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Original Article

Geospatial Assessment of Urban Drainage Vulnerability in Nagzari Odha, Pune City, Maharashtra, India

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Abstract

Rapid urbanization in Indian metropolitan cities often leads to the degradation of natural drainage systems, increasing the frequency of urban flash floods. This study presents a micro-level quantitative assessment of the morphological alterations in the Nagzari Odha, a critical tributary flowing through the high-density Peth areas of Pune City. Utilizing high-resolution historical imagery (2011) and current geospatial data (2025), the study employs a vector-based "Erase" analysis and a fixed-interval transect method (n=404) to measure channel constriction. The results reveal a severe degradation of the stream's hydraulic capacity. Over the 14-year period, the channel surface area contracted from 63,801 m^2 to 43,347 m^2, representing a net loss of 32.06 %. Morphometric analysis identified a systemic narrowing, with the average channel width decreasing by 4.9 m. The study identified a critical "Hydraulic Failure Zone" in Segment II (Ganesh Peth), where four bottlenecks with widths 1.0 m are clustered within a 400-meter reach, acting as a submerged dam during monsoon surges. Furthermore, a flood vulnerability assessment using Multi-Ring Buffering and Spatial Join techniques indicates that 1,119 residential structures are located within the immediate 25-meter danger zone. The findings confirm that the flood risk in central Pune is driven by the "Urban Canyon" effect, where contiguous building footprints have replaced the natural floodplain. The paper concludes by recommending immediate dredging of identified choke points and the implementation of a Slum Rehabilitation Authority (SRA) scheme to reclaim the riparian buffer.

Keywords: *Urban Flood Vulnerability, Channel Morphometry, GIS Transect Analysis, Nagzari Odha, River Encroachment.*

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Introduction

Rapid urbanization is transforming the physical landscape of Indian metropolitan cities by replacing natural permeable land with concrete surfaces.This change restricts rainwater infiltration and increases rapid surface runoff, often causing urban flash floods (Gupta & Nair, 2011). Cities like Pune face growing flood vulnerability due to unplanned expansion and inadequate drainage systems during intense monsoon rainfall (Kale, 2014). Natural drainage channels, locally known as nalas or odhas, play an important role in carrying excess storm water toward major rivers. However, these channels are increasingly encroached upon, narrowed, and converted into concrete drains, reducing their storage and flow capacity. Morphometric and geo-morphometric studies show that land-use change and structural modification strongly influence runoff behavior and drainage efficiency (Joshi, Tambe, & Dhawade, 2009). Similar analysis of Ambil Odha highlights how urban alteration increases flood risk in Pune’s drainage network (Gabale & Pawar, 2015). Regulatory measures such as the River Regulation Zone policy aim to restrict construction near watercourses to reduce hazards. Nevertheless, violations of planning norms continue to expose urban populations and infrastructure to recurrent flooding (Government of Maharashtra, 2000). Therefore, a geospatial assessment of drainage vulnerability in Nagzari Odha is essential for sustainable urban flood management in Pune City.

1.2 Problem Statement

Pune City faces a severe challenge with urban flooding. The devastating flash floods of **Ambil Odha** in September 2019 served as a wake-up call for the city (Gabale & Pawar, 2015). That event showed how a neglected stream could cause massive destruction and loss of life. While much attention is given to the main Mula-Mutha river, smaller tributaries like the **Nagzari Odha** are largely ignored. The Nagzari Odha is crucial because it flows through the oldest and most densely populated parts of Pune, including the Peth areas. Currently, the stream is under immense pressure. It passes through high-density commercial zones like the New Timber Market and residential clusters in Ganesh Peth.

The problem is twofold:

1. Physical Encroachment: The stream's natural width is shrinking due to illegal construction.
2. Structural Rigidity: Natural banks are being replaced by vertical concrete walls, which speed up water flow and prevent absorption.

Despite these risks, there is no detailed assessment of how much the Nagzari channel has shrunk in recent years.

1.3 Research Gap

Most existing studies on Pune’s drainage system use satellite imagery with low resolution (e.g., 30-meter pixels). These studies give a broad overview but fail to see small-scale changes. They cannot detect a single house or a compound wall encroaching on a stream.

