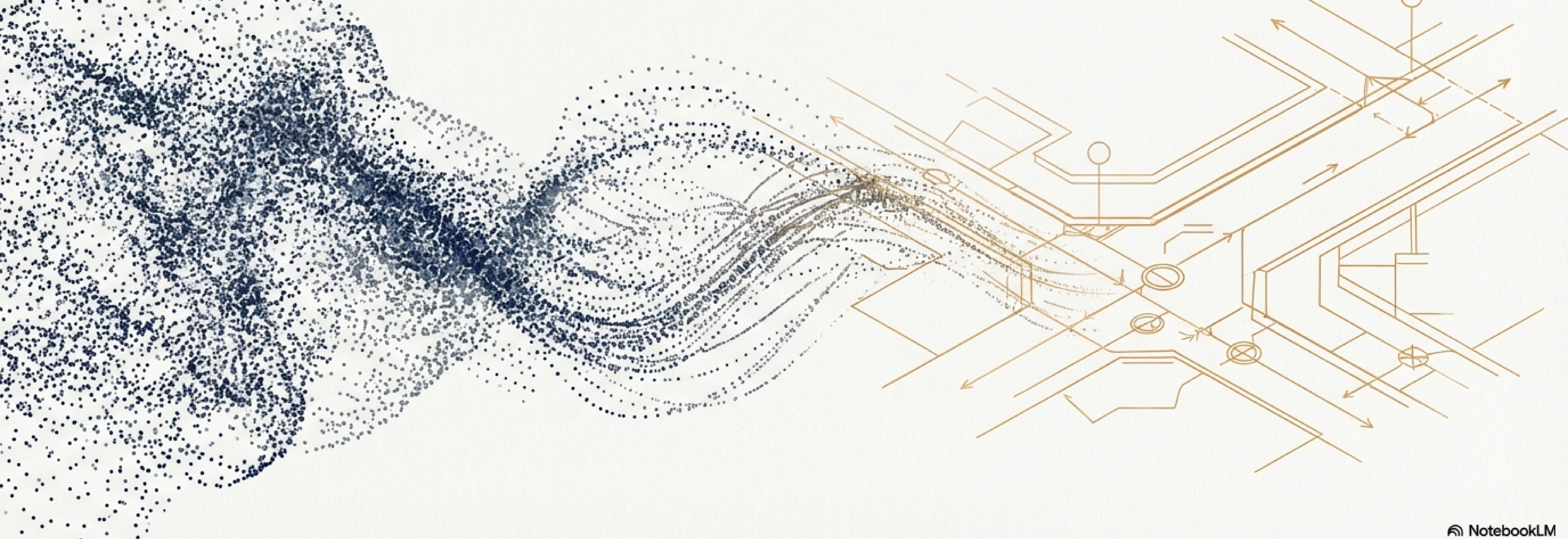
From Digital Noise to Drainage Blueprint
Drainage Bluesint

An AI-Powered Pipeline for Automated Topographic Analysis and Infrastructure Design in Abadi Areas



