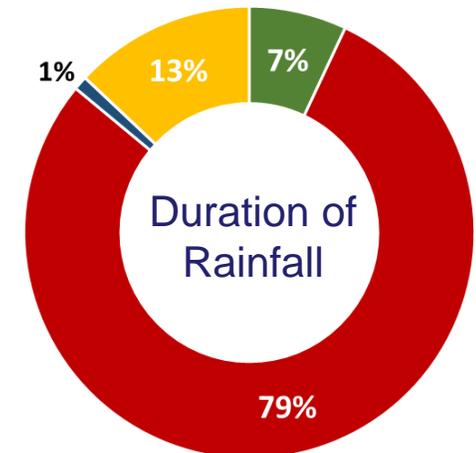
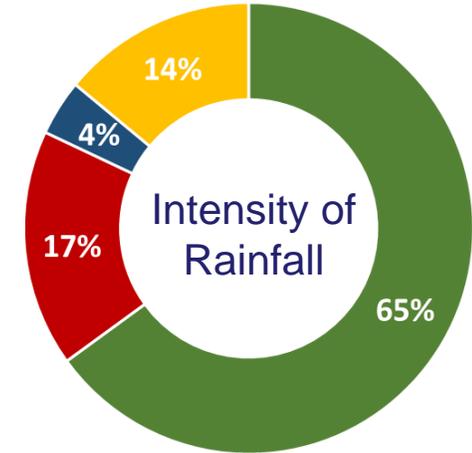
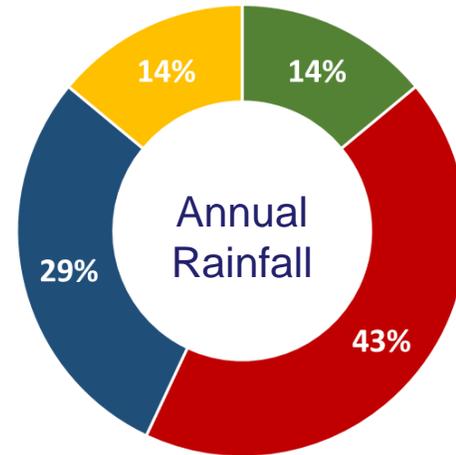


RESULTS AND DISCUSSION

Time series	Trend Test (1989-2018)		
	Test Z	Sig.	Q
Annual	-0.036	-	-0.144
Monsoon (Jun-Sep)	0.285	-	1.341
Post-Monsoon (Oct-Nov)	0.250	-	0.127
Winter (Dec-Feb)	-1.070	-	-0.642
Pre-Monsoon (Mar-May)	0.214	-	0.438

Category	Indices	Slope
Intensities Indices (I)	Rx1day	0.261
	Rx5day	0.042
	SDII	0.043
	R95p	1.516
	R99p	-0.297
	PRCPTOT	0.676
Duration Indices (D)	CDD	0.226
	CWD	-0.076
Frequency Indices (F)	R10mm	0.063
	R20mm	0.127
	R25mm	0.074

Experts Experience



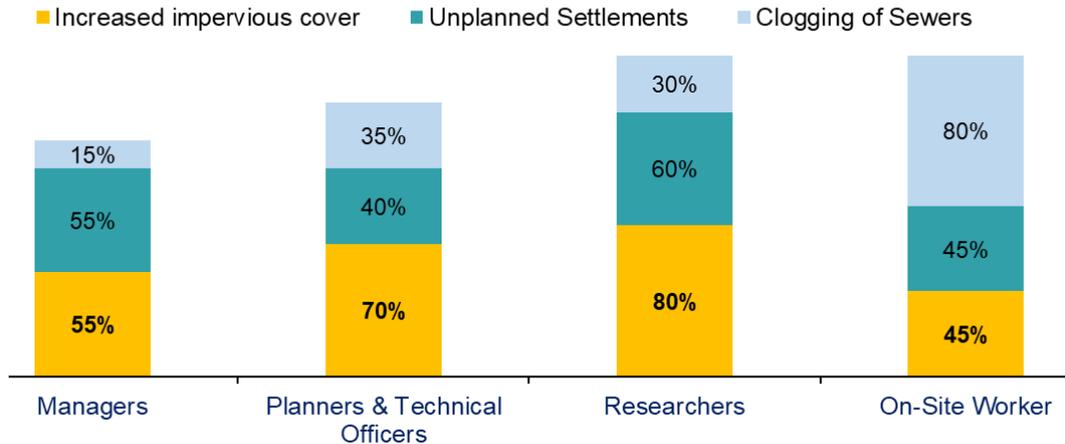
■ Increased ■ Decreased
■ Unchanged ■ Don't Know



