Note: Charts below are illustrative placeholders and should be replaced with official series before publication.

CHAPTER 2

Population Distribution (Ethiopia focus plus global lens)

Aynalem Adugna, October 2025

Suggested citation: Aynalem Adugna, Chapter 2. Population Distribution (Ethiopia focus plus global lens), www.EthioDemographyAndHealth. Org, October 2025.

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    Visuals: animated or small multiple maps; table of fastest-growing woredas/urban footprints.
15. **Methods Corner: Small-Area Estimation & Smoothing**
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16. **Data Quality, Boundaries & Reconciliation**
    Aim: Dealing with kebele splits/mergers, unofficial shapefiles, and inconsistent vintages.
    Visuals: boundary-change diagram; checklist table for harmonizing time series.
17. **Policy Applications & Planning Use-Cases**
    Aim: Targeting social protection, siting facilities, disaster preparedness, urban planning, and corridor development.
    Visuals: case-study map; table linking use-case → data inputs → decision metric.

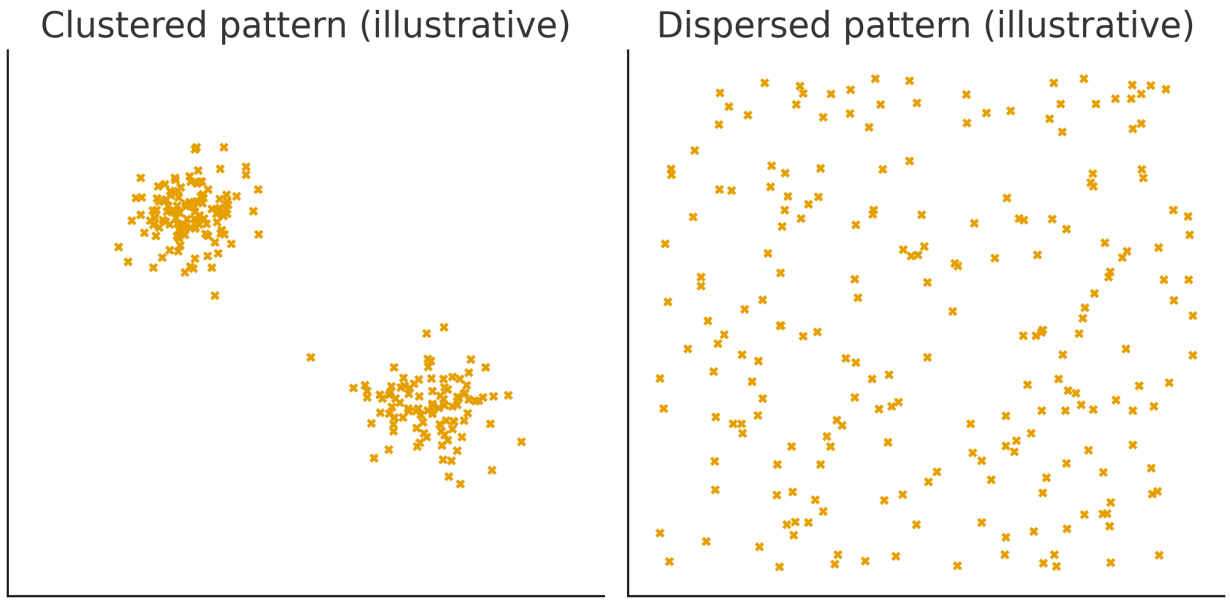
2.1) Concepts & Measures of Distribution

Purpose. Define how we measure where people live in Ethiopia—what “dense”, “dispersed”, or “concentrated” mean—and set common terms for the rest of Chapter 2.

Table.7¡.Core.measures.of.population.distribution

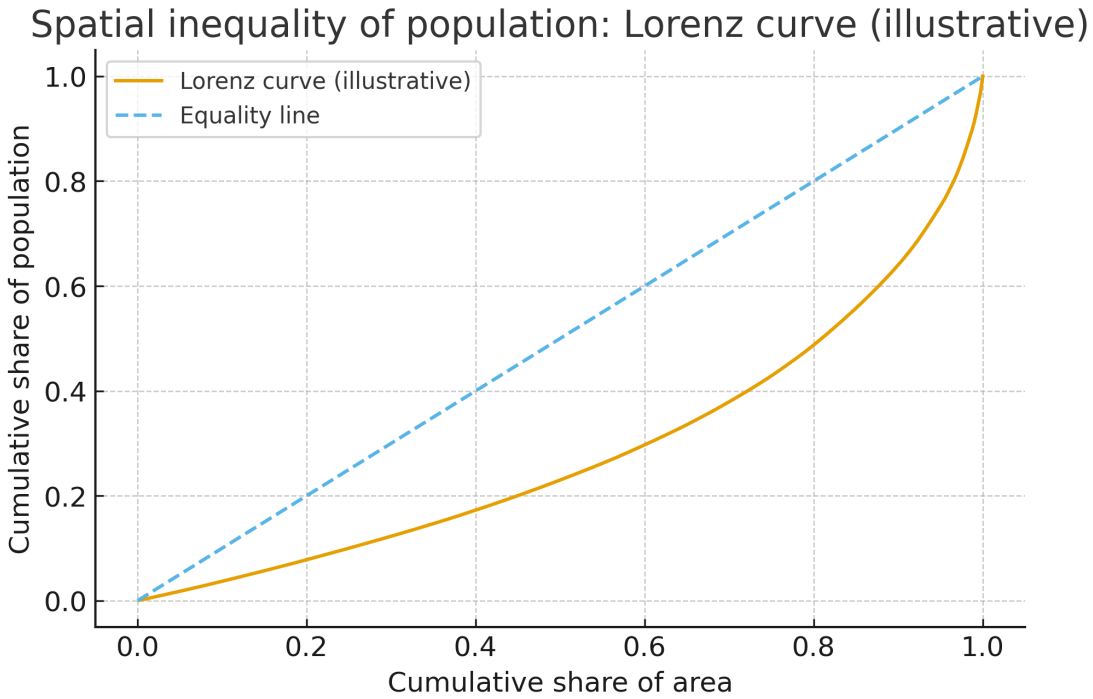
Measure	Definition (plain language)	Why it’s useful
Population density	People per unit area (e.g., per km^2); computed for region/zone/woreda/kebele or grid (e.g., 100 m).	Comparisons across geographies; service planning; denominators.
Concentration (Lorenz/Gini)	Lorenz curve & Gini summarize unevenness of people across space.	Track spatial inequality; identify ‘crowded’ cores vs sparse peripheries.
Entropy / Theil	Information-theory measures of dispersion vs concentration.	Compare dispersion over time or across regions.
Spatial autocorrelation (Moran’s I)	Correlation of values with neighbors; detects clusters vs randomness.	Hotspot analysis for density, poverty, or service deficits.
Settlement hierarchy (rank–size)	Relationship between city rank and size (Zipf-like).	Urban system balance (primacy vs polycentricity).
Accessibility/catchments	Population within travel-time bands to a facility/market.	Service coverage, equity of access; location-allocation planning.

Figure.7¡.Clustered.vs¡.dispersed.settlement.patterns.(illustrative)



Spatial inequality (Lorenz/Gini). The Lorenz curve compares cumulative population vs cumulative area; the further the curve from the diagonal, the more concentrated the population.

Figure.8¡.Lorenz.curve.of.population.vs¡.area.(illustrative)



Settlement hierarchy (rank–size). Ethiopia's urban system can be summarized with a rank–size plot—useful for detecting strong primacy (Addis) versus emerging secondary cities.

Figure.9¡.Settlement.rank-size.distribution.(illustrative)

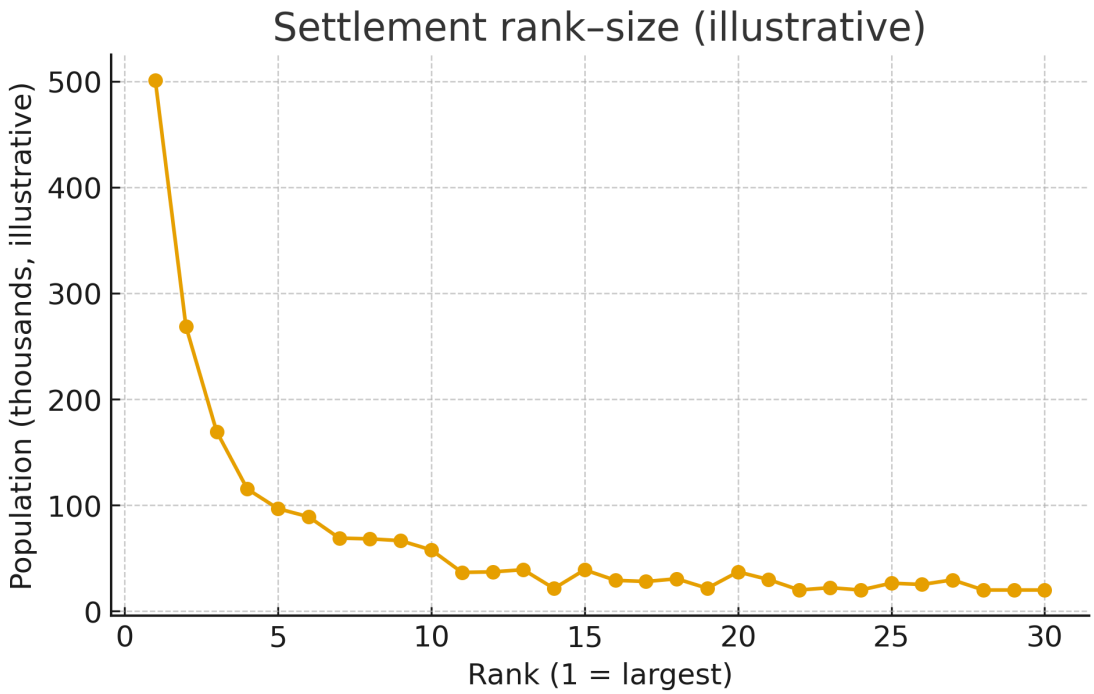


Table.8¡.Concepts.™.caveats.for.interpreting.maps.and.charts

Concept/caveat	What to keep in mind
MAUP (Modifiable Areal Unit Problem)	Patterns change with boundary/scale choices; grids help reduce bias.
Scale & zoning	Region → zone → woreda → kebele give different pictures; cite boundary vintage.
De facto vs de jure	Where a person slept on census night vs usual residence; crucial for cities & mobility.
Reference date / seasonality	Dry vs rainy season and shocks alter apparent distribution; note time window.
Denominator integrity	Use consistent, current population baselines for rates (health, education, WASH).

Table.9¡.Ethiopia_focused.indicators.to.be.featured.next

Indicator	How we'll present it
Highlands vs lowlands density contrast	Median density by elevation; top/bottom woredas.
Urban system & corridors	Rank–size of major cities; population along Addis–Djibouti corridor.
Pastoral mobility overlays	Population × water points/NDVI seasonality in Afar/Somali/Borena.
Service accessibility	% population within 2/5/10 km of primary school/health post by woreda.
Risk exposure	% population in flood/drought/landslide zones by region/kebele class.

References — Section 2.1 (Concepts & Measures of Distribution)

- UN Statistics Division (UNSD). Principles and Recommendations for Population and Housing Censuses (latest revision).

- Openshaw, S. (1984). The Modifiable Areal Unit Problem (MAUP).

- Anselin, L. (1995). Local Indicators of Spatial Association—LISA. Geographical Analysis.

- Theil, H. (1967). Economics and Information Theory. (Entropy/Theil index).

- Zipf, G. K. (1949). Human Behavior and the Principle of Least Effort. (Rank–size/Zipf's law).

- Weiss, D. J. et al. (2018). A global map of travel time to cities. Nature (accessibility/catchments concept).

2.2) National Patterns: Highlands vs. Lowlands

Why this matters. Ethiopia's settlement pattern reflects its topography: densely populated highlands with cooler climate and cultivable land, and sparser lowlands with pastoral and agro-pastoral livelihoods. Understanding this macro-pattern helps target infrastructure, services, and climate adaptation.