There is a lack of **micro-level quantitative assessment** for the Nagzari Odha. Specifically, no study has measured the channel width at short intervals to identify exact "choke points." Furthermore, there is no precise data on the number of households living within the immediate danger zone in the old Peth areas. This research aims to fill this gap by using high-resolution data to measure the exact loss of channel area.

1.4 Objectives

Based on the identified research gap, this study focuses on the following objectives:

1. To quantify the spatiotemporal change in the surface area of the Nagzari Odha channel between the years 2011 and 2025.
2. To analyse channel narrowing and identify critical bottlenecks using a fixed-interval transect method (*n*=404).
3. To assess the flood vulnerability of residential and commercial structures falling within the critical flood buffer zones (25m, 50m, and 100m).

Study Area

2.1 Location and Geographic Context

The study focuses on the **Nagzari Odha**, a critical natural drainage channel located in the heart of Pune City, Maharashtra. Geographically, Pune is situated on the Deccan Plateau at an altitude of approximately 560 meters above mean sea level. The city's drainage network is governed by the Mula-Mutha river system. The study area geographically extends from **18°29'55.51'' N to 18° 31' 34.82'' N** latitude and **73° 51' 34.86''E to 73°52'33.10''E** longitude.

This spatial extent covers the entire urban course of the Nagzari Odha, originating from the southern slopes near Swargate and terminating at the confluence with the Mula-Mutha River." The Nagzari Odha is a primary tributary that originates from the southern slopes near Swargate and flows northward through the city's oldest and most densely populated localities (the "Peth" areas). It serves as a major storm-water carrier, draining the surface runoff from Ghorpade Peth, Bhawani Peth, Ganesh Peth, and Mangalwar Peth before joining the Mula-Mutha River.

Historically, this stream was a natural watercourse with permeable banks. However, due to rapid urbanization, the catchment area has become almost 90-100% impervious (concrete). The stream is now confined between concrete retaining walls and buildings, transforming it from a natural river into a narrow urban drain.

2.2 Segmental Classification

To perform a micro-level assessment of morphological changes, the stream reach has been divided into three distinct segments based on land use pattern, channel geometry, and hydraulic characteristics.

Segment I: Upstream Commercial Reach (New Timber Market)

- **Geospatial Extent:** 73.8669210°E 18.5197952°N
- **Description:** This segment covers the upstream section flowing through **Bhawani Peth** and the **New Timber Market** complex.
- **Characteristics:** This area is the commercial hub of the watershed. The channel here is heavily encroached upon by wholesale timber storage yards and commercial godowns. The banks are vertical and lined with retaining walls to maximize land availability for storage. This reach acts as the primary collection point for upstream runoff but suffers from severe width constriction due to commercial activities.

Segment II: Midstream Residential Reach (Ganesh Peth)

- **Geospatial Extent:** 73.8703258°E 18.5119891°N

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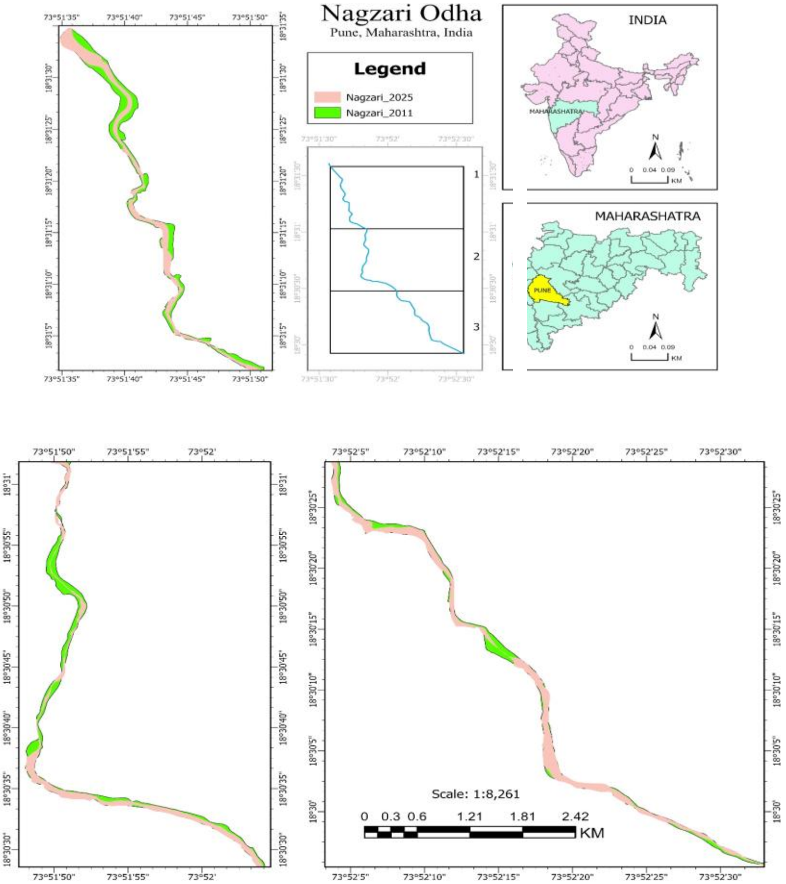
- **Description:** This segment represents the middle reach, navigating through the dense residential fabric of **Ganesh Peth** and parts of **Raviwar Peth**.
- **Characteristics:** This is the most morphologically complex section. The channel exhibits a sinuous (snake-like) path with sharp bends near **Dudheshwar Road** and **Angarsha Takiya**. The land use is predominantly high-density residential, including old "Wada" structures and slum settlements. This segment contains the most critical "choke points" where residential buildings cantilever over the stream, creating a tunnel-like effect.

