



Stormwater Drainage Data Inventory

Samtse Urban Centre

June 2025

*Strengthening Risk Information for Disaster
Resilience in Bhutan (RIR) Project*

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ROYAL GOVERNMENT OF BHUTAN



ACKNOWLEDGEMENT

The Infrastructure Planning and Flood Adaptation Division (IPFAD) under the Department of Human Settlement, Ministry of Infrastructure and Transport, would like to extend its sincere gratitude to the World Bank for financing this study through the ‘Strengthening Risk Information for Disaster Resilience in Bhutan (RIR) Project. This document was made possible with the financial support of the Climate Investment Funds and the Japan-World Bank Program for Mainstreaming Disaster Risk Management in Developing Countries, which is financed by the Government of Japan and receives technical support from the World Bank Tokyo Disaster Risk Management Hub.

IPFAD would also like to express its appreciation to the Samtse Dzongkhag Administration and the Samtse Damdum Industrial Park for their kind cooperation and on-site assistance throughout the course of the study. Their support and facilitation were vital in ensuring the smooth execution of the field surveys and data collection.

We would also like to thank Geomatics and Logistic Division (GLD), DHS for developing the web-based GIS platform for the stormwater inventory that can be viewed online and downloaded.

TABLE OF CONTENTS

1. INTRODUCTION	1
1.1. Background.....	1
1.2. Objective	1
1.3. Description of Study Area.....	2
2. METHODOLOGY	3
2.1. Field Survey.....	3
2.1.1 Data Collection at Site	4
2.2 Digitization and GIS Integration	6
3. RESULTS AND INVENTORY OUTPUT	8
3.1. Overview of Collected Data.....	8
3.2 GIS data inventory of existing drainage.....	9
3.3 Web-Based GIS Platform.....	11
4. IDENTIFIED ISSUES AND OBSERVATIONS	13
4.1. Problematic Points	13
5. CONCLUSION	16

TABLE OF FIGURES

Figure 1: Study Area	2
Figure 2: Field Data Collection	5
Figure 3: Data Collected at the Site.....	6
Figure 4: Drainage classification (Functional Type)	Figure 5: Drainage Classification (Opening Type)..... 8
Figure 6: Drainage Classification (Section Type)	Figure 7: Drainage Classification (Material Type)..... 8
Figure 8: Drainage with survey point ID in GIS	9
Figure 9: Sample Attribute Table.....	10
Figure 10: Overview of Web-Based Drainage System.....	11
Figure 11: Overview of web-based drainage system with linked attribute.....	12
Figure 12: Overview of web-based drainage system with photos of the drains.....	12
Figure 13: Problematic Drains observed in Samtse.....	14

1. INTRODUCTION

1.1. Background

In Bhutan, until recently, the majority of urban towns, including Samtse, have developed organically in the absence of structured urban planning frameworks. As a result, essential infrastructure systems such as stormwater drainage were often constructed without proper design guidelines, planning standards, or climate resilience considerations. This has significantly increased the vulnerability of urban areas to localized flooding, waterlogging, and other socio-environmental risks.

Despite the growing need, stormwater management planning remains largely absent across Bhutan's urban centers. Furthermore, there is a lack of reliable, spatially referenced data on existing drainage infrastructures across the country. This data deficiency poses a significant barrier to the effective planning, design, and implementation of climate-resilient stormwater management solutions.

As part of the initiative to address these gaps, the Infrastructure Planning and Flood Adaptation Division (IPFAD) under the Department of Human Settlement, Ministry of Infrastructure and Transport, has initiated a stormwater drainage inventory for Samtse Urban Centre. The study was undertaken with financial support from the World Bank through the 'Strengthening Risk Information for Disaster Resilience in Bhutan Project.

1.2. Objective

The primary objective of this initiative was to establish a comprehensive web-based geospatial database of existing stormwater drainage infrastructure within the Samtse urban center. The data collected through this inventory will support future formulation of stormwater management plans.

The specific objectives are:

- Document and digitize existing drainage networks.
- Assess current conditions.
- Identify critical problem areas.

1.3. Description of Study Area

The study area includes the Samtse Municipality Area and Damdum Industrial Park, as shown in Figure 1.