Table.7¡.Elevation.band.summary.(illustrative)

Elevation band	Share of land area (%)	Share of population (%)	Median density (people/km^2)	Mean density (people/km^2)
< 1,500 m (Lowlands)	55.0	18.0	25	30
1,500–2,300 m (Mid-Highlands)	30.0	47.0	190	180
> 2,300 m (Highlands)	15.0	35.0	240	220

Figure.7¡.Population.vs¡.land.area.by.elevation.band.(illustrative)

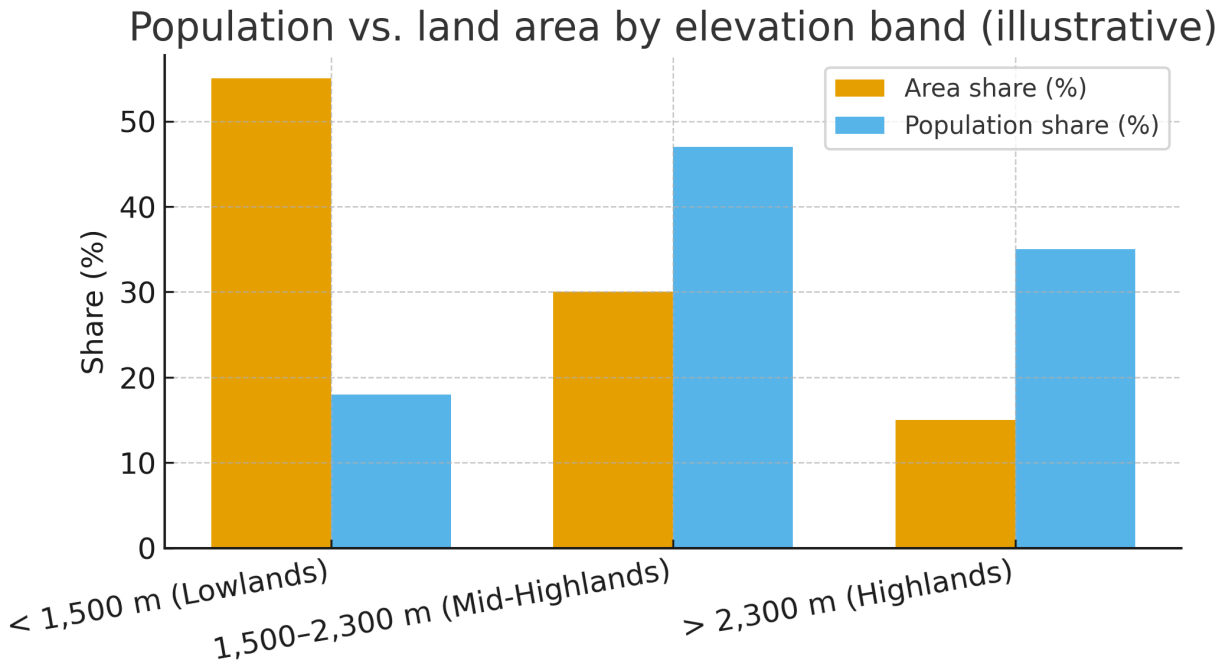


Figure.8¡.Median.population.density.by.elevation.band.(illustrative)

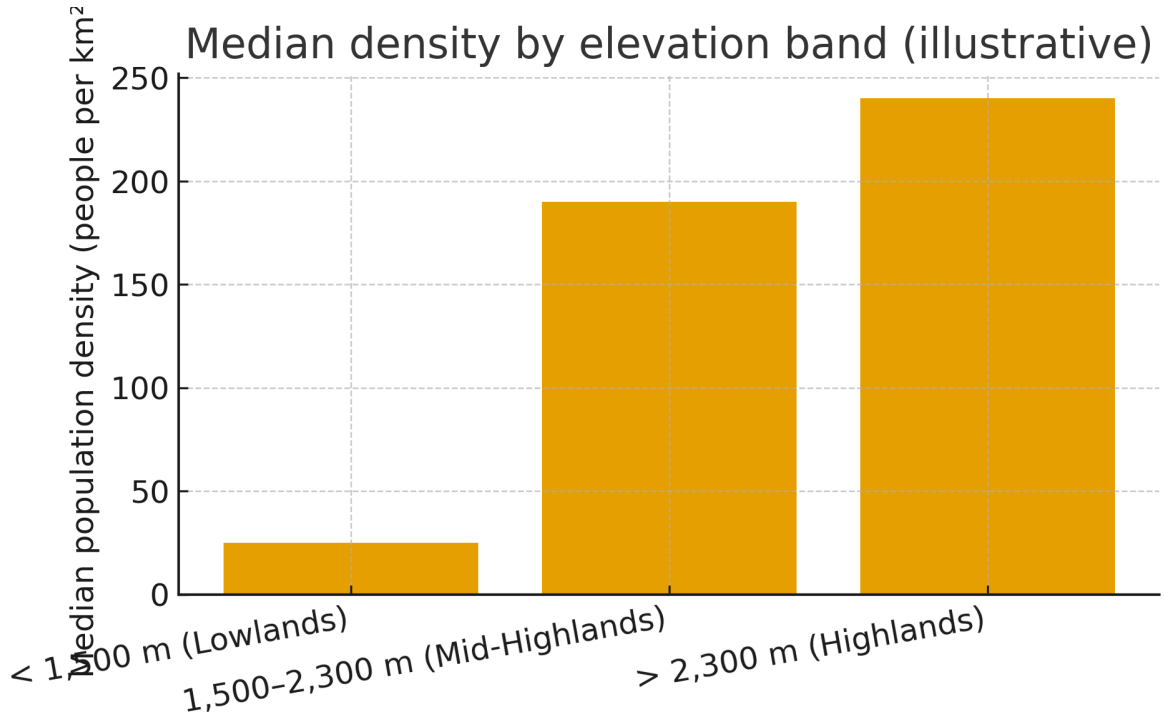


Figure.9¡.Schematic.distribution¿denser.highlands.vs.sparser.lowlands.(illustrative)

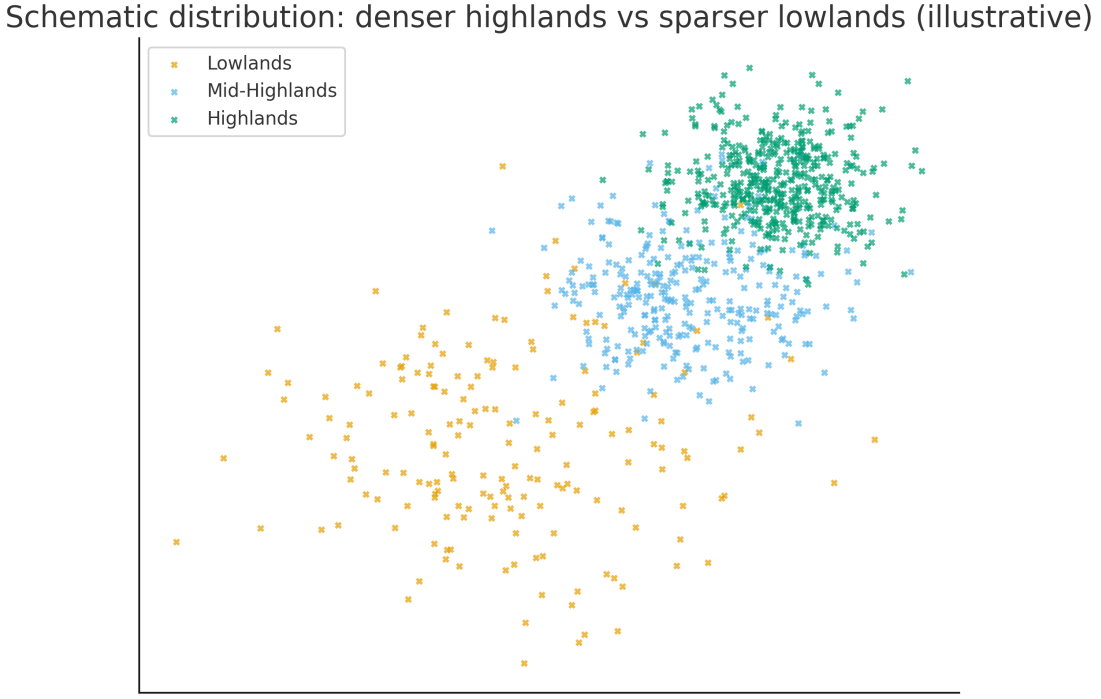


Table.8¡.Ethiopia-focused.indicators.to.track

Indicator	How to present
Density by agro-ecology	Population density by crop suitability/land cover within each elevation band.
Urban share by elevation	Share of urban population residing in highland vs lowland bands.
Accessibility gaps	Population beyond 60/120 minutes of primary facilities by band.
Growth fronts	Change in built-up area and population grid cells by band (2000–2025).
Service coverage	% of households with electricity/water/sanitation by band (from surveys/admin).

Table.9¡.Data.sources.™.caveats.for.highland–lowland.analysis

Component	Notes for analysis
Elevation and terrain	SRTM/DEM (30–90 m); check void-filled versions; ensure consistent projection.
Population baselines	ESS census/projections; gridded datasets (WorldPop, GHS-POP) for small-area depiction.
Urban footprints	GHSL/WSF; building footprints; verify epochs/vintages across years.
Agro-ecology & land cover	ESA CCI, Copernicus land cover; national agriculture stats for context.
Accessibility	OSM roads; friction surfaces; facility masterlists (MoH/EMIS).
Caveats	MAUP, reference year alignment, de facto vs de jure differences; pastoral seasonality in lowlands.

Sidebar: Practical choices for Ethiopia

• Use 1,500 m and 2,300 m as pragmatic elevation thresholds; report exact definitions in captions.

• Align elevation with the same reference year and boundary vintage as population layers.

• For pastoral lowlands, pair density maps with mobility/seasonality overlays before drawing conclusions.

References — Section 2.2 (Highlands vs. Lowlands)

- SRTM/DEM elevation data (30–90 m) — standard basis for elevation analyses.

- UN Statistics Division (UNSD). Principles and Recommendations for Population and Housing Censuses (map comparability & MAUP notes).

- EC-JRC Global Human Settlement Layer (GHSL) — built-up footprints and GHS-POP population grids.

- WorldPop Project — gridded population estimates (methods and vintages).

- ESA Climate Change Initiative (CCI) / Copernicus Land Cover — agro-ecology context layers.

- Weiss, D. J. et al. Travel time to cities (accessibility context for service catchments).

2.3) Administrative Scale Matters: Region → Zone → Woreda → Kebele

Why scale and boundaries matter. Apparent population patterns depend on the administrative level and boundary vintage. This section illustrates MAUP and provides a harmonization workflow for Ethiopia.

Table.7¡.Ethiopia"s.administrative.hierarchy.(analysis.notes)

Level	Role & notes for analysis
Region	Top administrative tier; policy/strategic planning; boundary changes affect comparability.
Zone	Intermediate coordination tier; sometimes restructured; names and extents may change.
Woreda	Primary local government unit; key for service planning; frequent splits/mergers.
Kebele	Most granular official admin layer; frequent updates; community-level programs.

Figure¡.Boundary.changes¿split.and.merge.schematic.(illustrative)

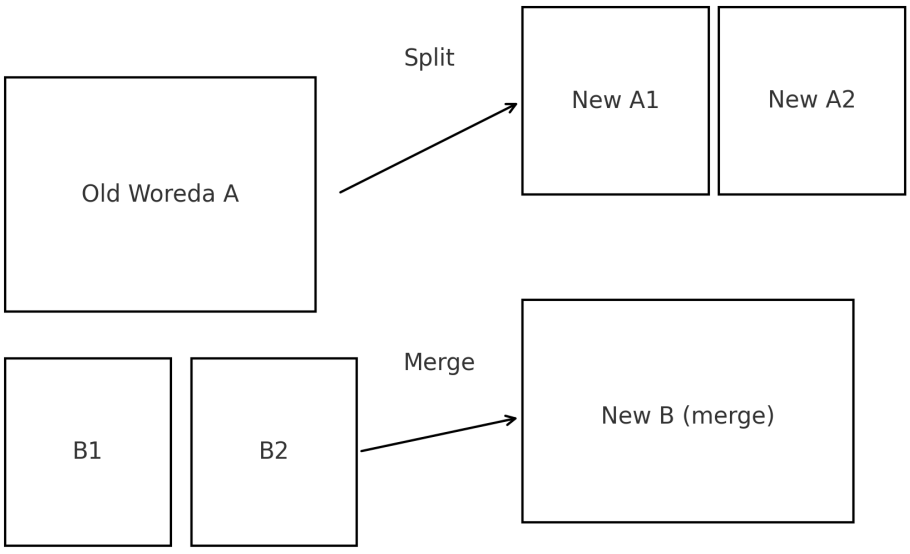


Table.8¡.MAUP.pitfalls.and.how.to.mitigate.them

Pitfall	Mitigation
Hotspots appear/disappear when aggregating	Triangulate with multiple scales (grid + admin). Show sensitivity.
Rates distorted by uneven denominators	Use population-weighted rates and comparable time references.
Boundary changes create artificial trends	Harmonize to a common vintage; publish a mapping crosswalk.
Urban–rural misclassification	Document criteria; check with settlement layers (GHSL/WSF).
Over-smoothing at higher tiers	Complement with fine-grid or kebele stats for targeting.