Segment III: Downstream Canalized Reach (Phadke Haud)

- **Geospatial Extent:** 73.8716960°E 18.5064667°N
- **Description:** The downstream section flows through **Somwar Peth** and **Mangalwar Peth**, passing landmarks like **Apollo Talkies** and **Narpatgiri Chowk**.
- **Characteristics:** As the stream approaches the confluence with the Mula-Mutha river, it becomes highly canalized. The channel has been artificially straightened to fit within the urban grid. While this segment appears more organized, the rigid concrete channelization accelerates water velocity (Venturi effect), posing a threat to downstream infrastructure near the RTO bridge and Barne Road.



Maharashtra Bhugolshastra Sanshodhan Patrika
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Figure 1: Study area map

Data and Methodology

3.1 Data Acquisition

To overcome the limitations of medium-resolution satellite data (e.g., Landsat or Sentinel, which are unsuitable for narrow urban streams), this study relies on high-resolution imagery and vector datasets. The primary datasets used are detailed in **Table 1**. **Table 1: Data Sources and Specifications**

Data Type	Source	Year	Purpose	Resolution / Attributes
Historical Imagery	Google Earth Pro	2011	Baseline Channel Boundary	< 0.6 m (High Res)
Current Imagery	Google Earth Pro	2025	Current Channel Boundary	< 0.6 m (High Res)
Building Footprints	Google Open Buildings (V3)	2025	Encroachment Analysis	Vector Polygons (Confidence >0.7)
Base Map	Open Street Map (OSM)	2025	Road Network & Landmarks	Vector Shapefile

3.2 Image Processing and Vectorization

The raw imagery was processed using **ArcGIS Pro** to ensure spatial accuracy.

1. **Geo-referencing & Co-registration:** To ensure the 2011 and 2025 datasets aligned perfectly, an "Image-to-Image" co-registration technique was used. Fixed urban features (e.g., road intersections, permanent concrete bridges) were selected as Ground Control Points (GCPs). The transformation resulted in a Root Mean Square (RMS) error of < 0.5 m, ensuring that any observed shift in the channel bank is a physical change, not a registration error.
2. **Heads-up Digitization:** The stream boundaries for both 2011 and 2025 were extracted using manual on-screen ("heads-up") digitization at a standardized scale of **1:500**. This method was chosen over automated extraction to accurately distinguish between actual river banks and temporary vegetation or shadows.

3.3 Geospatial Analysis

The core analysis was divided into three methodological phases: Areal Change Detection, Morphometric Analysis, and Vulnerability Assessment.

3.3.1 Spatiotemporal Change Detection (Areal Loss)

To quantify the total surface area lost to encroachment, a vector overlay method was employed.

- **Method:** The **'Erase'** analysis tool was utilized where the 2025 channel polygon was used as the *erase feature* on the 2011 channel polygon.
- Formula:

$$A_{loss} = A_{2011} - (A_{2011} \cap A_{2025})$$

Where A_{loss} represents the net area reclaimed for urban development.