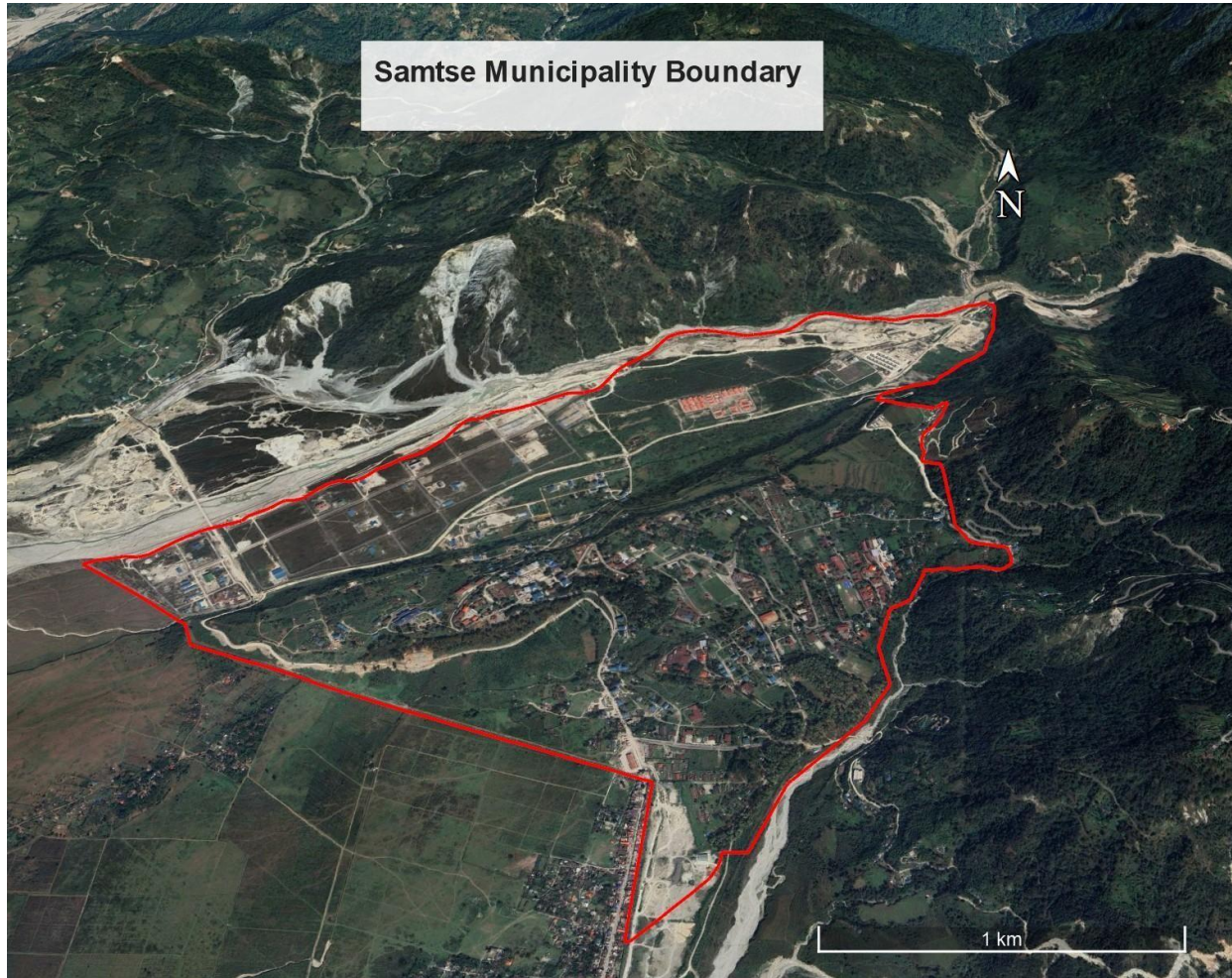


Figure 1: Study Area

2. METHODOLOGY

2.1. Field Survey

The field survey for the stormwater drainage inventory in Samtse was conducted by the Infrastructure Planning and Flood Adaptation Division (IPFAD) using high-precision Real-Time Kinematic (RTK) surveying equipment. The use of RTK ensured accurate geolocation of each drainage asset, forming the spatial backbone of the geodatabase.

The survey was structured to capture a wide array of data points essential for assessing the drainage infrastructure. Each drainage segment was uniquely identified by a specific ID and name, facilitating accurate tracking and reference throughout the assessment process. This systematic approach not only enhances data integrity but also streamlines future monitoring and maintenance efforts.

The drains were classified by function into two categories:

- **Primary Drains:** These drains constitute the main conduits for stormwater conveyance and are responsible for managing the main flow of water.
- **Secondary Drains:** These drains collect and channel runoff from smaller catchments or local sources into the primary network.

This functional differentiation is vital for understanding the overall efficiency of the drainage system and for prioritizing the maintenance activities.

Additionally, the survey recorded the type of drainage for each identified drain, categorizing them as either:

- **Open Channels:** These are exposed systems and typically easier to inspect and maintain.
- **Closed Channels:** These are enclosed systems that are either covered or piped systems requiring more specialized maintenance and diagnostics.