Table.9¡.Boundary.harmonization.workflow.for.Ethiopia

Step	Action
1) Inventory vintages	List boundary files and dates; note splits/mergers/renames.
2) Choose a target vintage	Pick a reference year for the chapter; justify choice.
3) Build crosswalks	Create many-to-one/one-to-many mapping tables with area/pop weights.
4) Reaggregate indicators	Use population or area weights to transform time series to target vintage.
5) Validate & document	Spot-check totals; publish crosswalks, code, and assumptions.

Sidebar: Practical tips for Chapter 2 maps

• State the boundary vintage (ESS official) and analysis scale in every caption.
• For time comparisons, reaggregate to a single target vintage via crosswalks.
• Pair woreda maps with a fine grid (e.g., 100 m) to avoid misleading uniform areas.

References — Section 2.3 (Administrative Scale & MAUP)

- Openshaw, S. (1984). The Modifiable Areal Unit Problem (MAUP).

- UN Statistics Division (UNSD). Principles and Recommendations for Population and Housing Censuses (map comparability & boundary changes).

- Ethiopian Statistics Service (ESS) official boundary vintages and changelogs.

- Anselin, L. (1995). Local Indicators of Spatial Association (LISA).

- EC-JRC GHSL & WorldPop—grid-based comparisons alongside administrative units.

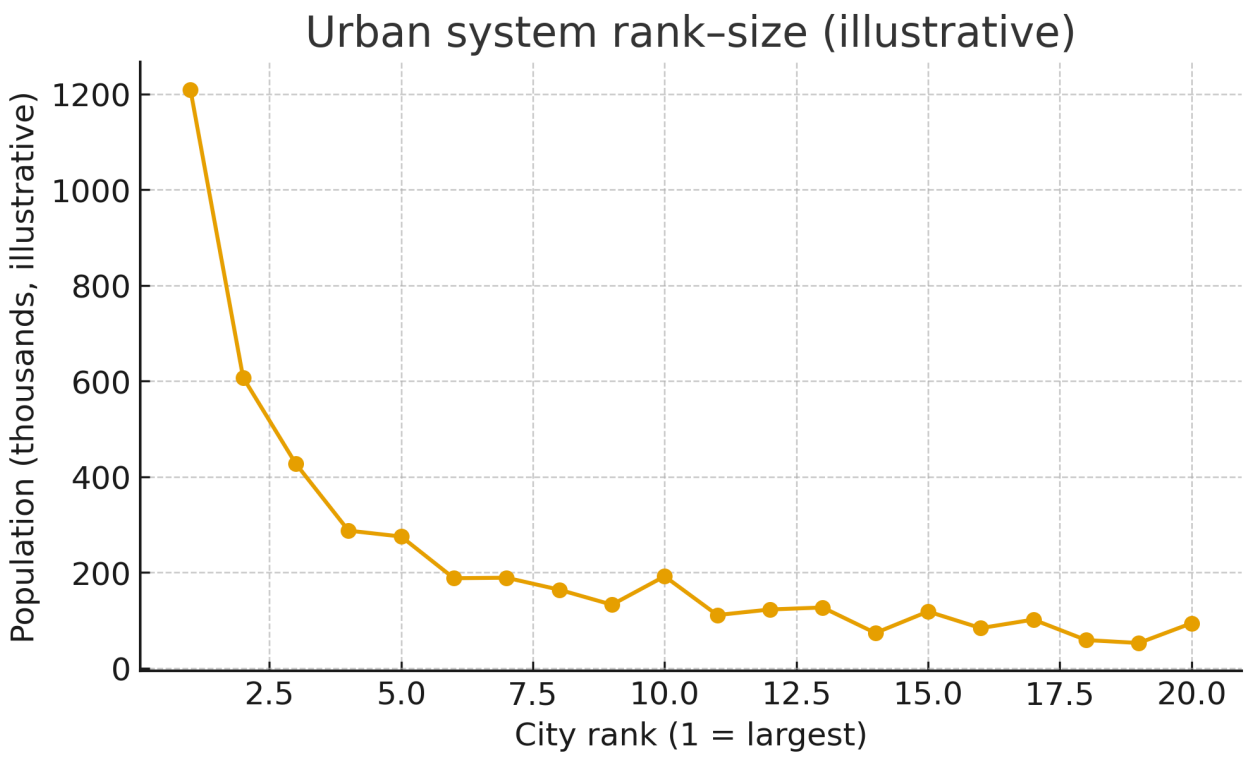
2.4) Urbanization & the Settlement System

Why this matters. Ethiopia's growth is increasingly urban and corridor-linked. Understanding the settlement hierarchy—from Addis to emerging towns—helps plan housing, services, jobs, and transport.

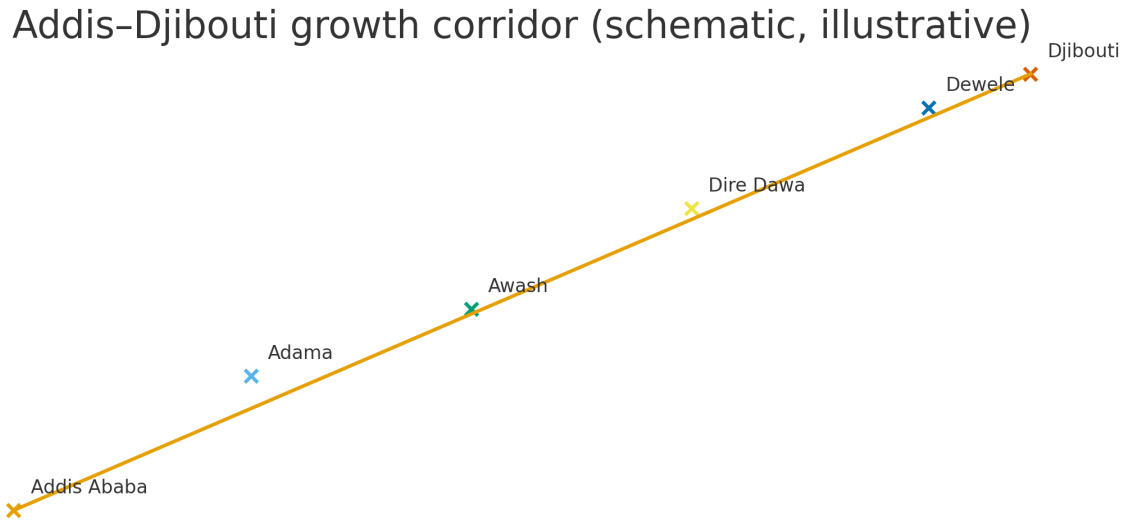
Table.7¡.What.counts.as»urban‹ ?.National.vs.global.delineations

Definition/system	Implications for analysis
National (ESS/CSA legal definition)	Administrative status; settlements declared urban; may lag morphology.
GHS-SMOD (degree of urbanization)	Built-up density + population thresholds; comparable across countries.
WSF/GHSL built-up footprints	Physical extent of built environment; no direct population threshold.
Hybrid (recommended)	Use national definition for governance + global layers for morphology and growth analysis.

Figure.7¡.Rank- size.distribution.of.cities.(illustrative)



.Figure.9¡.Addis-Djibouti.corridor.schematic.(illustrative)



.....Table.8¡.City.tiers.and.example.indicators.(illustrative)

Tier	Examples (illustrative)	Key indicators
Tier 1 (metro)	Addis Ababa	Core population; built-up area; density; jobs; NTL intensity
Tier 2 (secondary)	Dire Dawa, Mekelle, Hawassa, Adama, Bahir Dar	Population; footprint growth; connectivity; service coverage
Tier 3 (emerging towns)	Assosa, Jigjiga, Semera, Gambela, Shashemene, etc.	Growth rate; corridor proximity; basic services

.....Table.9¡.Indicators.to.track.for.Ethiopia's.urban.system

Metric	Definition / how to compute
Primacy index	Population of largest city / next k cities (e.g., top 5).
Rank–size exponent	Slope of log(size) vs log(rank).
Footprint expansion	Built-up area change (km^2) by epoch (2000, 2010, 2020, 2025).
Densification vs sprawl	Population change vs footprint change; density trajectories.
Accessibility	Travel time to metro core; corridor and ring-road effects.
Service coverage	% households with improved water, sanitation, electricity (surveys/admin).

Table.0¡.Data.sources.and.cautions

Source	Notes
ESS/CSA urban stats	Official counts/definitions; note reclassifications over time.
GHSL (built-up, SMOD), WSF	Consistent epochs; check version/vintage for comparability.
WorldPop/GHS-POP	Population distribution for density and city delineation.
VIIRS/DMSP night-time lights	Economic intensity proxy; saturates in very bright cores; clouds/stray light.
Roads & rail (OSM/national)	Connectivity analyses and corridor delineation.

Sidebar: Practical choices for Ethiopia's urban analysis

• Use the national definition for governance reporting, but complement with GHSL/WSF footprints to capture morphology and growth.
• Report city statistics both for administrative boundaries and for functional urban areas (where feasible).
• Always specify dataset vintages (e.g., GHSL 2015/2020 epochs; WorldPop 2023).

References — Section 2.4 (Urbanization & Settlement System)

- Ethiopian Statistics Service (ESS/CSA). Urban statistics and definitions (official publications).

- EC-JRC Global Human Settlement Layer (GHSL) — built-up, GHS-POP, GHS-SMOD (degree of urbanization).

- DLR World Settlement Footprint (WSF).

- WorldPop — gridded population estimates.

- VIIRS/DMSP night-time lights — urban/economic intensity proxy.

- OpenStreetMap and national transport datasets — corridor and connectivity mapping.

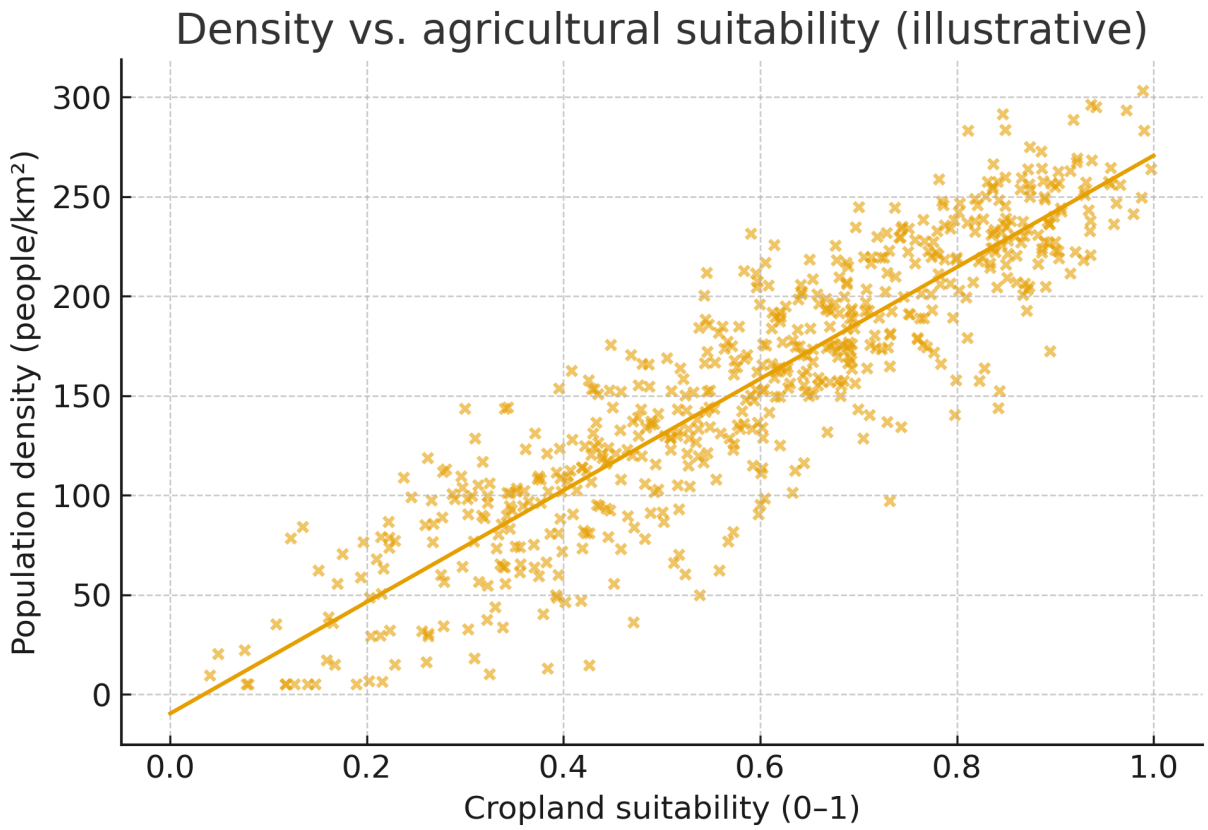
2.5) Rural Settlement Patterns & Agricultural Potential

Why this matters. Most Ethiopians still live in rural areas. Understanding how agricultural potential and accessibility shape settlement helps target rural services, market links, and climate-smart investments.

