Task B: Portfolio Allocation

1. Objective

Allocate a $25 million budget across districts and climate-resilience interventions to maximize risk reduction per dollar.

2. Inputs

- district_profile.csv - 120 districts with poverty, infrastructure, and demographic data
- hazard_timeseries.csv - Monthly flood, heat, heatwave, and NDVI data per district
- interventions_catalog.csv – intervention details with cost, complexity, and risk reduction
- dist_int_delivery.csv - Delivery probability for each district x intervention pair (from Task A)

3. Algorithm Flow

Step 1: Compute District Vulnerability Scores and Feasibility Score

Each district receives a vulnerability score (0-1) combining six normalized indicators: Poverty index (25%), Population (15%), Historical flood losses (15%), Historical heat losses (15%), 2024 mean heat index (15%), 2024 mean flood index (15%). Outliers in historical losses are capped at the 99th percentile before normalization. For every district and intervention pair, feasibility score is derived from delivery probability from Task A. Districts are assigned to poverty quintiles, the top quintile (Q5) is flagged for equity targeting.

Step 2: Calculate Objective Per Dollar

For every district and intervention pair, a score for objective per dollar is calculated as= vulnerability x risk_reduction x feasibility / (cost/ 1M). Candidates whose cost exceeds the $1.2M per-district cap are excluded upfront. All remaining candidates are sorted by objective (descending).

Step 3: Constrained Greedy Allocation (Two-Pass)

The allocation uses a multi-pass greedy approach to balance efficiency with constraints:

- Pass 1a - Equity Floor: Iterate through the highest-objective candidates from top-poverty-quintile districts. Greedily add until >= 40% of budget is committed to these districts.
- Pass 1b - Regional Coverage: For any region not yet covered, add the best-objective candidate from that region. Ensures every region receives at least one funded intervention.
- Pass 1c - Heat Balance: If the heat-focused share of total spend is below 30%, continue adding the best heat-focused candidates until the floor is met.
- Pass 2 - Fill Remaining Budget: Walk through all candidates sorted by objective and greedily add any that fit within remaining budget and the per-district $1.2M cap

5. Sensitivity Analysis: Equity 40% to 50%

To understand the cost of prioritizing equity more aggressively, the allocation is re-run with the equity floor raised from 40% to 50%.

What Changes

- More budget is directed to top-poverty-quintile districts, which may have lower feasibility or risk-reduction scores than the globally optimal set.
- The average objective (value-per-dollar) typically decreases, quantifying the efficiency cost of tighter equity.
- Some non-poverty districts funded in the base case may lose their allocation to make room for more poverty-targeted spending.
- Heat balance and regional coverage are re-enforced independently, so they may shift slightly but remain above their floors.

6. Output

- **portfolio_allocation.csv**
  Full portfolio with columns: district_code, district_name, region, country, poverty_index, is_top_poverty, vulnerability, intervention_id, intervention_name, hazard_focus, allocation (USD), risk_reduction, feasibility, impl_months, objective.
- **top10_districts.csv**
  Subset of portfolio_allocation.csv for the 10 districts with highest total funding.
- **top10_codes.json**
  JSON list of top-10 district codes, used by Task C chatbot.

7. Dependencies

- Python >= 3.8
- pandas, numpy
- json (standard library)
- No machine learning libraries required (uses pre-computed feasibility from Task A)