To facilitate assessment of the physical and hydraulic performance of each drain, detailed structural attributes were also collected, including:

- **Section Type:** Each drain was classified as either rectangular or trapezoidal.

- **Dimensions:** The drain height and width, which directly influence flow capacity, were measured. These measurements are essential for evaluating whether the drain can handle the expected water volumes during peak flow periods.
- **Wall thickness:** This provides an indication of structural stability and resistance to erosion or collapse.
- **Material Type:** This provides the material type that the drain is made up of, including Random Rubble Masonry (RMM), concrete or earthen drains.

Furthermore, the survey captured site-specific conditions and issues affecting system performance, including:

- Blockages due to debris accumulation,
- Sediments impairing the flow capacity,
- Structural failures, such as cracked or collapsed sections, and
- Poor or undefined discharge points, leading to localized flooding or erosion.

The location of each outlet was also recorded to complete the network mapping and to trace flow pathways from origin to discharge, facilitating both catchment-level analysis and identification of critical control points.

2.1.1 Data Collection at Site

The team from the Infrastructure Planning and Flood Adaptation Division visited the Samtse Dzongkhag on October 28, 2024, to collect the data for the existing drainage. On October 29, 2024, a site visit was conducted with Dzongkhag officials to inspect the existing drainage systems. For the actual survey, the survey team from IPFAD was assisted by the Dzongkhag. The storm drain survey took place over the course of one month, covering the urban area from the Sukhriti River to the Dhamdum River. The survey team from IPFAD was assisted by the Dzongkhag as and when required.



Figure 2: Field Data Collection

Demkhong/Zone	CLASSIFICATION	MATERIALS	DRAINAGE TYPE	SECTION TYPE	HEIGHT (H)mm	BOTTOM WIDTH(Bb) mm	TOP WIDTH(Tb) mm	WALL THICKNESS(t) mm	Problems (Blockages&clogging, sedimentation, flooding, Repair, disconnection, slope correction, no outlet)	Length (Problems)	Lat.	Long.	DRAIN NAME	Remarks
BPC	P	RRM	CC	Tr	1200	600	1000	400	1147 - Blocked 90% of thume pipe filled with sediments.				BP2	Outlet to CP3
Check Post	S	RRM	OC	Rec	450	300	300	200					CP1	Outlet to BP2
Check Post	S	RRM	OC	Rec	750	300	300	300					CP2	Outlet to CP1
Check Post	P	RRM	OC	Rec	700	750	750	450	(1447 to 1448) Collapsed				CP3	Outlet to CP4
									(1450 to 1451) Collapsed					
									(1454 to 1456) - collapsed					
wine shop	P	RRM	OC	Tr	1400	900	1300	450					CP4	Outlet to Awp2
Angle	P	RRM	OC	Rec	1500	1200	1200	700	1544 - 1545 - Collapsed.				Aw2	Outlet to BD2
									1551 - 1552 - Collapsed (1555 - 1571)					
Border	P	RRM	OC	Rec	650	1850	1850	600					BD2	Outlet to BD3
	P	RRM	CC	Rec	1500				1581				BD3	
FCB	S	RRM	OC	Rec	250	500	500	200					FC1	Outlet to CP3
wine shop	S	RRM	OC	Tr	700	700	850	400					CP5	Outlet to CP3
wine shop	S	RRM	OC	Rec	500	900	900	300					CP6	Outlet to CP5

Figure 3: Data Collected at the Site

2.2 Digitization and GIS Integration

After the field survey, the collected drainage data were organized, cleaned, and processed for integration into a GIS environment. Each drain's attributes, including location, type, dimensions, condition, and outlet points, were recorded using standardized formats to ensure consistency.

The data were then digitized and mapped using ArcGIS. This involved creating a geodatabase where each drainage segment was linked to its corresponding attribute data. Photographs taken during the survey were also tagged and attached for visual reference.

Furthermore, problem areas identified in the field, such as blocked or damaged drains, were marked on the map for easy identification and follow-up.

After the completion of digitization and GIS integration, the storm drainage inventory was published to a web-based GIS platform to allow remote access and visualization. This involved exporting the geospatial data layers to a compatible web format and uploading them to a GIS server environment. A web map was then configured with relevant symbology, layer controls, and attribute pop-ups to allow users to interact with the data. Customized tools such as search, filter, and identify functions were added to improve usability. The final web application was embedded into a publicly accessible website, ensuring that the drainage network data is easily navigable through a standard web browser without the need for specialized GIS software.

This digital integration ensures future updates can be seamlessly incorporated as the drainage infrastructure evolves.