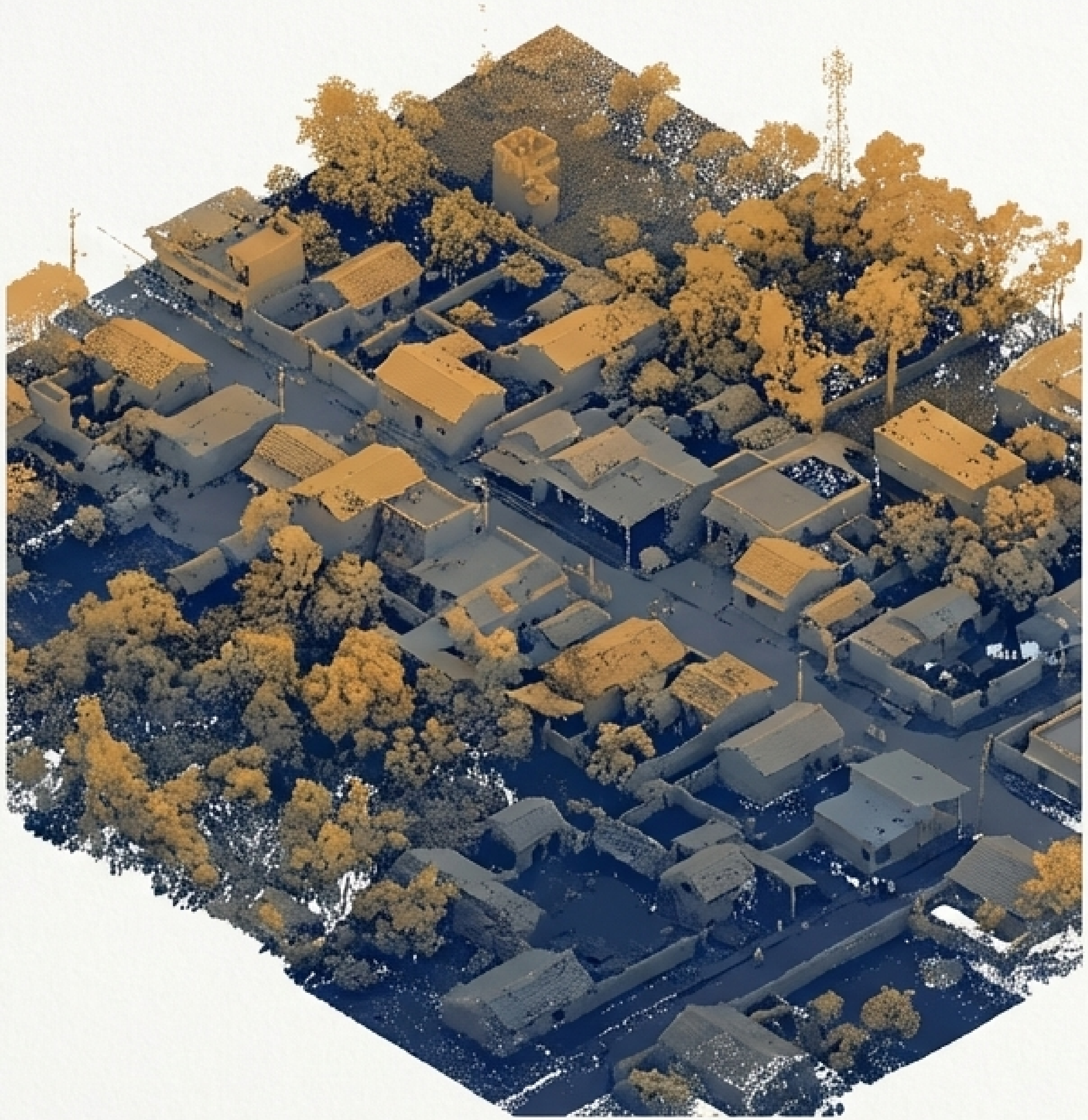
The Challenge: Protecting Villages from Waterlogging

- Inhabited village areas (Abadi) frequently suffer from poor sanitation and severe waterlogging, especially during rainfall.
- The primary cause is unplanned development that obstructs natural water flow paths.
- Traditional solution: Extensive, manual ground surveys for drainage design are slow, expensive, and difficult to scale across many villages.

A Modern Solution Creates a New Problem: Deceptive Data

While drone-captured 3D point clouds provide unprecedented data, this raw data is a Digital Surface Model (DSM). It is a noisy and misleading representation of the ground.

- The DSM captures thousands of 3D points per square metre.
- However, it sees everything: the tops of houses, tree canopies, vehicles, and power lines—not just the ground beneath them.