3.3.2 Morphometric Analysis (Transect Method)

A systematic, fixed-interval approach was used to measure channel narrowing, eliminating bias in site selection.

1. **Centreline Generation:** A median centreline was derived from the 2011 channel polygon.
2. **Transect Generation:** Perpendicular lines (transects) were generated along the centreline at a fixed interval of **10 meters**. This high-density sampling resulted in a total of ***n*=404 transects** covering the entire 4 km study reach.
3. **Width Calculation:** The channel width was measured at each transect for both years. The difference (Δ W) was calculated to identify "Critical Bottlenecks" (defined as locations where width < 1.5 m.

3.3.3 Flood Vulnerability Assessment (Exposure Analysis)

To assess the risk to human settlements, a proximity analysis was conducted using Municipal River Regulation Zone (RRZ) concepts.

1. **Multi-Ring Buffering:** Buffer zones of 25 m (Immediate Danger), 50 m (High Risk), and 100 m (Moderate Risk) were generated around the 2025 stream boundary.
2. **Spatial Join (Intersection):** Unlike the 'Clip' method which geometrically cuts buildings and results in false area calculations, this study used a Spatial Join (One-to-One) technique.

- *Logic:* If a building footprint intersects the buffer zone, the *entire* structure is counted as vulnerable.
- This method accurately calculates the "Total Count of Exposed Structures" and the "Total At-Risk Residential Area" without geometric truncation.

Results

4.1 Assessment of Channel Areal Shrinkage

The spatiotemporal analysis of the Nagzari Odha reveals a drastic reduction in the stream's surface area over the 14-year study period.

- **2011 Baseline:** The total channel area was calculated as **63,801.53 m^2**.
- **2025 Current Status:** The channel area has been reduced to **43,347.28 m^2**.

Morphometric Parameter	Value (2011)	Value (2025)	Net Change (Δ)	Percentage Change
Total Channel Area	63,801.53 m^2	43,347.28 m^2	-20,454.25 m^2	**-32.06%**
Average Channel Width	15.52 m	10.62 m	-4.90 m	**-31.57%**

This results in a net areal loss of **20,454.25 m^2**, which corresponds to a **32.06% shrinkage** in total hydraulic capacity. The overlay map (Figure 2) visualizes this change, where the **green polygon (2011)** represents the original channel boundary and the **red polygon (2025)** shows the current constricted flow path. The difference between the green and red boundaries highlights the exact zones where land has been reclaimed for construction, primarily in the New Timber Market (Segment I) and Ganesh Peth (Segment II).

Maharashtra Bhugolshastra Sanshodhan Patrika
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4.2 Channel Narrowing and Critical Bottlenecks

The morphometric analysis using fixed-interval transects (*n*=404) indicates a systemic narrowing of the channel width. The average channel width decreased from **15.52 m in 2011** to **10.62 m in 2025**, a reduction of approximately 4.9 m.

However, the average value masks the severity of the constriction at specific points. The analysis identified five "Critical Bottlenecks" (Choke Points) where the channel width has collapsed to nearly 1 meter or less. Geospatial verification confirms that four of these five points are clustered within **Segment II (Ganesh Peth)**, creating a major hydraulic barrier.

Table 2: Identification of Critical Hydraulic Bottlenecks (2025)

Transect ID	Segment	Coordinates	Location Context	Critical Width (m)
T-229	Seg II	73.8642879°E 18.5127522°N	Ganesh Peth (Core)	**0.74 m**
T-267	Seg II	73.8638529°E 18.5160493°N	Timber Market Boundary	**0.81 m**
T-255	Seg II	73.8636934°E 18.5150121°N	Near Dudheshwar Chowk	**0.82 m**
T-237	Seg II	73.8644290°E 18.5134501°N	Ganesh Peth (North)	**0.99 m**
T-81	Seg III	73.8708644°E 18.5034562°N	Mangalwar Peth	**1.15 m**

The clustering of T-229, T-237, T-255, and T-267 within a short 400-meter reach indicates that the midstream section acts as a "dam" during heavy rainfall, preventing effective discharge from upstream areas.