3. RESULTS AND INVENTORY OUTPUT

3.1. Overview of Collected Data

A total length of approximately 41.4 km of drainage is mapped, with 153 numbers of drainage segments identified. Of these, 20.3 % are Primary drains while the rest 79.7 % were identified as Secondary drains. Moreover, 85% are open channels while the remaining 15 % are closed channels. Furthermore, 77.5% are rectangular section type while the remaining 22.5% are trapezoidal. Finally, 74.5% are made of Random Rubble Masonry (RMM), 1.3% are made of Reinforced Cement Concrete (RCC), 2.6% made of Plain Cement Concrete (PCC), and the remaining 21.6% is made up of Brick Masonry.

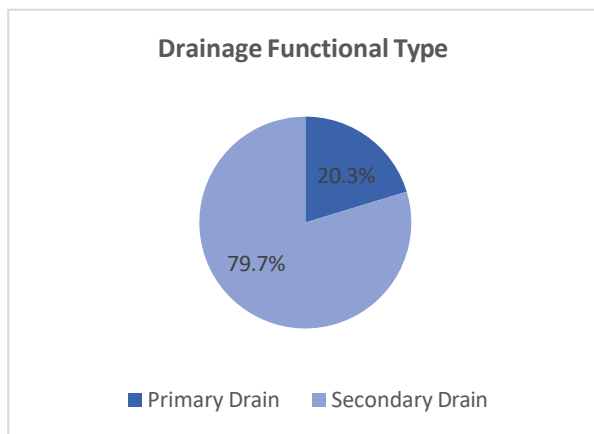


Figure 4: Drainage classification (Functional Type)

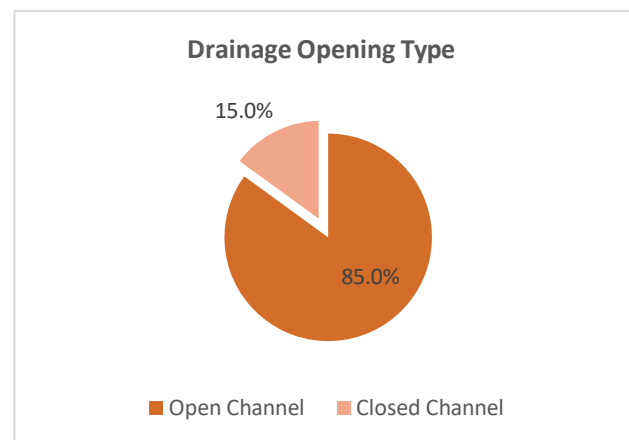


Figure 5: Drainage Classification (Opening Type)

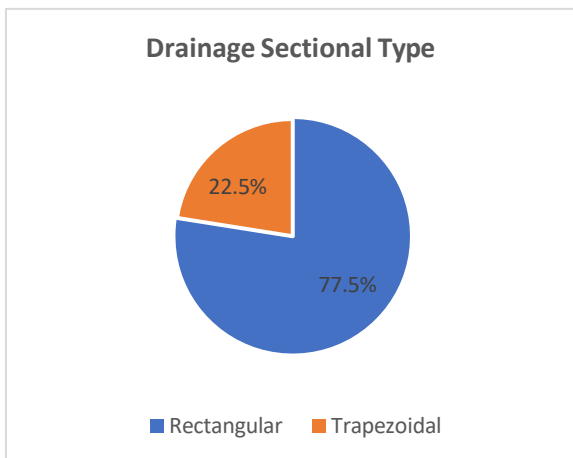


Figure 6: Drainage Classification (Section Type)

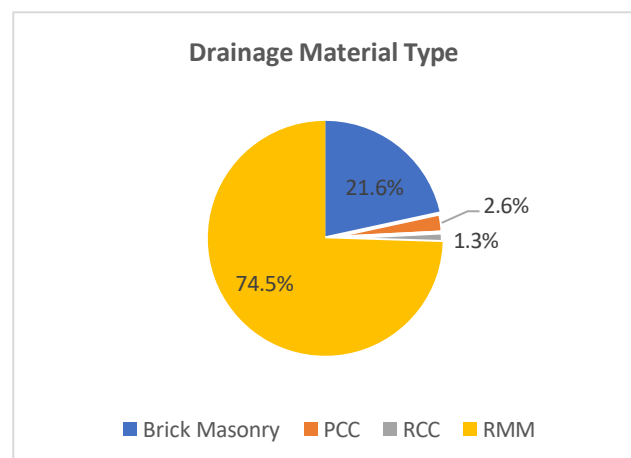


Figure 7: Drainage Classification (Material Type)

3.2 GIS data inventory of existing drainage

The GIS inventory produced through this project provides a detailed digital mapping of the existing stormwater drainage infrastructure within the Samtse Urban Centre, including Damdum Industrial Park. Each drainage segment captured during the survey was georeferenced and digitized in a GIS environment, with attributes linked to corresponding spatial features.