Table.7¡.Agro-ecological.zones.and.rural.settlement.signals.(illustrative)

Agro-ecological zone (illustrative)	Characteristics	Settlement signals
High-potential grain highlands	≥ 1,800 m; reliable rainfall; cereals & pulses	High densities; fragmented plots; higher service coverage
Mid-altitude mixed farming	1,200–1,800 m; mix of crops & livestock	Moderate densities; expanding small towns
Lowland cash crop/irrigated pockets	< 1,200 m; cash crops & irrigation nodes	Clustered densities near water & schemes
Pastoral & agro-pastoral rangelands	Arid/semi-arid; variable rainfall	Sparse & seasonal densities; mobility drives patterns

.....Figure.7¡.Density.vs¡.cropland.suitability.(illustrative)



..Figure.8¡.Density.distribution.by.land.cover.class.(illustrative)

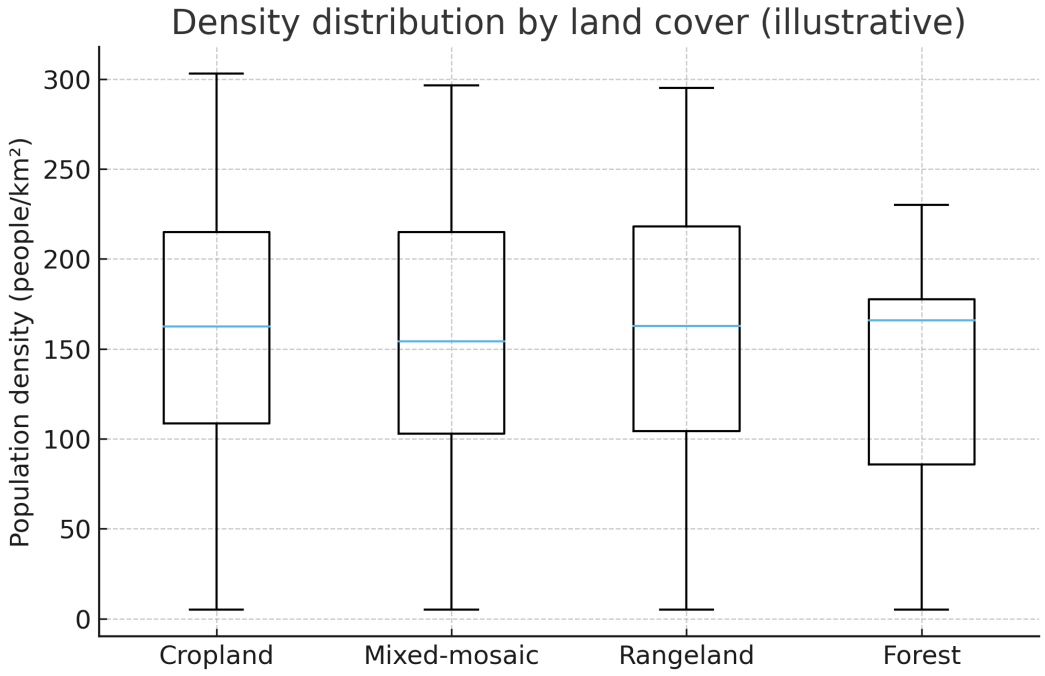
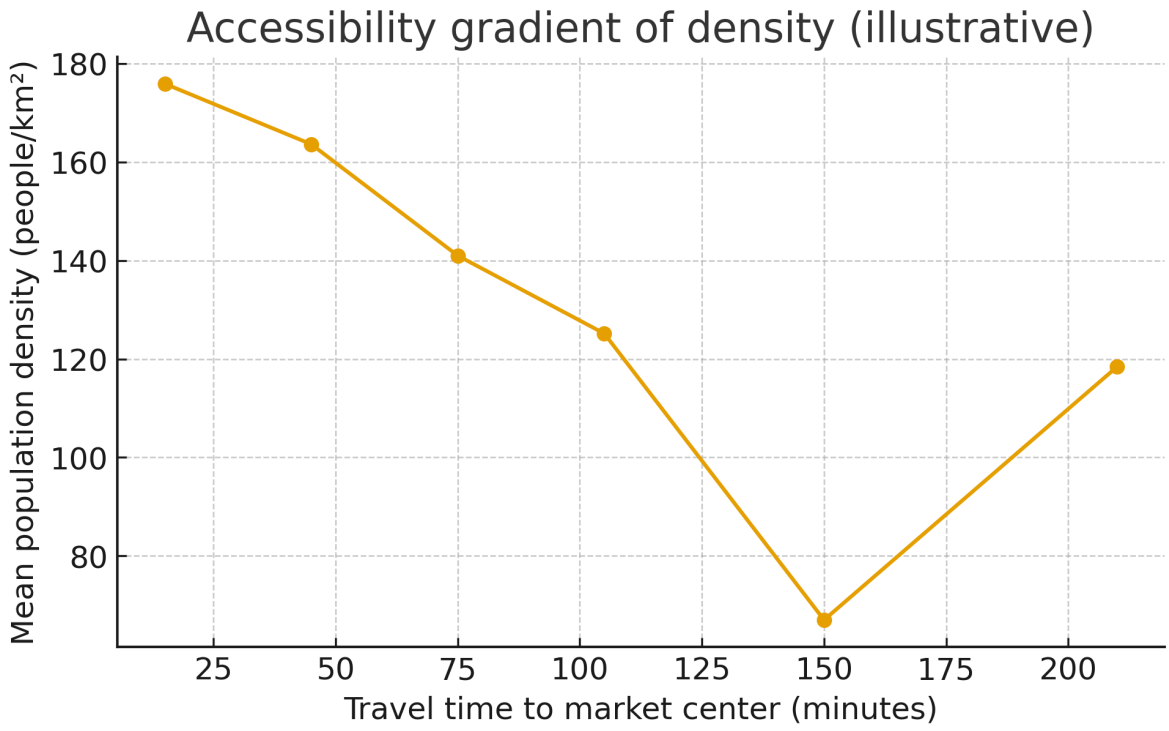


Figure.9¡.Accessibility.gradient.of.density.(illustrative)



.....Table.8¡.Ethiopia-focused.indicators.to.develop.for.Section.8¡❶

Indicator	How to present
Density × cropland suitability	Bivariate map and scatter; identify over/under-settled cells
Rural town emergence	Built-up growth in 1–5 km buffers around kebele centers
Accessibility gradient	Density and service coverage vs travel time to markets/clinics/schools
Land fragmentation proxy	Household size vs holding size (survey) cross-tab by zone
Irrigation influence	Density near schemes vs away (rings or difference-in-means)

Table.9¡.Data.sources.and.caveats.for.rural.analysis

Component	Notes
Population layers	ESS census/projections; WorldPop/GHS-POP for small-area patterns
Cropland & suitability	ESA CCI/Copernicus; global/country crop suitability layers (e.g., GAEZ)
Accessibility	Roads (OSM/national); friction surfaces; facility masterlists (MoH/EMIS)
Rural footprints	GHSL/WSF footprints; building footprints
Surveys	HICES/WMS; LFS; AGP/LSMS-ISA (ESS/World Bank)
Caveats	Seasonality & drought; irrigation season peaks; MAUP; boundary/vintage alignment

Sidebar: Practical choices for Ethiopia's rural analysis

• Use agro-ecological zones alongside elevation to interpret density.

• Align population baselines and land-cover vintage; account for seasonality in lowlands.

• Where possible, analyze 1–5 km buffers around kebele centers to capture rural town emergence.

References — Section 2.5 (Rural Settlement Patterns & Agricultural Potential)

- Ethiopian Statistics Service (ESS/CSA) — census/projections; rural–urban distributions.

- ESA CCI / Copernicus Land Cover — cropland and land cover layers.

- GAEZ (FAO/IIASA) — global agro-ecological zones & suitability layers.

- WorldPop / GHS-POP — gridded population estimates.

- OpenStreetMap & national transport datasets — accessibility; facility masterlists (MoH/EMIS).

- Weiss, D. J. et al. Global friction surface and travel time to cities.

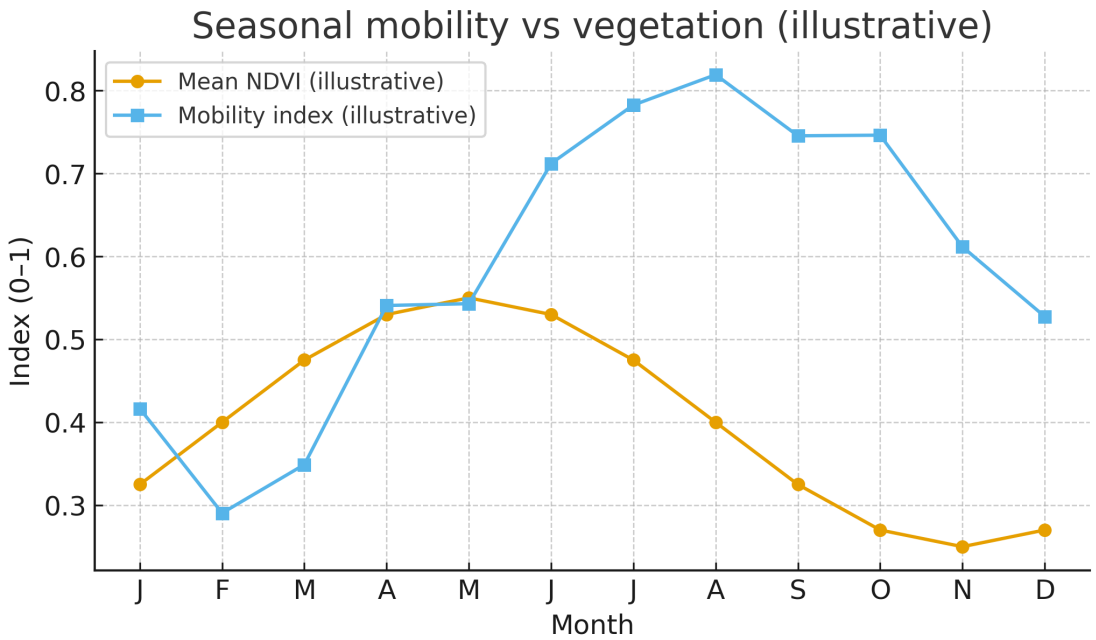
2.6) Pastoralist & Mobile Populations (Afar, Somali, Borena, South Omo)

Why this matters. Pastoral and agro-pastoral livelihoods drive seasonal population shifts in Ethiopia's lowlands. Infrastructure planning, service coverage, and humanitarian operations must account for mobility, water points, and climate variability.

Table.7¡.Ethiopia.regions.with.mobile.populations– key.characteristics.(illustrative)

Region (focus areas)	Key mobility characteristics
Afar	Arid lowlands; riverine & borehole water; cross-border/seasonal mobility; livestock focus.
Somali	Pastoral & agro-pastoral; water points define seasonal presence; border trade & shocks.
Oromia (Borena)	Rangelands; periodic drought; cross-regional movement; conflict sensitivity.
SNNP/South Omo	Agro-pastoral; transhumance; protected areas & tourism interactions.