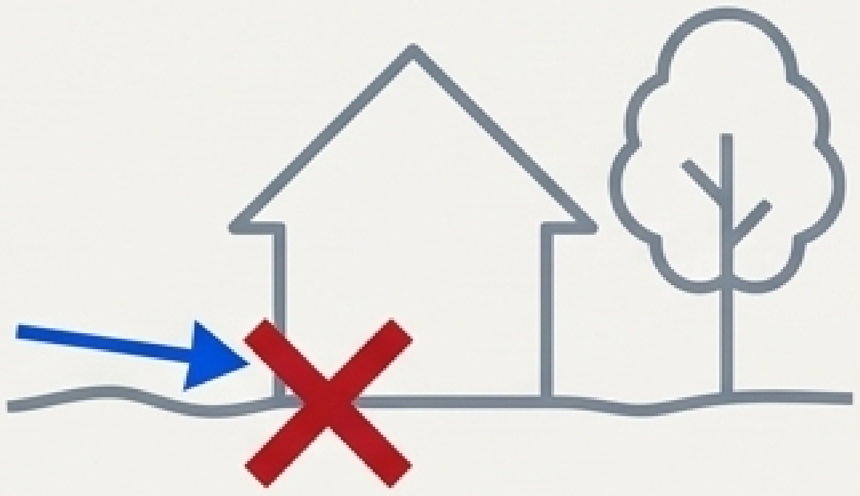


The Signal vs. The Noise: Why a DSM Fails Hydrology

For drainage design, we need to model how water flows on the bare earth (the “signal”). The DSM, full of surface objects (the “noise”), makes accurate simulation impossible.

Data Type	Conceptual Understanding	Hydrological Consequence
Input (DSM)	Views a house as a solid mountain and a tree as a hill. The true ground is hidden.	**Incorrect.** A simulation would conclude water “cannot flow through a house,” completely missing the reality that it must flow *around* it on the street below.
Required (DTM)	Houses, trees, and all other non-ground objects are digitally “stripped away.” Only the true street and ground levels remain.	**Correct.** Reveals the subtle, real-world slopes and depressions in alleyways where water actually accumulates and flows.

