Team Name: PEN - Phase 1 Submission

Basti-Swaraj: Generative In-Situ Upgrading for Informal Settlements

Theme: Smart Cities & Sustainability

1. Problem Statement

Rapid urbanization in India has led to the growth of dense informal settlements (slums) where millions lack basic amenities like sanitation, clinics, and ventilation. Current redevelopment approaches are "destructive"—they rely on demolishing entire neighborhoods to build high-rises, which displaces communities and destroys livelihoods. Urban planners lack a tool to scientifically visualize and plan "micro-upgrades" (e.g., inserting a community toilet or widening a lane) within the existing chaotic fabric of a settlement without resorting to mass demolition.

2. Motivation

The motivation stems from the concept of "**Generative Urbanism**." While GenAI is widely used for text and art, its potential to solve physical infrastructure challenges is untapped. We identified a critical gap: Municipal officers and NGOs struggle to "see" the potential in a crowded map. They cannot easily visualize how a vacant dump yard could be transformed into a sustainable clinic. By using GenAI as a "Co-Architect," we can empower local bodies to design in-situ upgrades 100x faster, ensuring development happens with the community, not against it.

3. Application

- **Real-World Use Case:** A municipal engineer or NGO worker uploads a drone/satellite image of a slum area. They highlight a specific underutilized zone (e.g., a garbage pile or an abandoned shed). The tool generates 3 photo-realistic, structurally viable designs for a public utility (e.g., "Bio-Toilet Complex" or "Anganwadi Centre") that fits perfectly into that specific geometry.

- **Target Users:**

  1. **Government**: Smart Cities Mission, Municipal Corporations (for planning).
  2. **NGOs:** Organizations like Slum Dwellers International (SDI) for advocacy.
  3. **Citizens:** Community leaders proposing changes to local authorities.

- **Impact Sector:** SDG 11 (Sustainable Cities and Communities) and SDG 6 (Clean Water and Sanitation).

4. Proposed Method

Our solution, Basti-Swaraj, utilizes a Multi-Modal Generative AI pipeline designed for "Precision Inpainting."

Step 1: Input & Segmentation (The Context): The user uploads a 2D satellite map. We utilize the **Segment Anything Model (SAM)** to automatically identify and semantic-segment different layers: rooftops (to be preserved), roads (to be kept clear), and open/waste land (potential intervention sites).

Step 2: Masked Generative Inpainting (The Architect): We employ Stable Diffusion XL (SDXL) with a custom ControlNet adapter. The user selects a target area (mask). The model takes the prompt (e.g., "Sustainable bamboo health clinic, low-cost architecture, top-down view") and generates the structure only within the masked area, ensuring it blends seamlessly with the surrounding texture and lighting of the satellite image.

Step 3: Feasibility Analysis (The Engineer): The generated image is passed to a Vision-Language Model (like **GPT-4o or LLaVA**). The model analyzes the new layout against engineering constraints (e.g., "Does this structure block the main drainage path?") and outputs a text-based "Feasibility Score" (0-100).

5. Datasets / Data Sources

- **Training/Fine-tuning Data:**

    1. **OpenStreetMap (OSM) & Google Earth:** For base satellite imagery of Indian semi-urban textures.
    2. **SpaceNet Dataset:** For training the segmentation model on building footprints in dense areas.

- **Knowledge Base (RAG):**

    - **National Building Code of India (NBC 2016):** To ground the LLM's feasibility analysis in actual Indian construction laws (e.g., minimum setback distances).

- **Availability:** All datasets and model weights (SAM, SDXL) are open-source and publicly available for academic/hackathon use.

6. Experiments & Validation

- **Structural Consistency Score:** We will evaluate 50 generated interventions. We will use edge-detection algorithms to calculate the **IoU (Intersection over Union)** between the generated structure and the available empty space to ensure the AI does not "hallucinate" buildings on top of existing homes.
- **User Preference Study:** We will conduct a blind A/B test with 5 civil engineering students, showing them a manual CAD drawing vs. our GenAI-generated visualization, asking them to rate based on "Visual Clarity" and "Speed of Concept."
- **Hallucination Rate:** Measuring the percentage of times the model generates physically impossible objects (e.g., floating roofs) to refine our negative prompts.

7. Novelty and Scope to Scale

- **Uniqueness:** Most GenAI applications in this hackathon will likely be chatbots or code assistants. Basti-Swaraj is a **Visual Generative Design Tool.** It applies the "Inpainting" capability of GenAI to a novel domain: Humanitarian Engineering. No existing tool allows for "Click-and-Build" visualization for slums.
- **Scalability:**

1. **Tech Scalability:** The core engine is API-based. It can be wrapped into a simple Web App (Streamlit/React) accessible on any government tablet.
2. **Market Scalability:** This tool can be licensed to Architecture firms and Urban Planning consultancies, or offered as a public-good tool for the *Pradhan Mantri Awas Yojana (PMAY).*