.....Figure.7¡.Seasonal.mobility.vs.vegetation.greenness.(illustrative)



.....Figure.8¡.Population.presence.vs.distance.to.water.points.(illustrative)

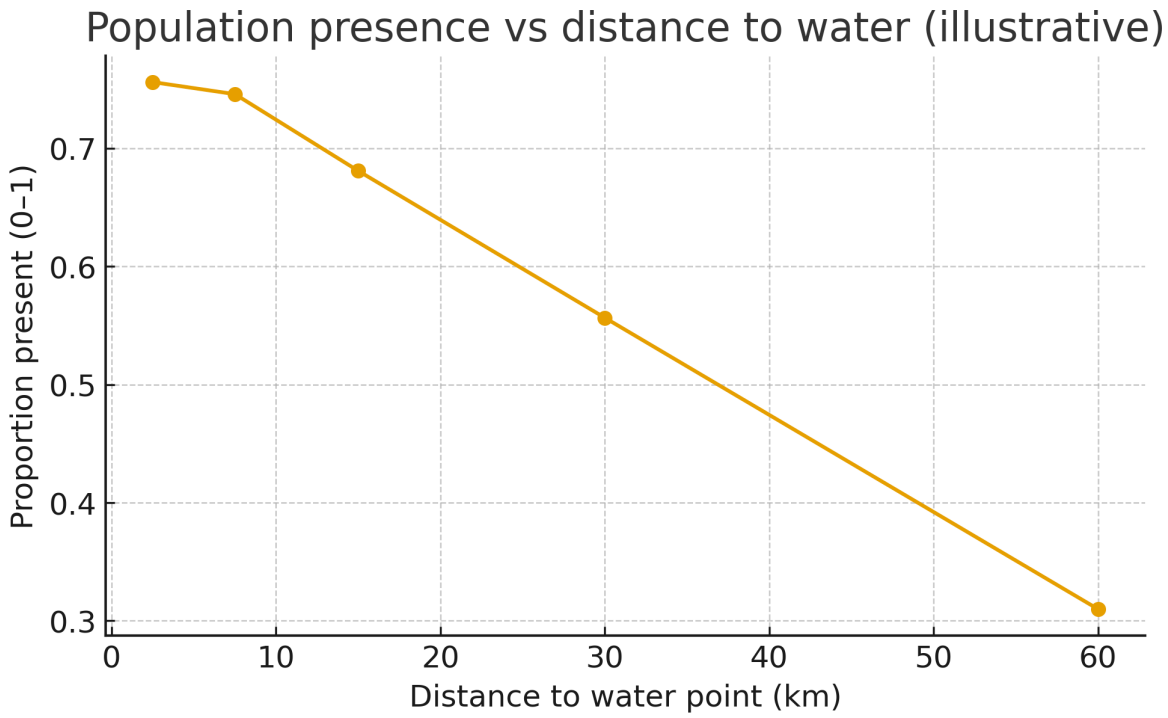
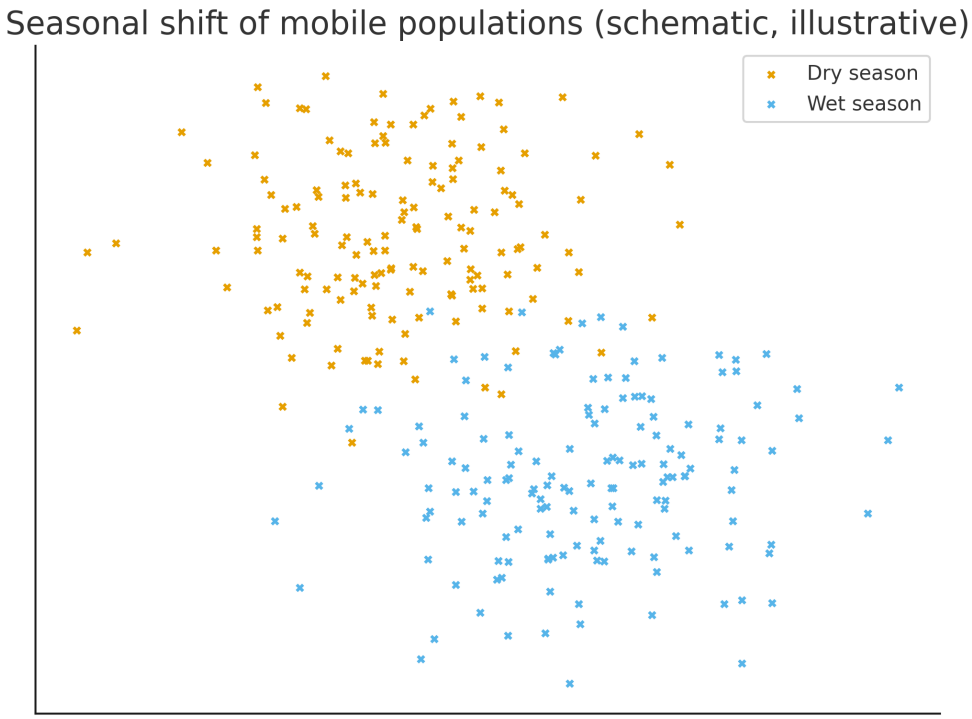


Figure.9¡.Seasonal.shift.schematic¿dry.to.wet.locations.(illustrative)



.....Table.8¡.Indicators.to.track.for.pastoralist.™ .mobile.populations

Indicator	Definition / how to compute
Seasonal presence index	Monthly proportion of population within zones (from surveys/admin proxies).
Distance to water points	Share of population within 5/10/20/40 km; seasonal comparison.
NDVI–presence relationship	Correlation between vegetation greenness and presence index.
Facility access (seasonal)	% population within 60/120 minutes of clinics/schools in dry vs wet seasons.
Market & corridor proximity	Presence vs distance to key markets/roads (seasonally).

.....Table.9¡.Data.sources.™ .ethics–protection.notes

Component	Notes
Population baselines	ESS projections; WorldPop small-area baselines for denominators.
Mobility & displacement	IOM DTM rounds; admin records; UNHCR site data (for refugees).
Environment & water	NDVI (MODIS/VIIRS); mapped water points; rainfall (CHIRPS).
Accessibility	Friction surfaces; OSM roads; facility masterlists (MoH/EMIS).
Ethics & protection	Do-no-harm: no individual tracking; aggregation; consent; avoid sensitive site disclosure.

Sidebar: Do-no-harm principles for mobility data

• Publish only aggregated indicators; avoid pinpointing sensitive sites.

• Obtain consent/clearance for primary data; minimize collection of personally identifiable information.

• Coordinate with protection clusters and local authorities before releasing analyses in conflict-sensitive areas.

References — Section 2.6 (Pastoralist & Mobile Populations)

- IOM Displacement Tracking Matrix (DTM) — Ethiopia rounds and methodology notes.

- UNHCR — refugee/returnee statistics and site datasets for Ethiopia.

- MODIS/VIIRS NDVI — vegetation greenness time series for seasonal analysis.

- CHIRPS — rainfall time series for drought/wet season context.

- WorldPop / GHS-POP — gridded population baselines for denominators.

- OpenStreetMap & national datasets — water points and roads (where available).

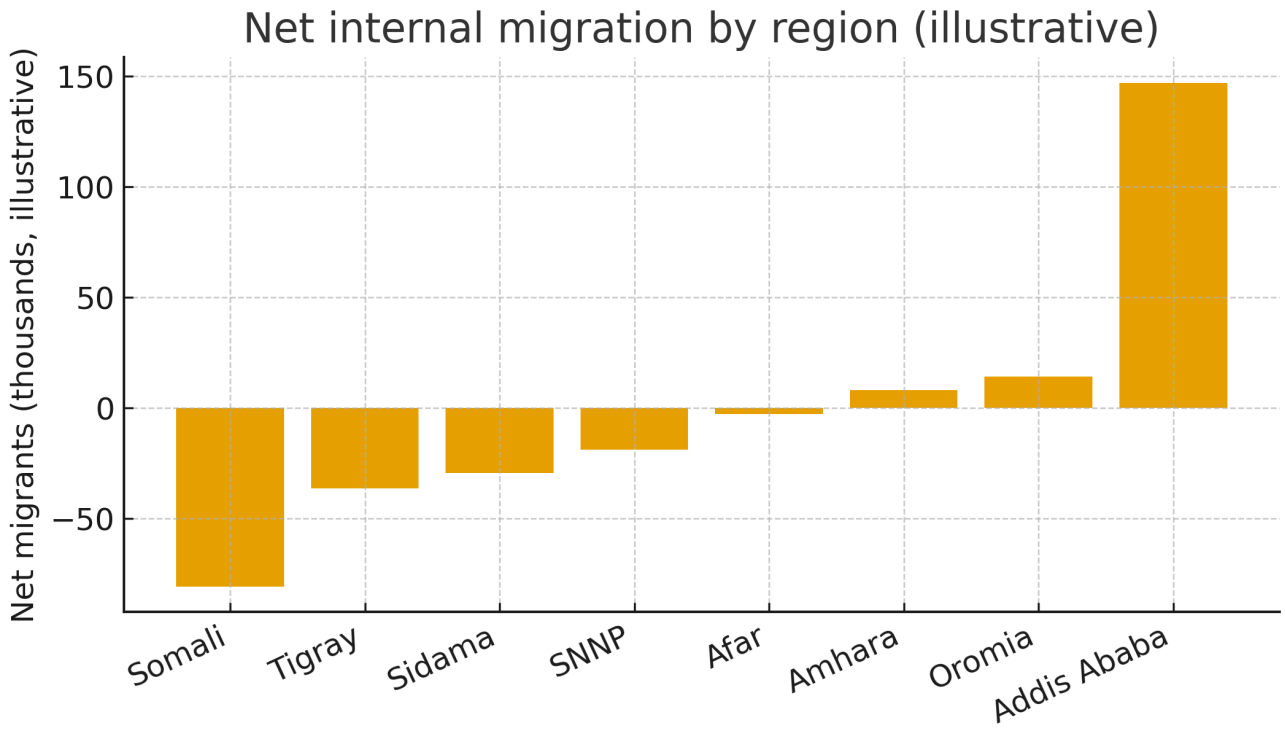
2.7) Internal Migration & Redistribution

Why this matters. Internal migration reshapes Ethiopia's regional and urban distribution—affecting labor markets, service demand, and infrastructure planning.

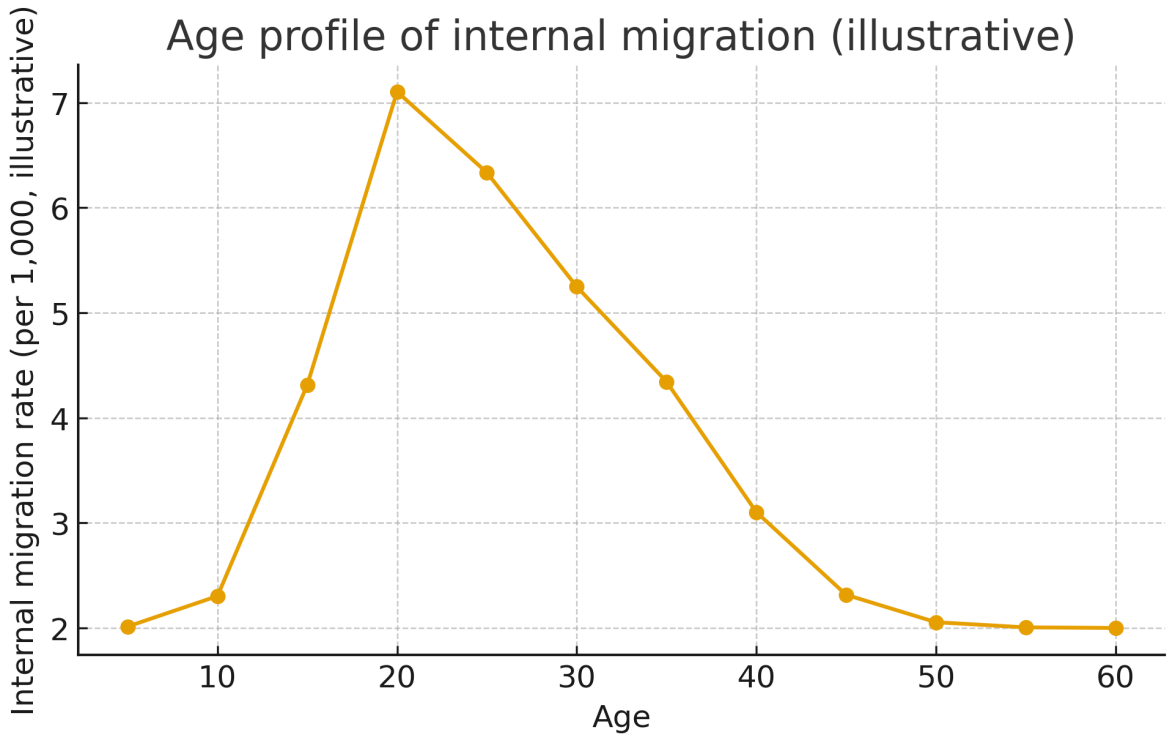
Table.7¡.Migration.concepts.™.measures.(plain.definitions)

Concept/metric	Plain definition
Lifetime migrant	Place of current usual residence differs from place of birth.
Recent migrant	Changed usual residence within the last 1/5 years (as defined by census/survey).
In-/Out-migration	Movements into/out of a region (or urban class) over a period.
Net migration	In-migration minus out-migration.
Migration rate	Number of migrants per 1,000 population over a period (age-specific or total).
Urban reclassification	'Growth' may reflect boundary/status changes, not physical movement—track separately.

Figure¡.Net.migration.by.region.(illustrative)



Figure¡.Age.profile.of.internal.migration.(illustrative)



.....Table.8¡.Ethiopia-focused.indicators.to.develop

Indicator	How to present
Regional net migration	Bar chart and map (inflows, outflows, net, by period).
City-ward flows	OD matrix for Addis/secondary cities vs surrounding regions/zones.
Education & labor links	Migration by education/occupation (surveys); student flows.
Urban–rural reclassification control	Separate effects of reclassification vs true migration.
Displacement interaction	Overlay DTM/UNHCR to separate forced vs voluntary movement.

.....Table.9¡.Data.sources.™.caveats

Component	Notes
Census/survey questions	Place of birth; previous residence; duration since move; reasons.
ESS, DHS, LFS, HICES/WMS	Regional/urban migration tabs; caution on sample for rarer flows.
Admin & education data	Student registries; civil service; social program registries (careful use).
Bias & comparability	Boundary changes; de facto vs de jure; reclassification; recall bias in duration.
Ethics	Use aggregates; avoid identifying small communities; careful with reasons when sensitive.