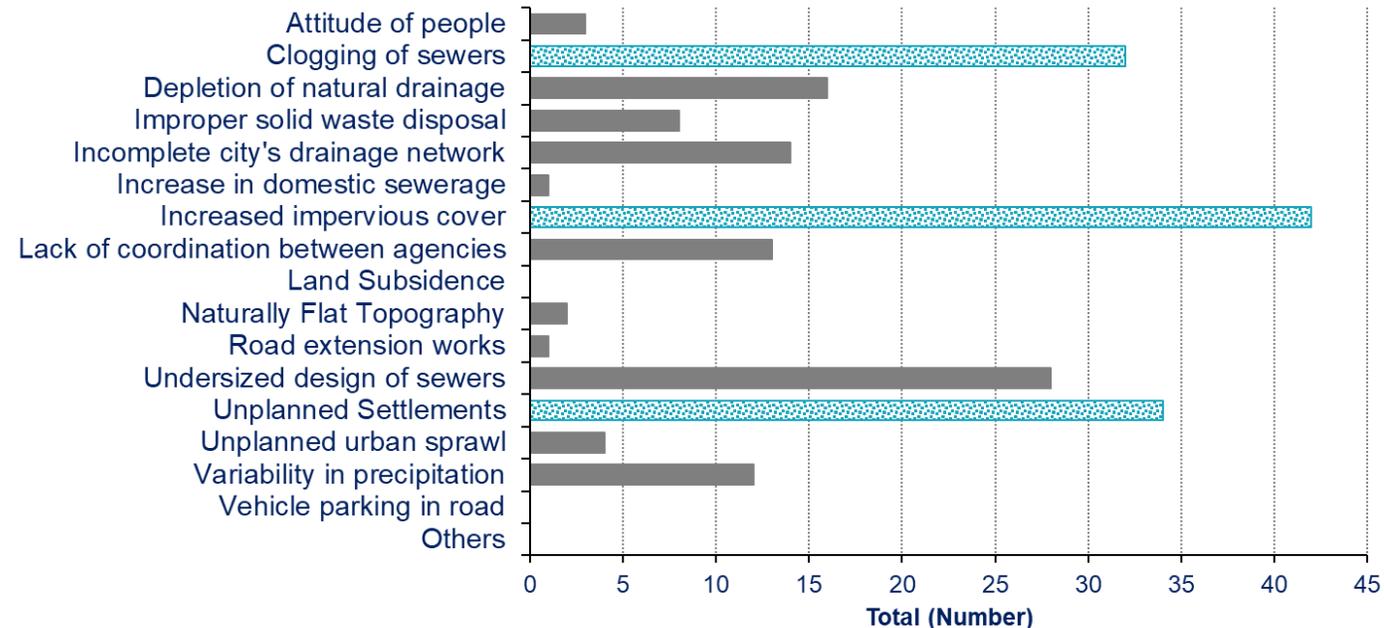
RESULTS AND DISCUSSION

- Major Causes of Pluvial Flooding: Increased Impervious Cover (60%), Unplanned Settlement (49%), Clogging of Sewers (46%)

Major Causes of Pluvial Flooding (KMC) - By Category



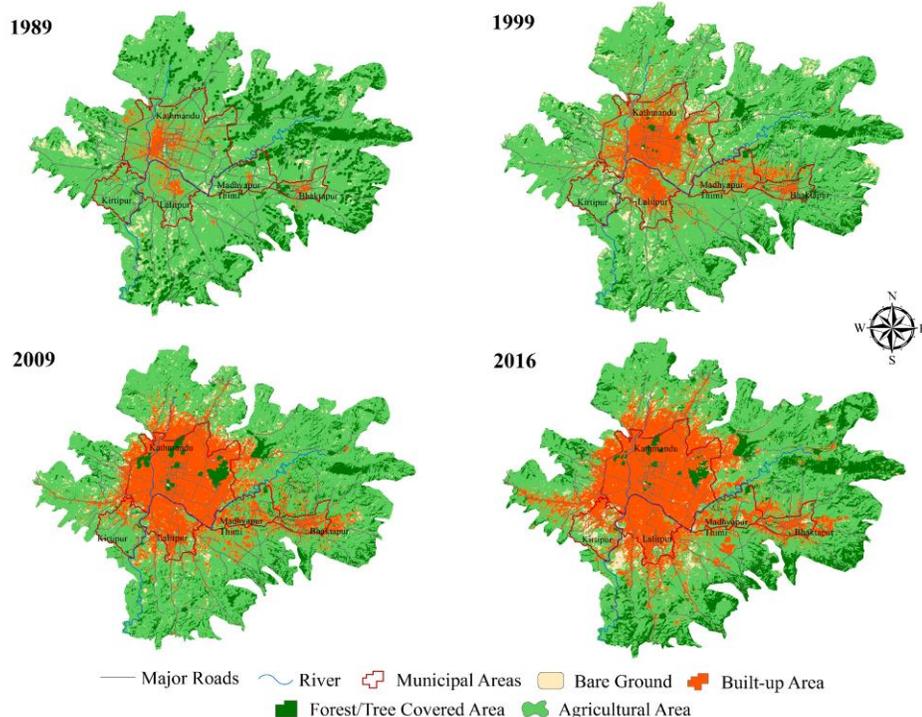
Causes of Pluvial Flooding in KMC





RESULTS AND DISCUSSION

- Imperviousness increased to 75% from 25% in 1990 (KVDA, 2016).
- More than 7% of sewers are clogged (Uprety, 2017 – UNESCAP).