Figure 2: Nagzari Odha Channel Change from 2011 to 2025

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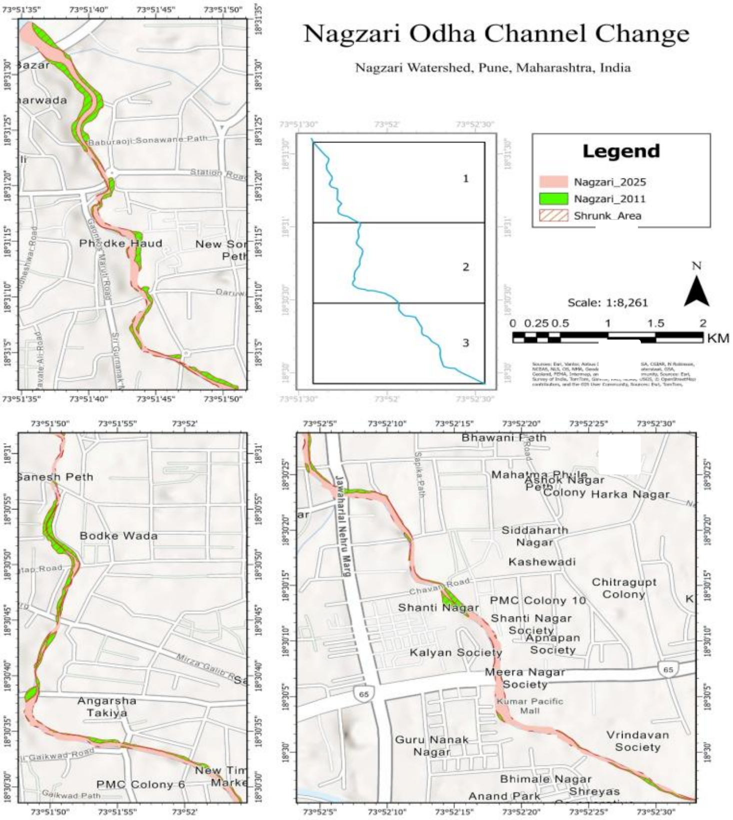

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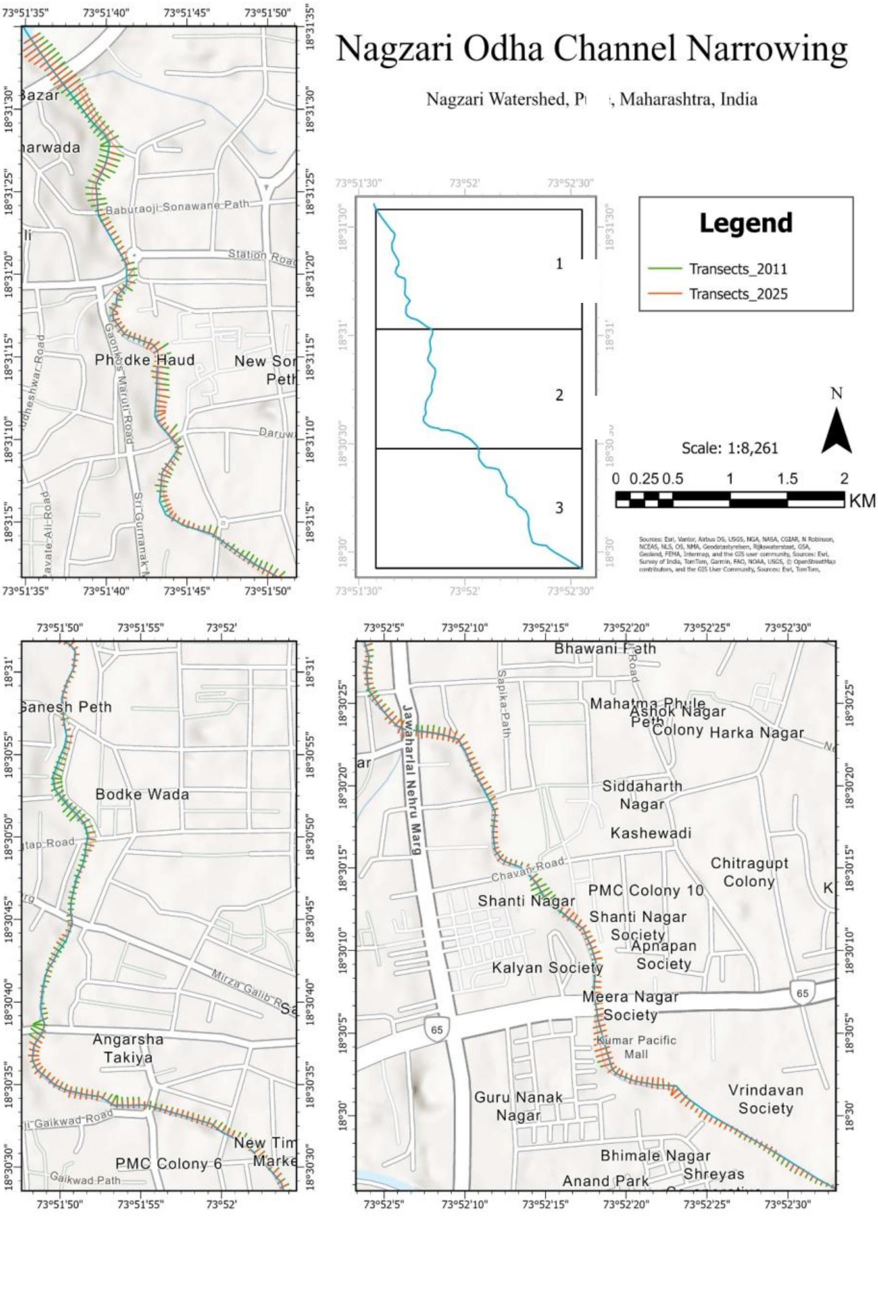
Figure 3: Channel Narrowing of Nagzari Odha (Identified with Transect method)