Sidebar: Distinguish migration from reclassification

• Track boundary/urban status changes separately from flows.
• Use both administrative and functional urban delineations.
• Reconcile census lifetime migration with recent migration and survey-based mobility.

References — Section 2.7 (Internal Migration & Redistribution)

- Ethiopian Statistics Service (ESS/CSA) — census migration tabs (place of birth, previous residence, duration).

- DHS / LFS / HICES-WMS — migration, education, occupation cross-tabs.

- UN DESA — internal migration methodologies and guidance (concepts/definitions).

- WorldPop / GHS-POP — gridded baselines for small-area denominators.

- Administrative sources (education registries, social programs) — careful interpretation and privacy considerations.

2.8) Displacement & Returns (IDPs, Refugees, Returnees)

Why this matters. Shocks and conflict can rapidly reconfigure Ethiopia's population distribution. Planning and protection require tracking the stock of displaced persons and the flows of new displacements and returns—while safeguarding sensitive information.

Table.7¡.Key.terms.(plain.definitions)

Term	Plain definition
Internally Displaced Persons (IDPs)	People forced to flee homes but remaining within Ethiopia's borders.
Refugees/Asylum-seekers	People seeking protection across international borders under international law.
Returnees (internal/external)	Formerly displaced persons who have returned to area of origin or resettled elsewhere.
New displacements	People newly forced to move in a period.
Returns	People who go back to previous place of residence (or resettle) during a period.
Stock vs flow	Total number displaced at a point vs movements into/out of displacement over time.

Figure.7¡.Displacement.dynamics¿IDP.stock?new.displacements?and.returns.(illustrative)

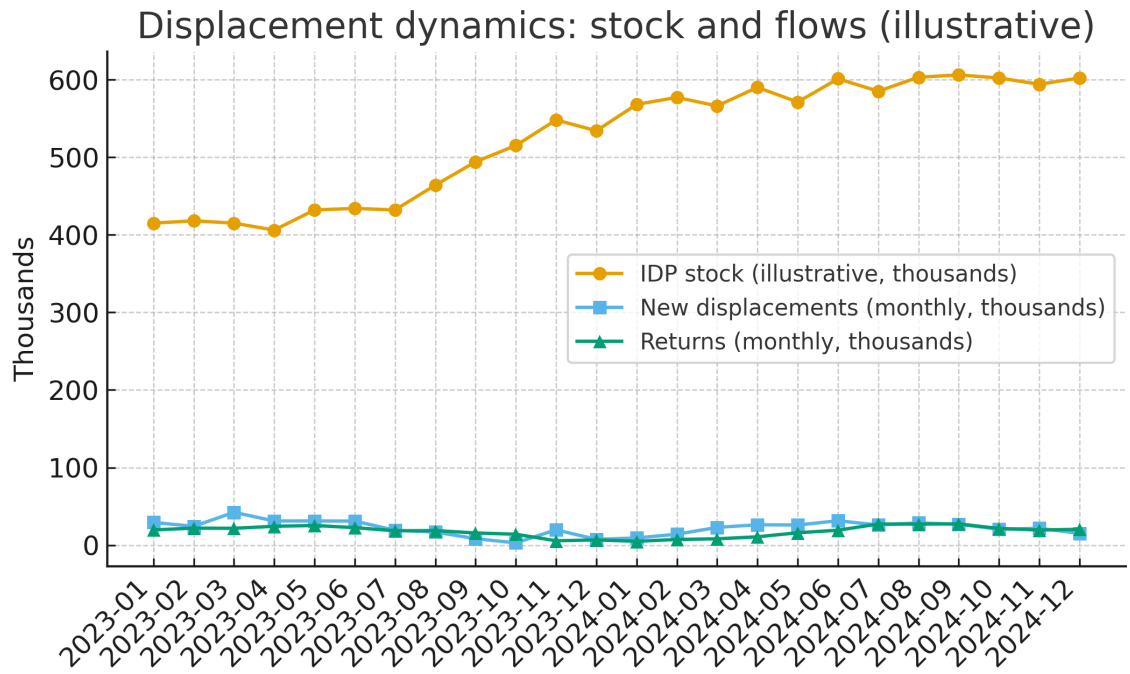


Figure.¡.Return–relocation.trajectories.by.region.(index?illustrative)

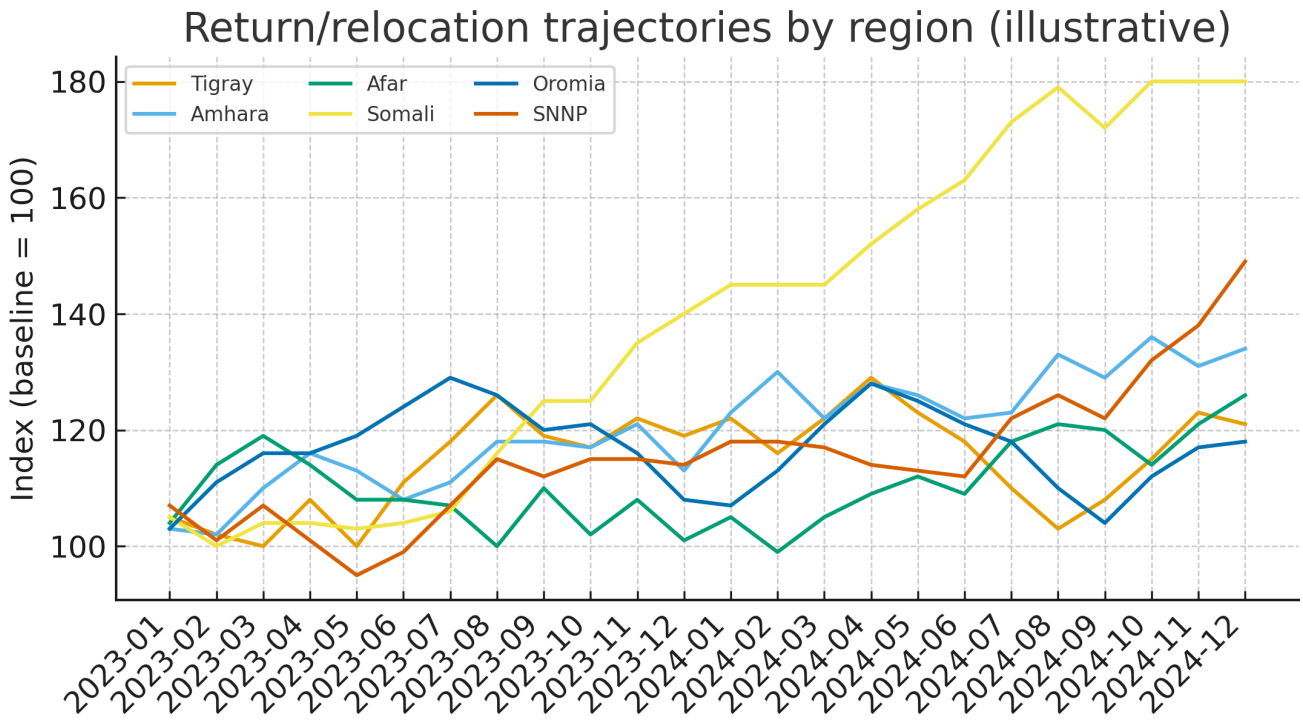


Table.8¡.Ethiopia-focused.indicators.to.develop.for.Section.8¡❹

Indicator	How to present
Hosting pressure	IDPs per 1,000 residents by woreda/zone; capacity & services overlay.
Stock–flow reconciliation	IDP stock consistency with new displacements, returns, relocations.
Site vs out-of-site	Share in collective sites vs host communities; service access gaps.
Duration & protractedness	Proportion displaced > 12/24 months.
Protection-sensitive mapping	Masking/blurring of sensitive locations; aggregation level disclosures.

Table.9¡.Data.sources.™ .protection.notes

Source/component	Notes
IOM DTM	Rounds for IDP/returnee stocks, sites, and critical needs; methodology notes.
UNHCR	Refugee/returnee statistics and operational data portals (camps/settlements).
ESS/admin sources	Population denominators; service capacity indicators (health/education).
Humanitarian clusters	Shelter/NFI, WASH, Health, Protection—facility & service datasets.
Ethics	Aggregate reporting; consent; do-no-harm; coordinate with protection clusters/local authorities.

Sidebar: Protection-first publication checklist

• Aggregate and mask: publish woreda-level (or higher) where sensitivity is high; never share identifiable coordinates.
• Consent & coordination: obtain appropriate approvals; align with protection clusters and local authorities.
• Timing & context: accompany figures with context notes (security, access constraints, seasonality).

References — Section 2.8 (Displacement & Returns)

- IOM Displacement Tracking Matrix (DTM) — Ethiopia rounds and methodology notes.

- UNHCR Operational Data Portal — refugee statistics for Ethiopia (camps/settlements).

- Ethiopian Statistics Service (ESS) — population denominators and admin boundaries.

- OCHA Humanitarian Data Exchange (HDX) — curated datasets (use with protection safeguards).

- WorldPop / GHS-POP — gridded population baselines for denominators.

- CHIRPS rainfall, MODIS/VIIRS NDVI — environmental context for shocks and returns.

2.9) Accessibility, Catchments & Service Areas

Why this matters. In Ethiopia's varied terrain, distance is not the same as time. Mapping travel-time catchments for health, schools, and markets reveals who is practically served and where new investments yield the greatest equity gains.

Table.7¡.Key.terms.(plain.definitions)

Term	Plain definition
Accessibility	Effort/time to reach services or markets (walk/road/terrain effects).
Isochrone	Area reachable from a point within a time threshold (e.g., 60 minutes).
Catchment	Population practically served by a facility given travel times and barriers.
Friction surface	Raster of per-cell travel 'cost' (e.g., min per meter) used to compute isochrones.
Location-allocation	Method to site facilities optimally to maximize coverage or minimize travel times.

Figure.7¡.Cumulative.population.coverage.by.travel.time.(illustrative)