Population Change		
Year	Population (Census)	Population Density (persons/ km ²)
1991	421,258	8,314
2001	671,846	13,259
2011	975,453	19,251

Source: Central Bureau of Statistics

Source (LULC Map): Ishtiaque et al., 2017



RESULTS AND DISCUSSION

Adaptation Options

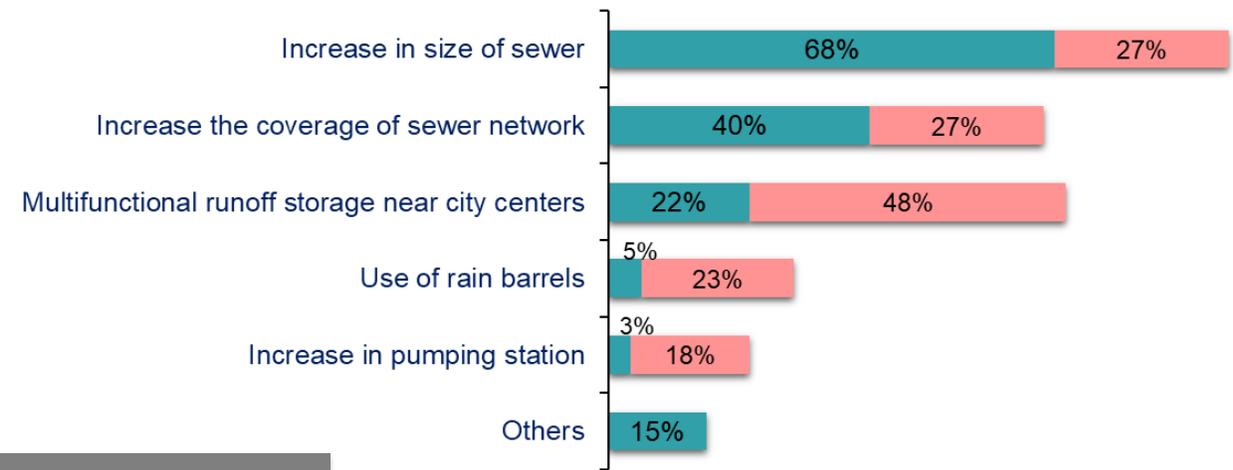
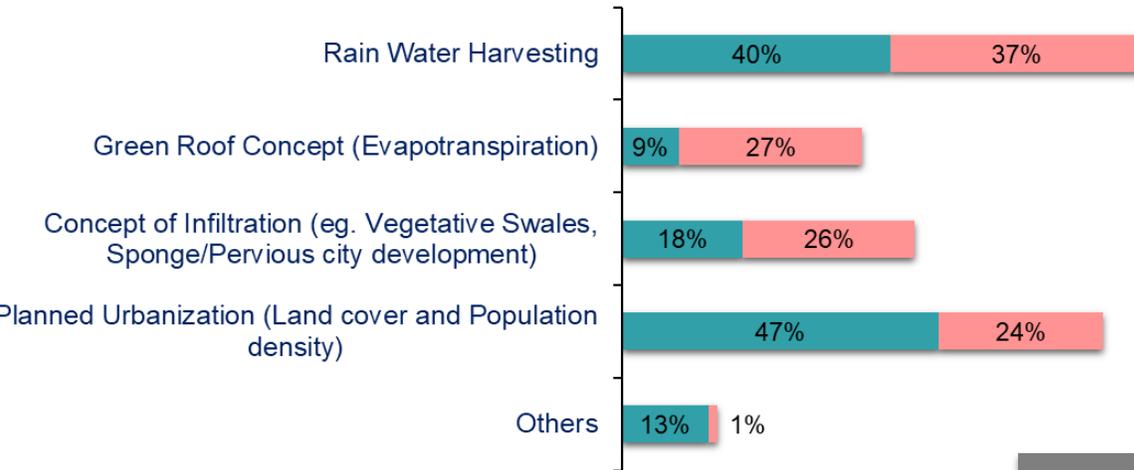
■ Most Effective ■ Moderately Effective

Experts Recommendation

Management Options

■ Most Effective ■ Moderately Effective

Validation



- Combination of small-scale rainwater harvesting, and overflow storage is likely to reduce flood volume by 20-35% (KC et al., 2021).



CONCLUSIONS

- The three major causes of frequent pluvial flooding in KMC are increased impervious cover, unplanned settlement and clogging of sewers.
- KMC is experiencing frequent high rainfall intensities of shorter duration though the annual rainfall has declined.
- Combination of location-specific adaptation and management options is likely to reduce frequent flooding.

THANK YOU

er.saurav.kc@gmail.com

Water Engineering and Management (WEM)

Asian Institute of Technology (AIT)

12120, Pathum Thani, Thailand

AGU FALL
MEETING