The attribute data includes segment ID, location, functional classification (primary or secondary), structural details (open or closed), section type (rectangular or trapezoidal), material type, and dimensional measurements (height, width, thickness). Additionally, photographs captured on-site were linked to their respective locations for visual reference.

cThis comprehensive geodatabase allows stakeholders to visualize the drainage network, query data based on attributes, and overlay other planning or hazard information for further analysis. Figures 8 and 9 illustrate the map showing survey point ID of drains and sample attribute tables extracted from the GIS database.

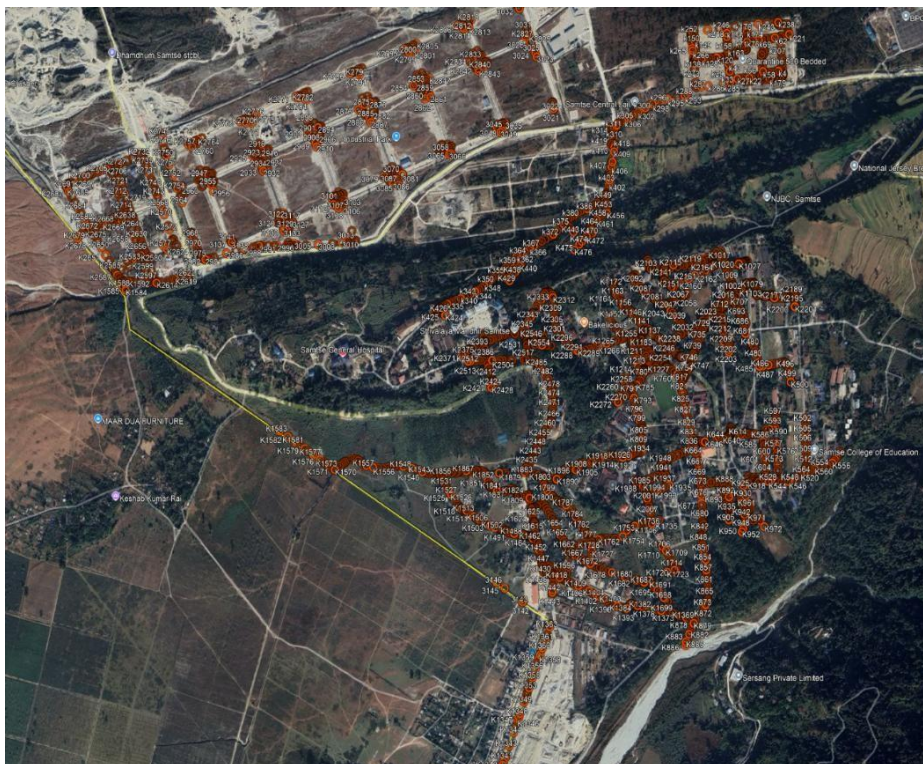


Figure 8: Drainage with survey point ID in GIS

Shape *	Id	Name	Drain Name	Class	Material	Type	Section	Height	Bottom wid	Top Width	Wall Thick	Problems
Polyline	43	Below School	SC3	Secondary	Brick	Open Drain	Rectangular	600	600	600	250	
Polyline	44	High School Gate	SC4	Secondary	RRM	Open Drain	Rectangular	700	350	350	250	
Polyline	45	High School MPH	SC5	Secondary	Brick	Open Drain	Rectangular	200	200	200	150	
Polyline	46	High School MPH	SC6	Secondary	RRM	Closed Drain	Rectangular	350	350	350	300	
Polyline	47	High School	SC7	Secondary	RRM	Closed Drain	Rectangular	350	350	350	300	
Polyline	48	High School Football Ground	SC8	Secondary	RRM	Open Drain	Rectangular	350	300	300	250	Blocked with debris
Polyline	49	Dzongkhag Court	DC4	Secondary	RRM	Open Drain	Rectangular	650	650	650	300	
Polyline	50	Army Camp	AC1	Secondary	RRM	Open Drain	Rectangular	450	550	550	300	Collapsed from K993 - K994
Polyline	51	Army Camp	AC2	Secondary	RRM	Closed Drain	Rectangular	800	550	550	400	
Polyline	52	Army Camp	AC3	Secondary	RRM	Closed Drain	Rectangular	800	550	550	400	
Polyline	53	Army Camp	AC4	Secondary	Brick	Open Drain	Rectangular	200	600	600	150	
Polyline	54	Army Camp	AC5	Secondary	Brick	Open Drain	Rectangular	400	370	370	150	
Polyline	55	Army Camp	AC6	Secondary	Brick	Open Drain	Rectangular	450	380	380	150	Collapsed from K1085 - K1089
Polyline	56	Army Camp	AC7	Secondary	Brick	Open Drain	Rectangular	370	600	600	150	
Polyline	57	Post Office	PO1	Secondary	RRM	Open Drain	Rectangular	700	580	580	400	
Polyline	58	Post Office	PO2	Secondary	RRM	Open Drain	Rectangular	700	550	550	450	
Polyline	59	Revenue and Custom Office	RC1	Secondary	RRM	Open Drain	Rectangular	350	420	420	400	
Polyline	60	Revenue and Custom Office	RC2	Secondary	RRM	Open Drain	Rectangular	500	420	420	300	
Polyline	61	Revenue and Custom Office	RC3	Secondary	RRM	Open Drain	Rectangular	550	450	450	300	
Polyline	62	Revenue and Custom Office	RC4	Secondary	RRM	Open Drain	Rectangular	200	300	300	150	
Polyline	63	Border near Dry Port	BD1	Primary	RRM	Open Drain	Trapezoidal	1000	1200	1400	400	
Polyline	64	BPC	BP1	Secondary	RRM	Open Drain	Trapezoidal	1150	550	900	400	