DSM Simulation: Fails

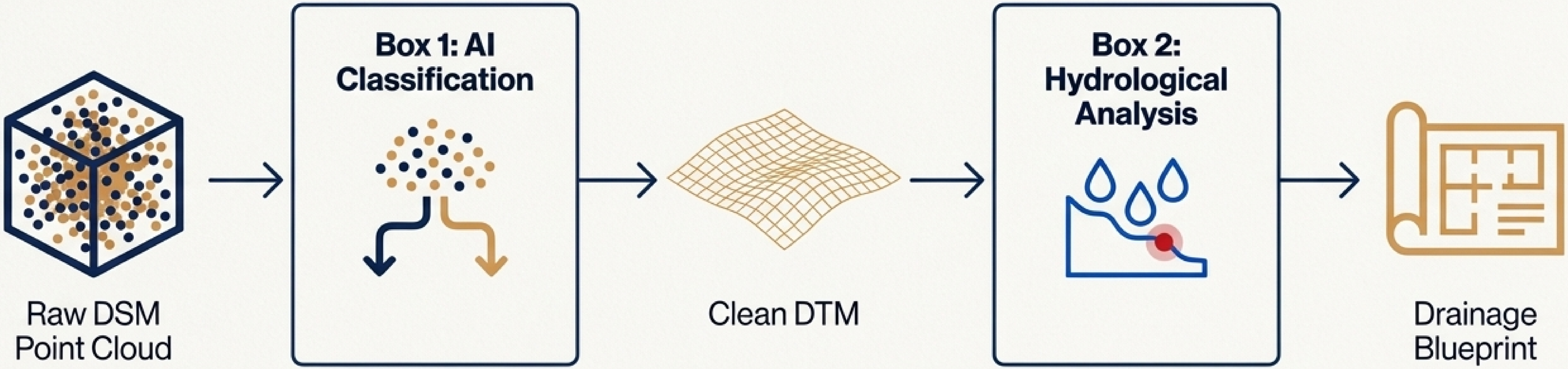


DTM Simulation: Succeeds

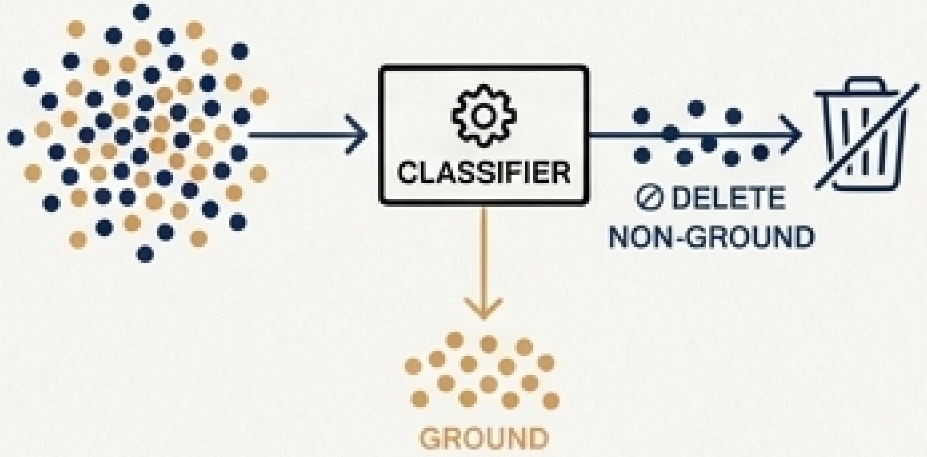
Our Solution: A Two-Step Pipeline to Engineer with Gravity

We have developed an automated pipeline that transforms the noisy DSM into an actionable blueprint. It works in two phases:

1. **See the Bare Earth:** An AI/ML model first classifies the raw point cloud, isolating the ground data by removing all non-ground objects.
2. **Find Gravity's Path:** With a clean ground model, we apply hydrological principles to simulate water flow and identify problem areas.



Step 1: Automated DTM Creation via Point Cloud Classification



The Fundamental Task

Convert a Digital Surface Model (DSM) into a Digital Terrain Model (DTM).

The AI's Role

The model processes the entire 3D point cloud and classifies every single point into one of two categories:

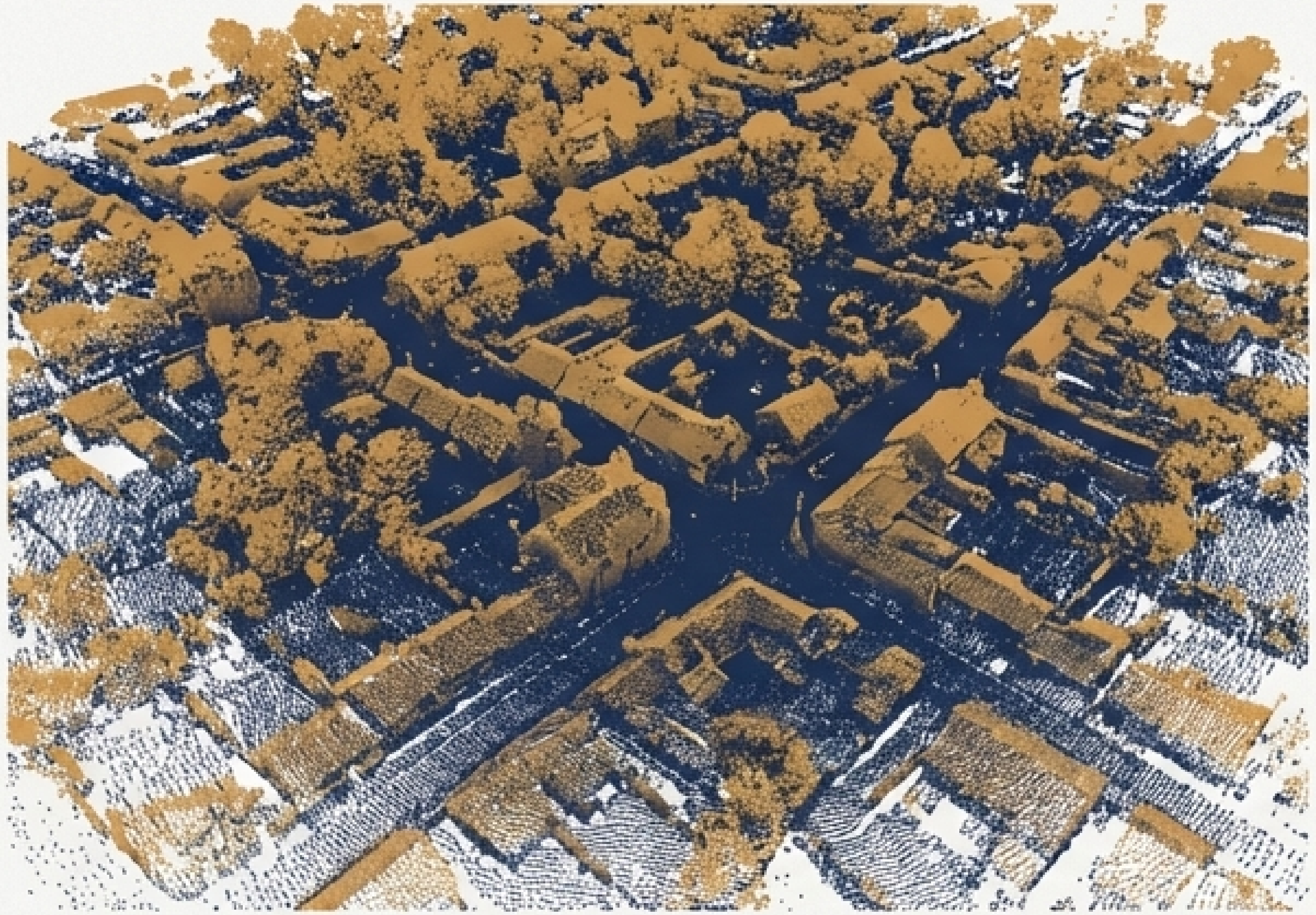
- **Category A:** **Ground Points**: Streets, alleys, open courtyards, bare earth.
- **Category B:** **Non-Ground Points**: Building roofs, walls, trees, vehicles, other obstructions.