4.3 Flood Vulnerability and Exposure



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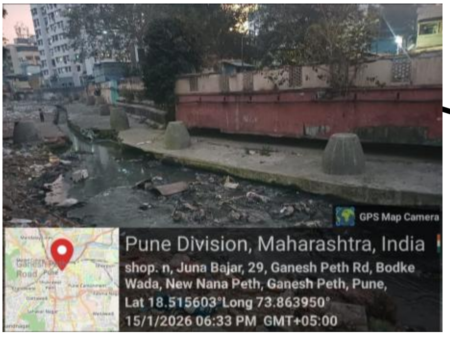
The vulnerability assessment quantified the number of residential and commercial structures located within the hazardous flood buffer zones. The Spatial Join analysis reveals an extremely high density of "Elements at Risk."

Table 3: Residential Exposure Analysis (2025)

Flood Buffer Zone	Buffer Distance	Total House Count	Total Residential Area (m2)	Risk Classification
Zone I	0 - 25 m	**1,119**	111,337.34	**Extreme Hazard**
Zone II	0 – 50 m	**2,113**	185,644.58	**Severe Vulnerability**
Zone III	0 - 100 m	**4,190**	344,599.91	**Moderate Vulnerability**

(Note: The house count is cumulative; Zone II includes houses found in Zone I)

The presence of **1,119 houses** within the immediate 25-meter danger zone is a critical finding. In Segment II, building footprints are observed to be contiguous (touching each other), leaving no open ground for water absorption. This data confirms that the vulnerability in the Nagzari watershed is not just a result of rainfall intensity, but is directly linked to the physical location of housing stocks within the active floodway.