Polyline	65	BPC	BP2	Primary	RRM	Closed Drain	Trapezoidal	1200	600	1000	400	Blocked and hume pipe filled with sediments
Polyline	66	Check Post	CP1	Secondary	RRM	Open Drain	Rectangular	450	300	300	200	
Polyline	67	Check Post	CP2	Secondary	RRM	Open Drain	Rectangular	750	300	300	300	
Polyline	68	Check Post	CP3	Primary	RRM	Open Drain	Rectangular	700	750	750	450	Collapsed (K1447-K1448, K1450-K1451 & K1454-K1456)
Polyline	69	Check Post	CP4	Primary	RRM	Open Drain	Trapezoidal	1400	900	1300	450	
Polyline	70	AWP Drain	AWP2	Primary	RRM	Open Drain	Rectangular	1500	1200	1200	700	Collapsed (K1544-K1545, K1551-K1552 & K1555-K1569)
Polyline	71	Border	BD2	Primary	RRM	Open Drain	Rectangular	800	1850	1850	600	
Polyline	72	Border	BD3	Primary		Hume	Circular	1300	0	0	0	
Polyline	73	FCB	FCB1	Secondary	RRM	Open Drain	Rectangular	250	500	500	200	
Polyline	74	Check Post	CP5	Secondary	RRM	Open Drain	Trapezoidal	700	700	850	400	
Polyline	75	Check Post	CP6	Secondary	RRM	Open Drain	Rectangular	500	900	900	300	
Polyline	76	Check Post	CP7	Secondary	RRM	Open Drain	Trapezoidal	1000	500	750	400	
Polyline	77	BPC	BP3	Secondary	RRM	Open Drain	Rectangular	800	1800	1800	500	
Polyline	78	BPC	BP4	Secondary	RRM	Open Drain	Trapezoidal	900	500	580	400	
Polyline	79	BPC	BP5	Secondary	RRM	Open Drain	Trapezoidal	1000	800	1150	400	
Polyline	80	BPC	BP6	Secondary	RRM	Open Drain	Trapezoidal	1200	800	1200	400	
Polyline	81	BPC	BP7	Secondary	RRM	Open Drain	Trapezoidal	900	500	800	400	
Polyline	82	BPC	BP8	Secondary	RRM	Open Drain	Rectangular	600	800	800	400	
Polyline	83	BPC	BP9	Secondary	RRM	Open Drain	Trapezoidal	1200	1000	1300	500	
Polyline	84	BPC	BP10	Secondary	RRM	Open Drain	Trapezoidal	500	400	600	400	
Polyline	85	BPC	BP11	Secondary	RRM	Open Drain	Trapezoidal	800	400	650	400	
Polyline	86	Check Post	CP8	Secondary	RRM	Open Drain	Trapezoidal	1000	500	750	350	
Polyline	87	Check Post	CP9	Primary	RRM	Open Drain	Trapezoidal	1200	1000	1300	400	
Polyline	88	AWP	AWP3	Primary	RRM	Open Drain	Rectangular	1200	1200	1200	500	Collapsed from K1859 - K1867
Polyline	89	AWP	AWP4	Primary	RRM	Open Drain	Trapezoidal	1800	2600	3600	600	
Polyline	90	AWP	AWP5	Primary	RRM	Open Drain	Rectangular	1300	2400	2400	500	Collapsed from K1921 - K1922

Figure 9: Sample Attribute Table

3.3 Web-Based GIS Platform

To enhance accessibility and usability, the digitized drainage inventory was published on a web-based GIS platform. The system allows users to interact with the drainage data through a standard web browser without requiring specialized GIS software. The platform includes features such as attribute pop-ups, whereby clicking on any drainage segment displays its detailed attribute information. The inventory can be accessed through the website <https://inframap.ddnsfree.com/#/> Figures 10, 11, and 12 provide screenshots demonstrating the structure and usability of the web GIS system.