The Outcome

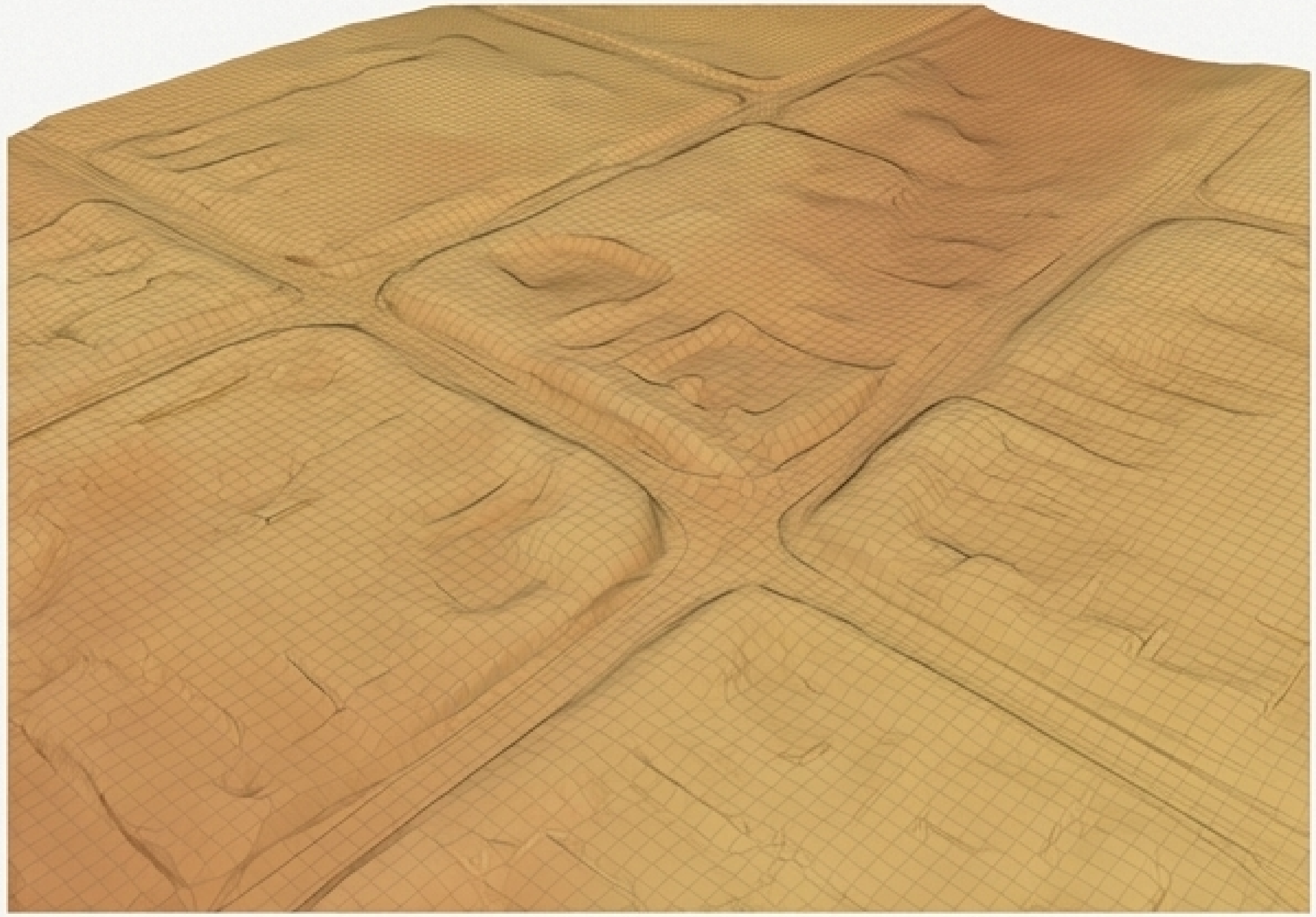
All points classified as 'Non-Ground' are programmatically deleted. The remaining points constitute the DTM—a pure representation of the ground topography.

Technical Note: The model architecture (e.g., PointNet/RandLA-Net) is designed specifically for this type of unstructured 3D data.

Visualising the Transformation: The AI Reveals the True Ground



Input: Digital Surface Model (DSM)



Output: Digital Terrain Model (DTM)

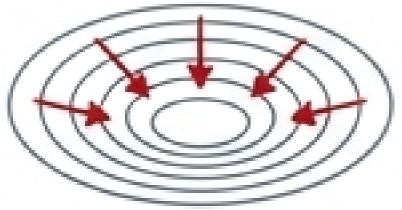
The AI automatically removes the 'noise' (buildings, trees) to reveal the 'signal' (the bare earth), making accurate hydrological analysis possible.

Step 2: Hydrological Analysis on the Clean DTM

With an accurate DTM, we can apply physics-based models to precisely simulate how water will behave.