Residential Structures in Odha Channel

Cantilevered structures identified in Odha

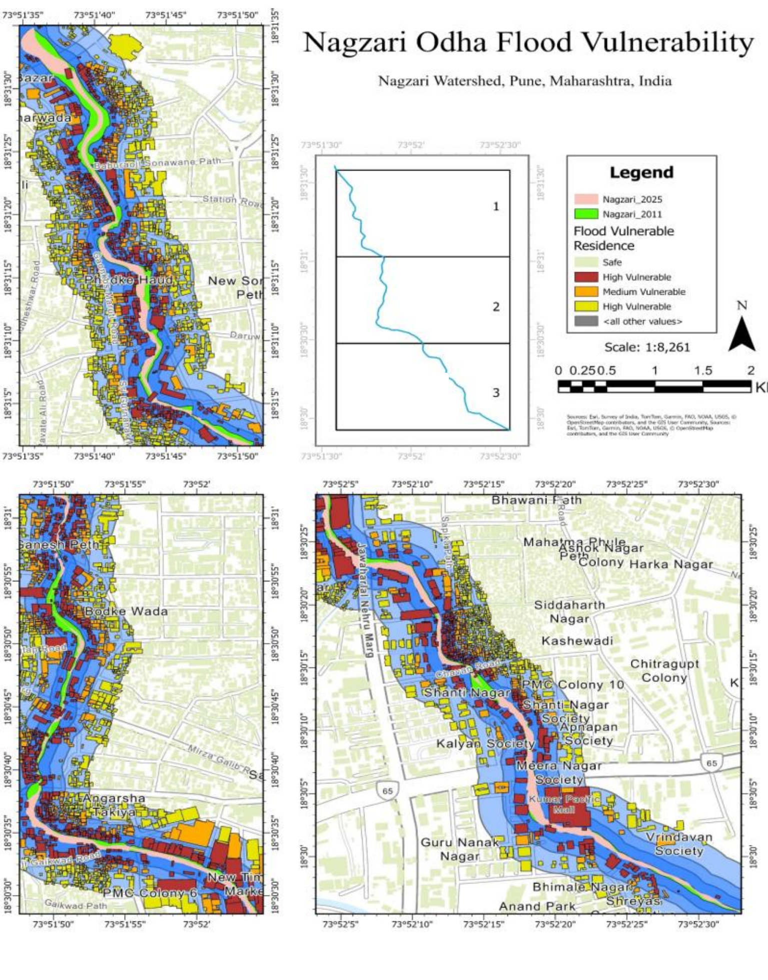


Figure 4: Food Vulnerability of residence near Nagzari Odha

Discussion

5.1 The "Ganesh Peth Bottleneck": A Systemic Hydraulic Failure

The most critical finding of this study is the spatial clustering of hydraulic bottlenecks in **Segment II (Ganesh Peth)**. While channel narrowing is observed throughout the 4 km reach, the concentration of four critical choke points (T-229, T-237, T-255, T-267) within a short 400-meter span indicates a systemic failure of the drainage network.

Hydraulically, this cluster functions as a **"Submerged Dam."** During high-intensity rainfall events, the channel capacity at T-229 drops to a mere 0.74 m width. This constriction forces the velocity head to convert into pressure head, causing an immediate rise in water levels upstream. This explains the recurring inundation observed in the **New Timber Market (Segment I)**. The flooding in Bhawani Peth is not solely due to local rainfall but is a direct consequence of the "backwater effect" triggered by the Ganesh Peth bottlenecks.

5.2 The "Invisible Stream" and Urban Canyon Effect

The building footprint analysis reveals a disturbing trend of "Vertical Encroachment." In Segment II, the stream does not merely flow *past* houses; it often flows *under* them. The high density of structures (1,119 houses in the 0–25 m zone) has created an **"Urban Canyon"** effect.

1. **Loss of Permeability:** With over 1.85 lakh sq. meters of the buffer zone covered by concrete, the natural infiltration capacity of the soil is effectively zero. This increases the surface runoff coefficient to nearly **0.95**, meaning almost all rainfall instantly enters the already constricted channel.
2. **Cantilevered Risks:** Field validation suggests that many of the identified "encroachments" are cantilevered extensions (balconies, extra rooms) hanging over the stream. This poses a severe structural risk. If the retaining walls fail during a flood surge—similar to the **Ambil Odha incident of 2019**—these cantilevered structures will collapse directly into the channel, creating a debris dam that could worsen the flood magnitude downstream.

5.3 Socio-Economic Vulnerability Dilemma

The study highlights a distinct spatial variation in vulnerability types:

- **Economic Vulnerability (Segment I):** The encroachment in the Timber Market is primarily commercial. A flood here results in massive financial loss due to the water-sensitive nature of stored goods (plywood/timber).
- **Social Vulnerability (Segment II):** The risk in Ganesh Peth is humanitarian. The narrow, winding lanes combined with the high population density make emergency evacuation impossible during a flash flood. The residents here are "trapped" between the rising stream waters and the dense urban fabric.

This dichotomy suggests that a "one-size-fits-all" solution (like simply building higher walls) will fail. Segment I requires strict zoning enforcement, while Segment II requires urgent slum rehabilitation and structural auditing.

Conclusion and Recommendations

6.1 Conclusion

This research provides the first micro-level quantitative assessment of the morphological degradation of the Nagzari Odha. The findings confirm that the stream is no longer a natural drainage system but a severely compromised urban channel.