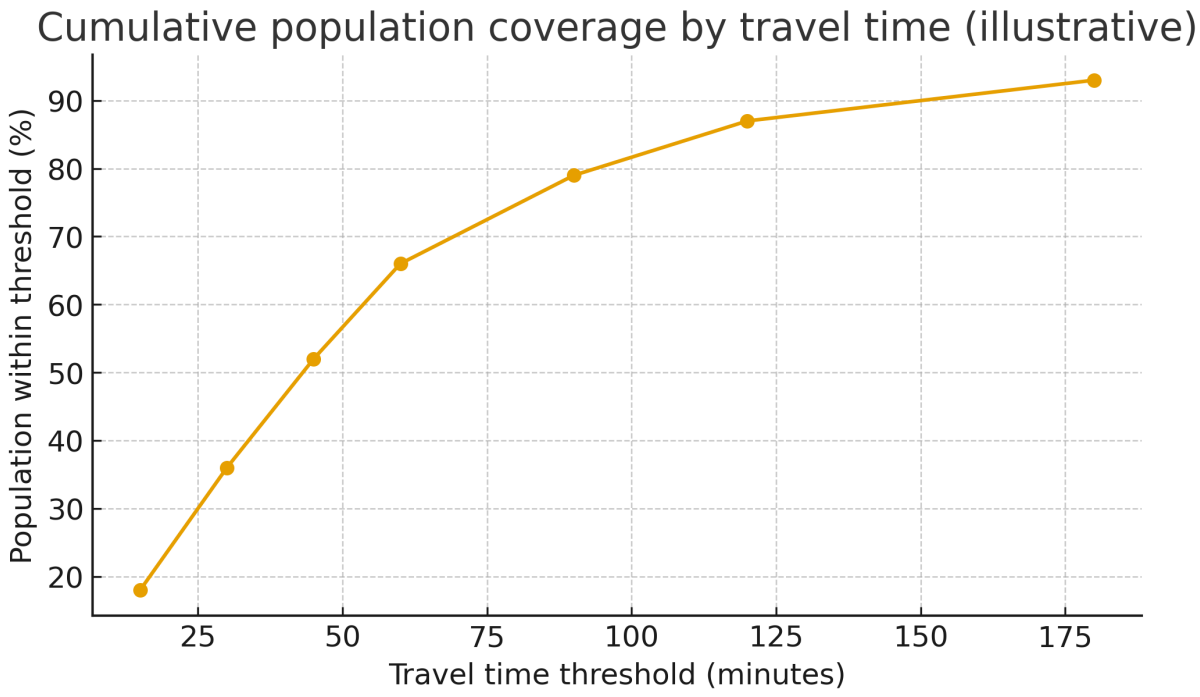
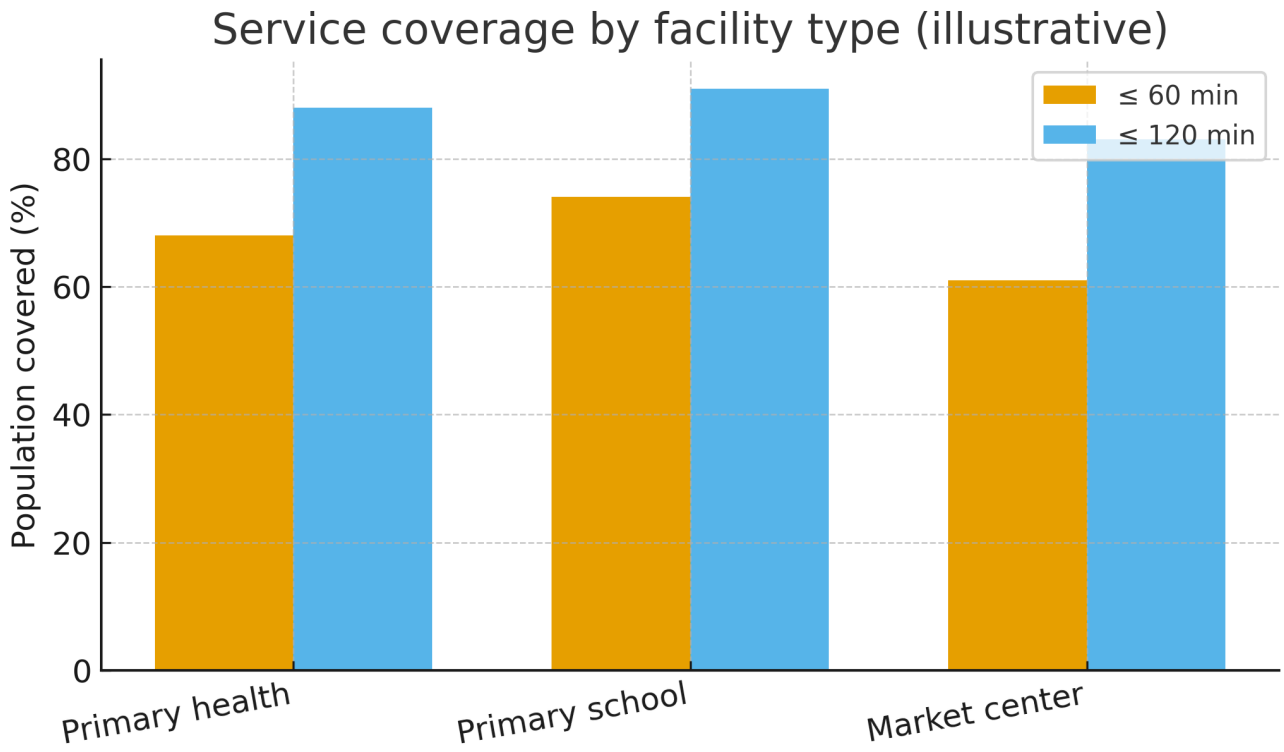


Figure.8¡.Service.coverage.by.facility.(∞❷6.and.∞786.minutes?illustrative)



.Figure.9¡.Accessibility.gradient.of.settlement.density.(illustrative)

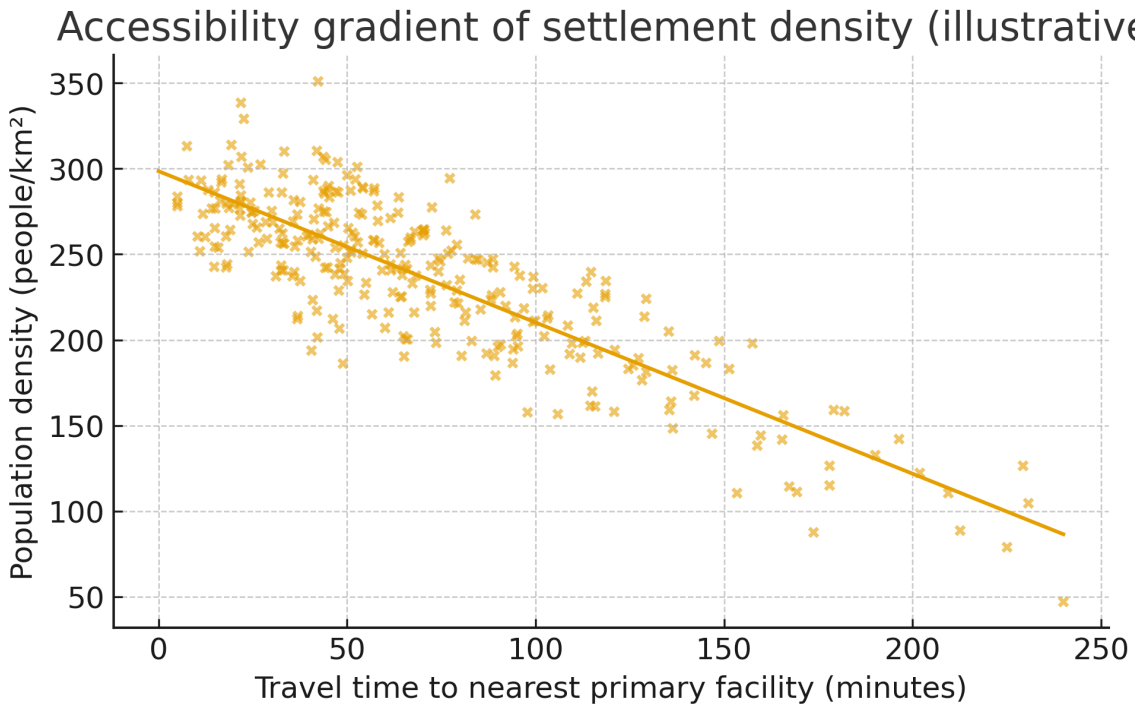


Table.8¡.Ethiopia-focused.indicators.to.develop.for.Section.8¡❺

Indicator	How to present
Coverage within 30/60/120 minutes	Share of population reachable by facility type.
Marginal coverage gain	Increase in coverage when moving from 60 to 120 minutes.
Equity gaps	Coverage by region/urban class/wealth quintile (surveys + modeled travel times).
Catchment load	Population per facility within each threshold; identify overloaded sites.
Scenario siting	Added coverage from k new facilities (location-allocation scenarios).

Table.9¡.Data.sources.™.cautions

Component	Notes
Roads & paths	OpenStreetMap (OSM) + national road authority datasets (quality varies by region).
Friction surfaces	Global travel time surfaces (e.g., Weiss et al.); adjust for local speeds/barriers.
Facilities masterlists	MoH health posts/centers/hospitals; EMIS schools; markets (trade/municipal).
Population baselines	ESS projections; WorldPop/GHS-POP for small-area denominators.
Cautions	Seasonality, security/access constraints, and boundary/vintage alignment.

Table.0¡.Example.regional.coverage.for.primary.health.(illustrative.↘)

Region	≤60 min to primary health (%)	≤120 min to primary health (%)
Addis Ababa	98	100
Oromia	72	89
Amhara	69	86
Tigray	63	82
SNNP	70	87
Somali	42	65
Afar	38	61
Sidama	66	85

Sidebar: Practical workflow for Ethiopia

• Compile official facility masterlists and clean duplicates; verify coordinates.
• Use a friction surface adjusted for walking/vehicular speeds and terrain; validate with local travel times.
• Produce 30/60/120-minute isochrones; compute coverage and catchment load; publish vintages and methods.

References — Section 2.9 (Accessibility, Catchments & Service Areas)

- Weiss, D. J. et al. Global travel time to cities and friction surfaces (accessibility modelling).

- Ethiopian Ministry of Health (MoH) — facility masterlists and service availability.

- EMIS (Ministry of Education) — school masterlists and locations.

- OpenStreetMap (OSM) & national road datasets — road networks and paths.

- WorldPop / GHS-POP — denominators for coverage calculations.

2.11) Night-time Lights & Economic Density

Why this matters. Night-time lights (NTL) provide a consistent, frequently updated proxy for economic activity and electrification. Used carefully with population layers, NTL helps reveal Ethiopia's economic density, urban growth, and corridor dynamics.

Table.7¡.Key.terms.(NTL.concepts?plain.definitions)

Term	Plain definition
VIIRS/DMSP	Satellite sensors capturing night-time lights; VIIRS (since ~2012) supersedes DMSP.
Radiance/brightness	Measured light intensity at night; proxy for human/economic activity.
Saturation & blooming	Very bright cores saturate; light 'bleeds' to neighboring pixels.
Stray light/cloud artifacts	Contamination in certain months/areas; need quality masking.
NTL index	Composite indicator of national/regional night-time light intensity.

Figure.7¡.City.night_time.lights.vs.population.size.(illustrative)

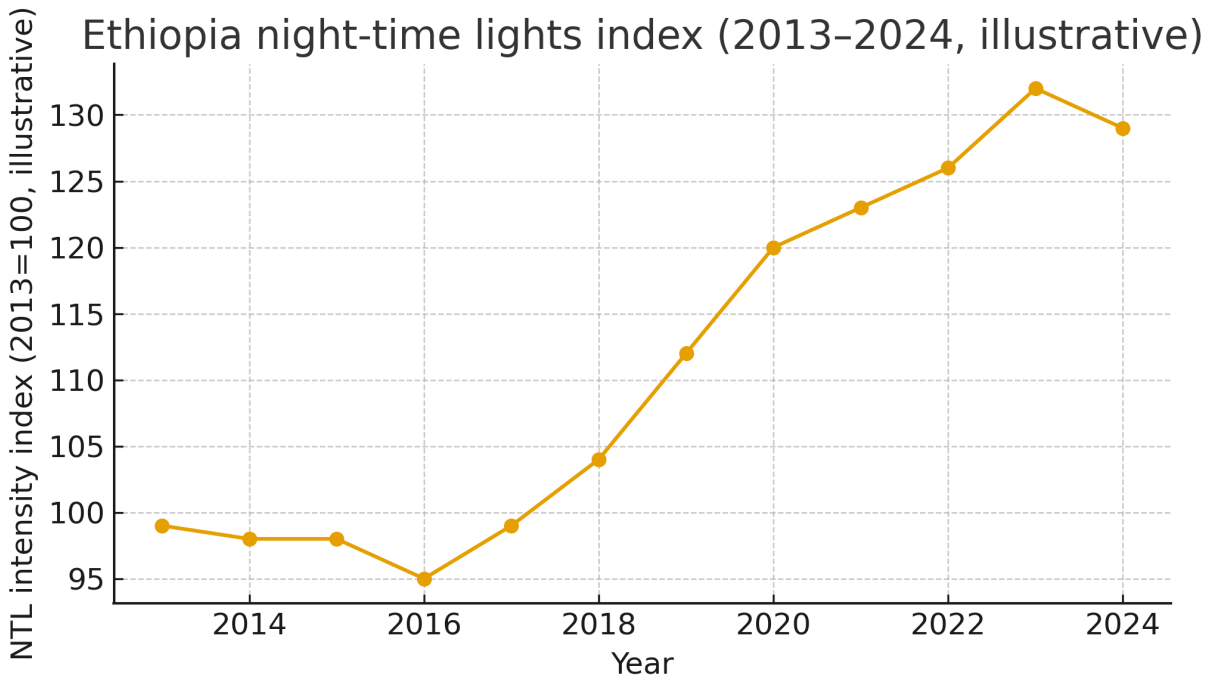


Table.8¡.Indicators.to.develop.for.Section.8¡77

Indicator	How to present / interpret
City NTL vs population	Scatter with labels; outliers may indicate industrial/energy bias.
Corridor intensity	Average radiance along major corridors (e.g., Addis–Djibouti).
Within-city inequality	NTL Gini across urban pixels as a proxy for spatial inequality.
NTL growth	Yearly change in NTL index by region/city cluster.
Lights-per-capita	Radiance divided by population as efficiency proxy (interpret cautiously).

Table.9¡.Data.sources.™.cautions

Source/component	Notes
VIIRS (NOAA/NGDC)	Monthly/annual composites; apply stray-light and cloud masks.
GHS-POP / WorldPop	Population denominators for lights-per-capita and density relationships.
GHSL/WSF footprints	Urban extent to normalize and bound NTL analysis.
Economic proxies	Firm registries, electricity use, mobile data (when available) for validation.
Cautions	Compare same months/years; sensor differences; rural electrification can change signals.

Sidebar: Practical choices for using NTL in Ethiopia

• Use annual VIIRS composites with quality masks; compare same months/years.

• Pair NTL with population/built-up footprints; report units/versions clearly.

• Treat NTL as a proxy—not a direct measure of GDP or income—and validate with ground data.

References — Section 2.11 (Night-time Lights & Economic Density)

- VIIRS Nighttime Lights (NOAA/NGDC) — annual/monthly composites and documentation.