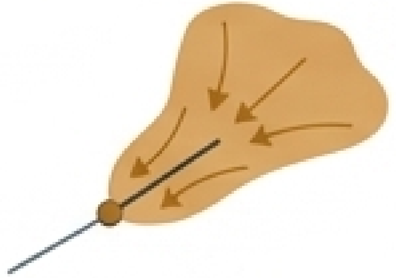
1. Delineate Flow Paths

We calculate the ‘steepest descent’ path from every single pixel in the DTM raster. This maps the exact route water will take under the force of gravity.



2. Identify Waterlogging Hotspots

The analysis automatically identifies all topographic depressions (sinks)—areas with no natural outlet where water will pool.



3. Define Catchment Areas

For each segment of the flow path, we calculate the total upstream area that drains to it, which is critical for sizing the infrastructure.

Predicting the Flow: Mapping Hotspots and Natural Drainage Lines

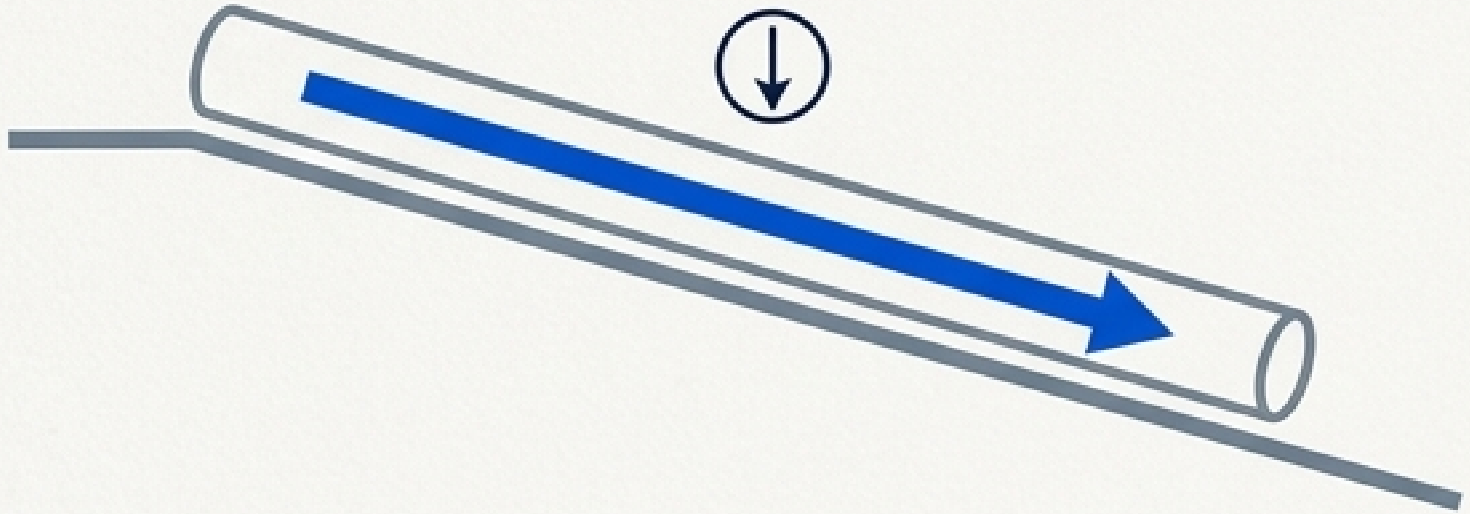
This analysis provides a predictive map of flood risk. The blue lines show us where nature *wants* the water to go, and the red zones show us where it will get trapped.

From Analysis to Action: Designing the Drainage Network

The proposed drainage network is not arbitrary. It is optimised and resilient by design.