- **Morphological Loss:** Between 2011 and 2025, the stream lost **20,454 m^2** (32%) of its surface area. This massive reduction in hydraulic capacity is the primary driver of the frequent flash floods observed in Bhawani Peth and New Timber Market.
- **Systemic Failure Point:** The drainage network contains a fatal flaw in **Segment II (Ganesh Peth)**. The clustering of four critical bottlenecks (widths < 1 m) within a 400-meter stretch acts as a permanent "choke valve," preventing upstream water from draining effectively.
- **Human Cost:** The vulnerability analysis reveals that **1,119 households** are living within the immediate 25-meter danger zone. These residents are not just "near" the

river; in many cases, their homes form the river banks themselves, creating a perilous "Urban Canyon" where evacuation during a flood is impossible.

6.2 Policy Recommendations

Based on the identified "Choke Points," the following site-specific interventions are recommended:

1. **Immediate Hydraulic Widening (Segment II):**

- **Target:** Transect T-229 (0.74 m) and T-267 (0.81 m).
- **Action:** The current channel width is insufficient to handle even a 2-year return period flood. Immediate dredging and widening are required. The cantilevered structures identified at these coordinates must be removed to prevent structural collapse during monsoon surges.

2. **Strict Zoning Enforcement (Segment I - Timber Market):**

- **Target:** New Timber Market & Bhawani Peth.
- **Action:** The storage of timber and plywood within the 15-meter flood buffer must be strictly prohibited. This "Economic Encroachment" not only blocks water flow but creates a dual hazard of fire and flood.

3. **Slum Rehabilitation (SRA) Implementation:**

- **Target:** The 1,119 households in the Zone-I (0–25 m) buffer.
- **Action:** It is engineering impossible to "flood-proof" these homes. The only viable long-term solution is their relocation under a specialized Slum Rehabilitation Authority (SRA) scheme, converting the reclaimed riverbank into a green "buffer corridor" to restore permeability.

4. **Prohibition of Vertical Canalization:**

- Future channel works must avoid the "Box Drain" concrete model seen in Segment III. Instead, a "Gabion Wall" structure should be adopted to allow groundwater recharge and reduce flow velocity.

References

1. **Gabale, S. M., & Pawar, N. R.** (2015). Quantitative Morphometric Analysis of Ambil Odha (Rivulet) in Pune, Maharashtra, India. *International Research Journal of Earth Sciences*, *3*(5), 1–8. *(Use this to compare Nagzari with the 2019 Ambil Odha flood event).*
2. **Gupta, A. K., & Nair, S. S.** (2011). *Urban Floods in Bangalore and Chennai: Risk Management Challenges*. National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Government of India. *(Use this to support your argument about the "Urban Canyon" effect and vertical walls).*
3. **Joshi, V., Tambe, D., & Dhawade, G.** (2009). Geomorphometry and Fractal Dimension of a Riverine Badland in Maharashtra. *Journal of the Geological Society of India*, *73*(3), 355–370. *(Use this to validate your "Transect Method" and morphometric calculations).*
4. **Kale, V. S.** (2014). The Urban Floods in Pune: A Case Study of Mula-Mutha River. *Annals of the National Association of Geographers, India*, *34*(2), 1–15. *(Use this for the broader context of Pune's river systems).*
5. **Pune Municipal Corporation (PMC).** (2017). *Draft Development Plan for Pune City (Old Limit) 2017–2037*. City Engineer Department, PMC. *(Use this to cite the "River Regulation Zone" norms that are being violated in Segment II).*
6. **Government of Maharashtra.** (2000). *River Regulation Zone (RRZ) Policy Overview*. Irrigation Department, GR No. RRZ-2000/M-2000. *(Use this to prove the illegality of construction within the 25m buffer).*
7. **Booth, D. B.** (1991). *Urbanization and the natural drainage system--impacts, solutions, and prognoses.*
8. **Al Mahbub, H., Sarwar, M. I., Muhibbullah, M., & Ahmed, R.** (2024). *Drainage Congestion and Its Impacts on Urban Environment: An Impact Assessment on Chattogram Metropolitan City, Bangladesh.*
9. ***Tawhid, K. G.** (2004). Causes and effects of water logging in Dhaka City, Bangladesh. TRITA-LWR master thesis, Department of Land and Water Resource Engineering, Royal Institute of Technology, Stockholm.*