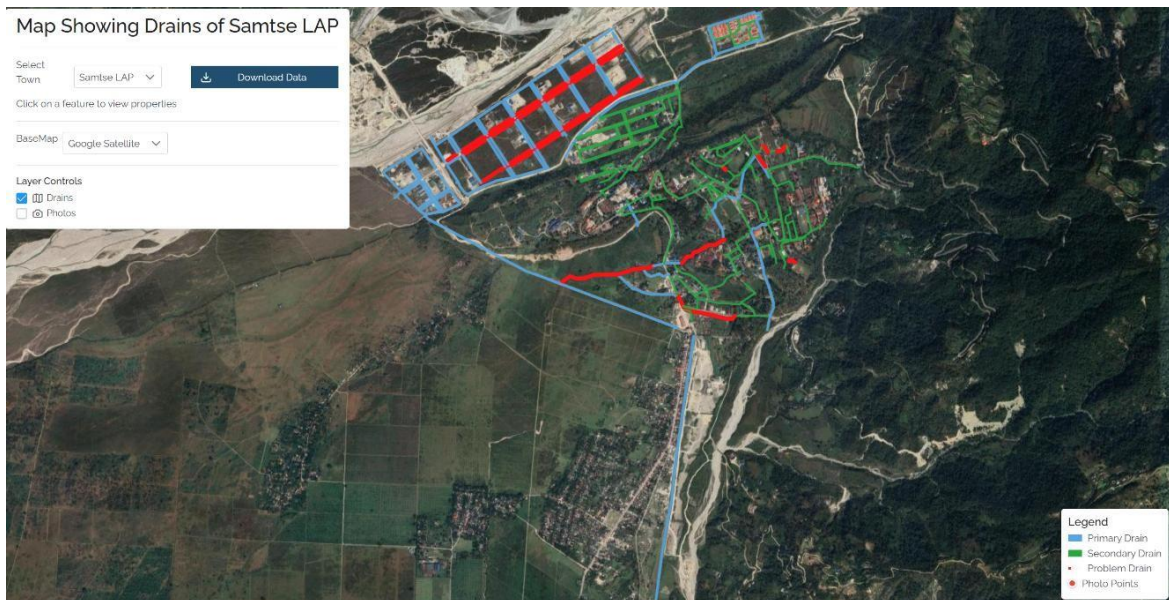


Figure 10: Overview of Web-Based Drainage System

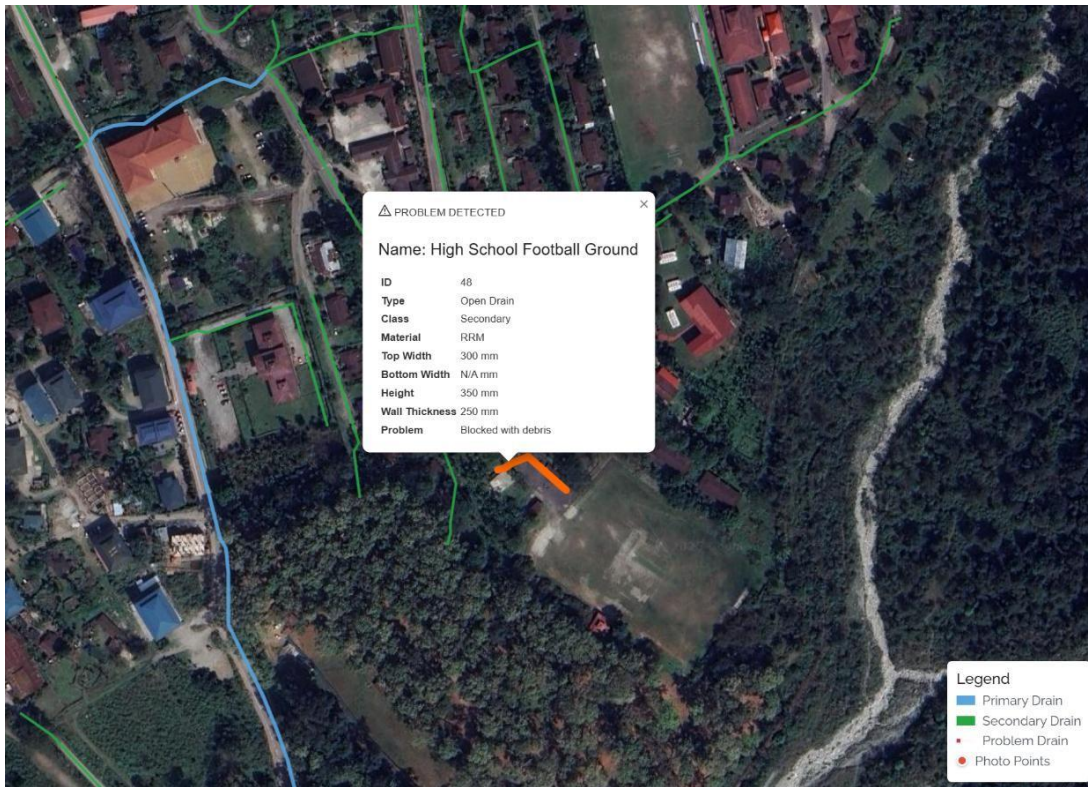


Figure 11: Overview of web-based drainage system with linked attribute



Figure 12: Overview of web-based drainage system with photos of the drains

4. IDENTIFIED ISSUES AND OBSERVATIONS

4.1. Problematic Points:

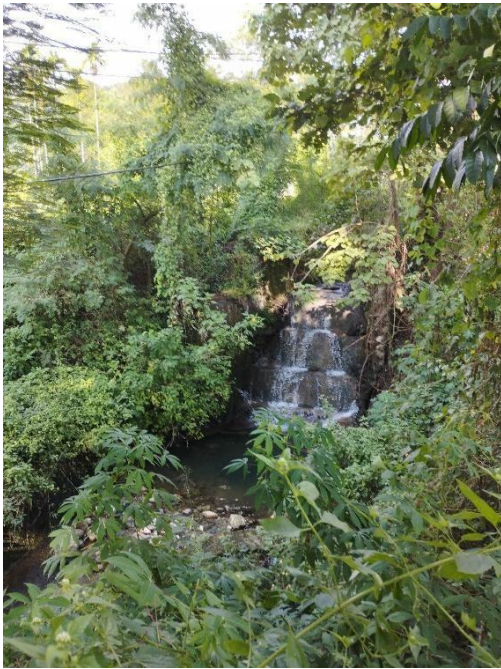
Several problematic points were identified during the field survey. In the geodatabase, these points are marked with red lines. Common issues include blockages, deteriorated conditions, undersized drains, and missing outlet connections. These problems are primarily attributed to poor maintenance, siltation, structural failures, and informal extensions of the drainage network.



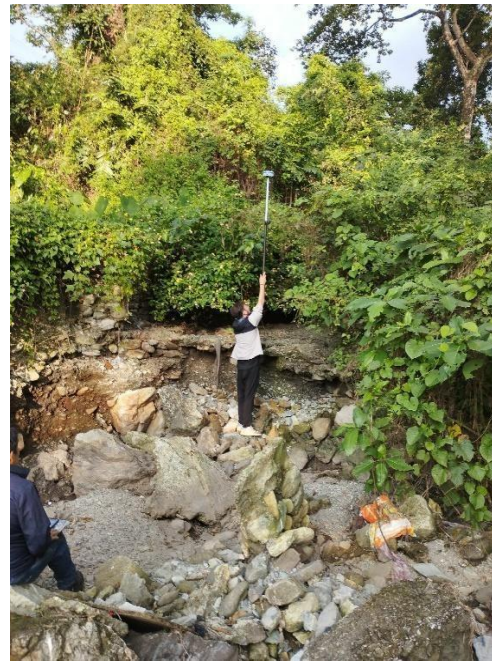
Collapsed Drain near Checkpost



Collapsed Drain at the end of the AWP drain



Collapsed Drain at AWP Drain



Collapsed Drain at AWP Drain



Collapsed Drain inside Army Camp



Collapsed Drain near Army Camp

Figure 13: Problematic Drains observed in Samtse

The majority of the failures occurred in areas with steep gradients or inadequate maintenance. Structural deficiencies, lack of lining, and clogged inlets were common contributing factors.

5. CONCLUSION

This spatial mapping supports analysis of drainage coverage. The final GIS output provides a clear, organized view of the existing drainage network in Samtse and serves as a valuable tool for future stormwater planning and infrastructure development. The inventory can be accessed through the website <https://inframap.ddnsfree.com/#/>

The storm drainage inventory conducted for Samtse Urban Centre has resulted in the successful development of a comprehensive spatial database and web-accessible GIS platform.

The key findings include:

- A total of 41.4 km of drains surveyed and digitized.
- Detailed classification by function, structure, section type, and material.
- Identification of several critical problem areas that require urgent intervention.

This geospatial inventory is intended to support:

- Strategic stormwater management planning,
- Infrastructure upgrading and maintenance scheduling,
- Integration into broader climate resilience and urban planning frameworks.