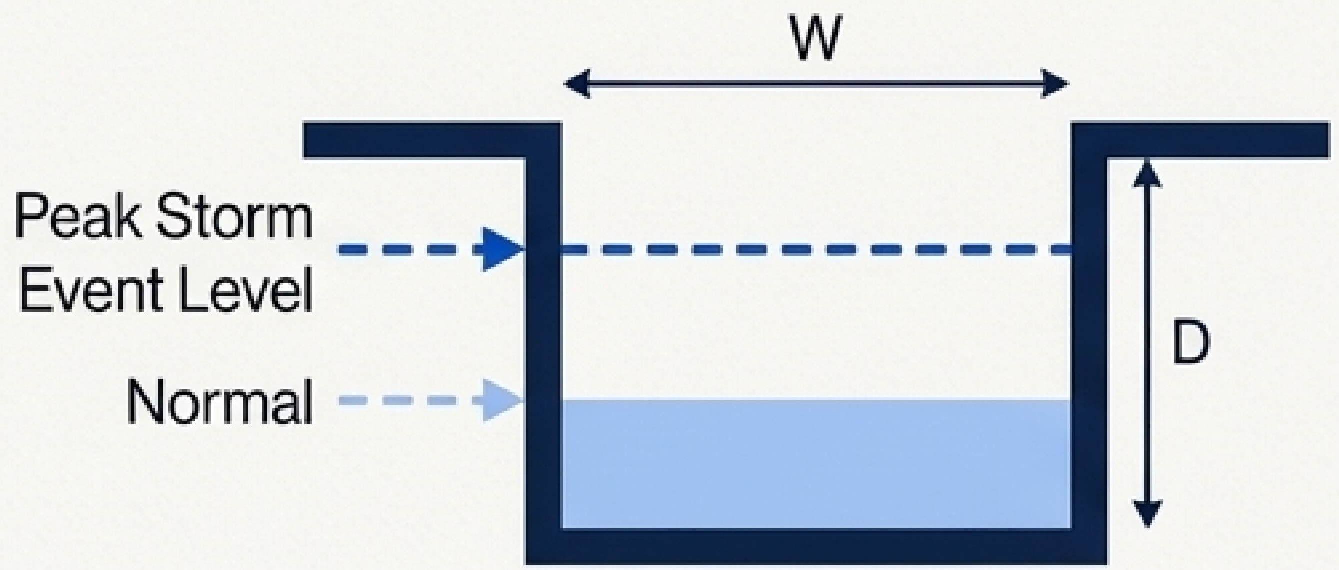
Optimised for Cost & Efficiency

- The drain alignments are designed to follow the natural flow paths identified in the analysis.
- This maximises the use of gravity, drastically minimising the need for expensive and high-maintenance pumping systems.



Resilient by Design

- The dimensions (depth, width) of each drain segment are calculated based on its specific catchment area and local rainfall data.
- This ensures the network can handle peak storm events without overflowing, building in climate resilience.



Project Inputs & Deliverables

Required Input Data

- Raw 3D Point Cloud data for each village (standard LAS/LAZ format).

Key Functional Deliverables

1. **Automated Processing Tool:** A software pipeline that ingests a raw LAS file, applies the AI classification model, and outputs a standard DTM.
2. **Optimal Drainage Network Design (GIS Vector Data):**
   - Shapefiles of proposed drain centerlines.
   - Shapefiles of identified waterlogging hotspot polygons.
   - Attribute data for drain segments, including calculated slope and suggested dimensions.
3. **Complete Technical Documentation:** Detailed methodology, model training logs, accuracy metrics, and user guides.
4. **Final Summary Report:** A comprehensive report validating the DTM accuracy and the results of the hydrological analysis for each village.

The Result: An Actionable Infrastructure Blueprint

Raw Input	Step 1: AI Task	Step 2: Physics Task	Final Output & Use Case
3D Point Cloud (DSM)	**Point Cloud Classification**	**Hydrological Modelling**	**Infrastructure Blueprint**
"A chaotic 'digital twin' including rooftops and trees."	"The AI filters out all non-ground 'noise' to reveal the bare earth."	"We simulate dropping virtual water on the clean ground to see where it flows and pools."	"A clear map showing the SVAMITVA team precisely where to build drains to solve waterlogging."