- DMSP-OLS legacy lights — historical perspective (caveats on saturation and calibration).

- WorldPop / GHS-POP — denominators for per-capita and density analyses.

- GHSL / WSF — built-up footprints for city extents.

- Selected validation sources: electricity consumption and firm registries (where accessible).

2.12) Environment, Hazards & Exposure (Population at Risk)

Why this matters. Environment and hazard patterns shape where Ethiopians can safely live and work. Quantifying exposed populations—by flood, drought, and landslide—supports resilient planning and preparedness.

Table.7¡.Key.terms.(plain.definitions)

Term	Plain definition
Hazard	Potentially damaging physical event or process (e.g., flood, drought, landslide).
Exposure	People/assets located in places where hazards may occur.
Vulnerability	Propensity to suffer harm given exposure (sensitivity + capacity).
Risk	Expected loss = hazard × exposure × vulnerability (conceptually).
Return period	Average interval between events of a given severity (e.g., 1-in-100-year flood).

Figure.7¡.Share.of.population.exposed.by.hazard.and.region.(illustrative)

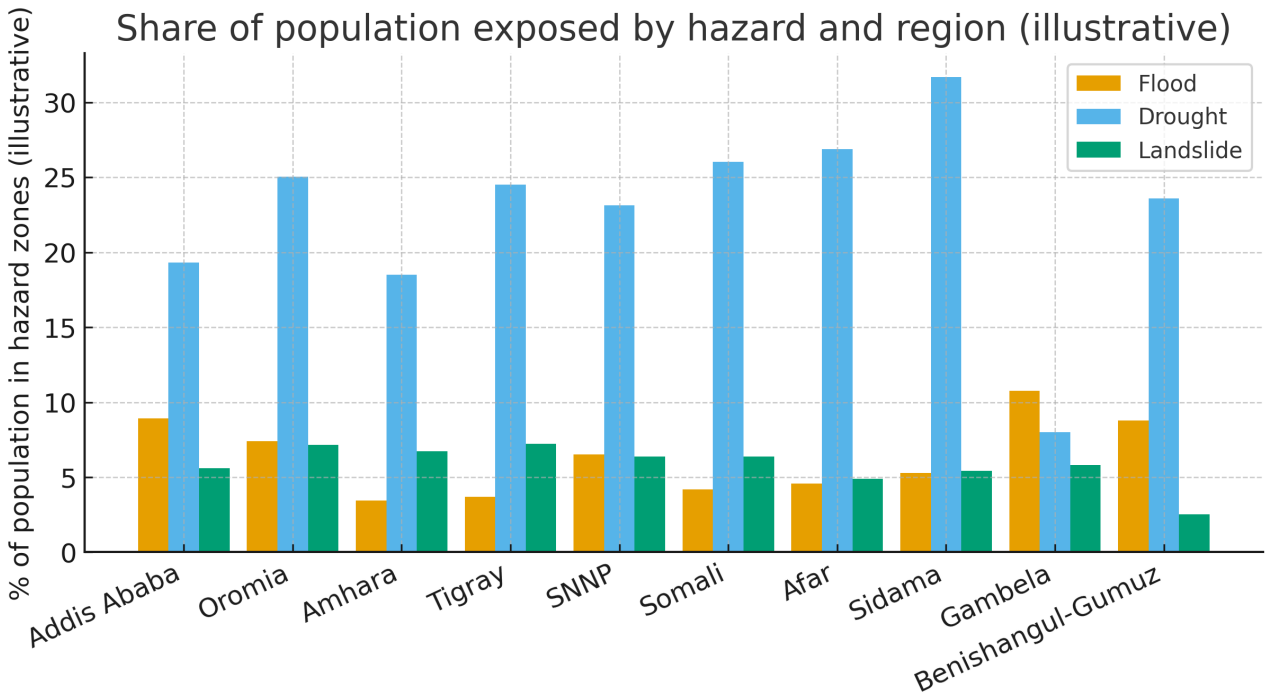


Figure.8¡.Multi_hazard.exposure.index.by.region.(illustrative)

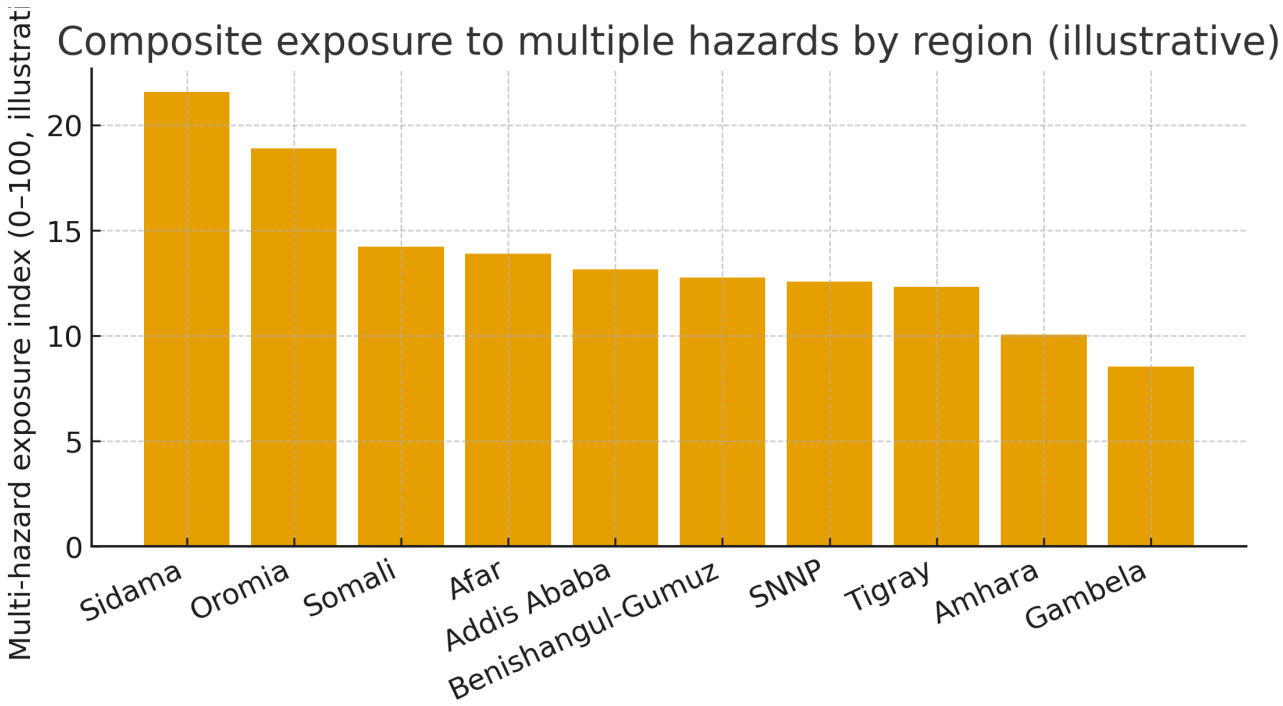


Figure.9¡.Flood.hazard.curves.at.example.sites.(illustrative)

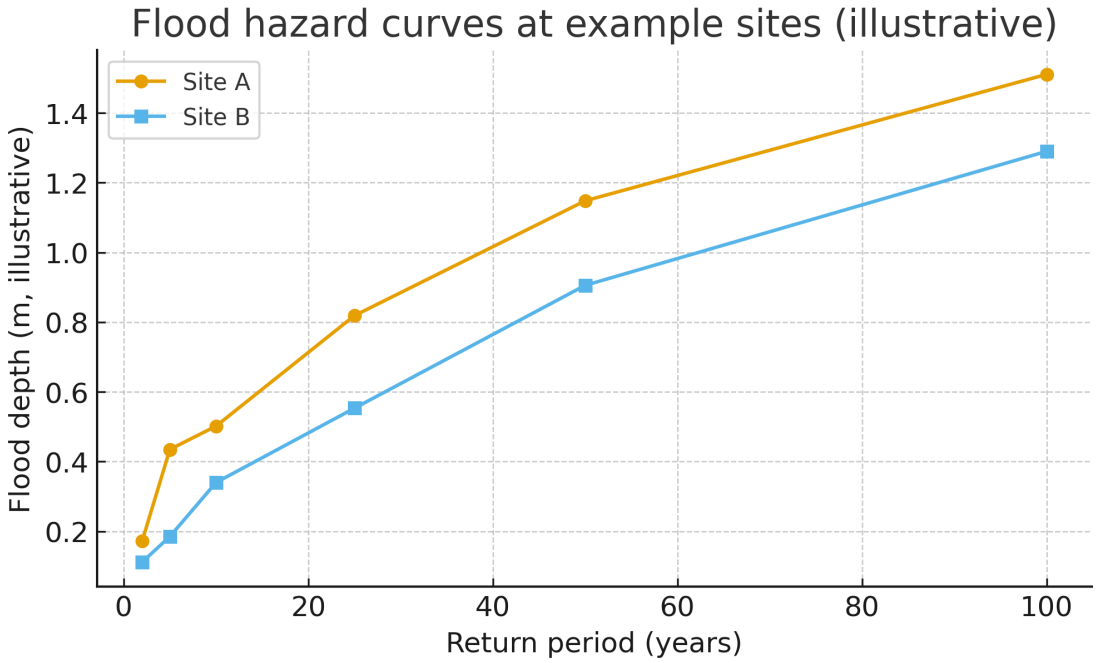


Table.8¡.Ethiopia-focused.indicators.to.develop.for.Section.8¡78

Indicator	How to present
Population in flood zones	% population within modeled flood extents (e.g., 1-in-10/100-year).
Population in drought-prone woredas	% population in high drought frequency cells (e.g., SPEI/CHIRPS).
Population in landslide-prone slopes	% population above slope/soil/geology thresholds.
Multi-hazard index	Composite of normalized hazard exposures; map and rank by region/woreda.
Critical facilities at risk	# health posts/schools within hazard zones; service catchment impact.

Table.9¡.Data.sources.™.cautions

Component	Notes
Population baselines	ESS projections; WorldPop/GHS-POP for denominators.
Flood maps	Global flood hazard layers (e.g., Fathom/JRC), river buffers; national studies where available.
Drought	CHIRPS rainfall, SPEI; NDVI anomalies; national early warning systems.
Landslide	Slope from SRTM/DEM; soil/geology; rainfall triggers; susceptibility maps.
Facilities	MoH/EMIS masterlists for critical assets (verify coordinates).
Cautions	Versioning and vintage alignment; model uncertainty; do-no-harm in conflict-sensitive areas.

Table.0¡.Regional.summary.(illustrative)

Region	Flood exposure (%)	Drought exposure (%)	Landslide exposure (%)	Multi-hazard index (0–100)
Addis Ababa	8.9	19.3	5.6	13
Oromia	7.4	25.0	7.1	19
Amhara	3.5	18.5	6.7	10
Tigray	3.7	24.5	7.2	12
SNNP	6.5	23.1	6.4	13
Somali	4.2	26.0	6.4	14
Afar	4.6	26.9	4.9	14
Sidama	5.3	31.7	5.4	22
Gambela	10.8	8.0	5.8	9
Benishangul-Gumuz	8.8	23.6	2.5	13

Sidebar: Practical workflow for hazard–exposure mapping in Ethiopia

• Align hazard layers and population denominators to the same year and boundary vintage.
• Report return periods and versions (e.g., 1-in-100-year flood, model vintage).
• Publish uncertainty notes and protection safeguards; avoid disclosing sensitive locations.

References — Section 2.12 (Environment, Hazards & Exposure)

- Global flood hazard datasets (e.g., Fathom/JRC) — modelled extents and depths (check versions).

- CHIRPS precipitation & SPEI drought indices — long-run rainfall anomalies for Ethiopia.

- MODIS/VIIRS NDVI — environmental greenness and drought context.

- SRTM/DEM-derived slope — landslide susceptibility inputs; national geology maps where available.

- WorldPop / GHS-POP — denominators for exposure metrics; ESS administrative boundaries.

- MoH/EMIS facility masterlists — critical infrastructure exposure (health, education).

2.14) Cross-Border Linkages & Regional Context

Why this matters. Ethiopia's population distribution is shaped by regional linkages—ports, corridors, refugee flows, and border towns. Understanding proximity to borders and corridor intensity helps interpret growth poles and service needs in frontier regions.

Table.7¡.Key.terms.(plain.definitions)

Term	Plain definition
Formal vs informal crossings	Official border posts with controls vs community tracks and seasonal routes.
Transit migration	Movement through Ethiopia to third countries; distinct from immigration.
Economic catchments	Border towns serve populations from both sides for trade/services.
Corridor	Transport axis linking domestic and international nodes (road/rail/port).
Cross-border displacement	Refugee/returnee flows interacting with domestic mobility and services.

Figure.¡.Schematic.cross_border.linkages.and.key.crossings.(illustrative)

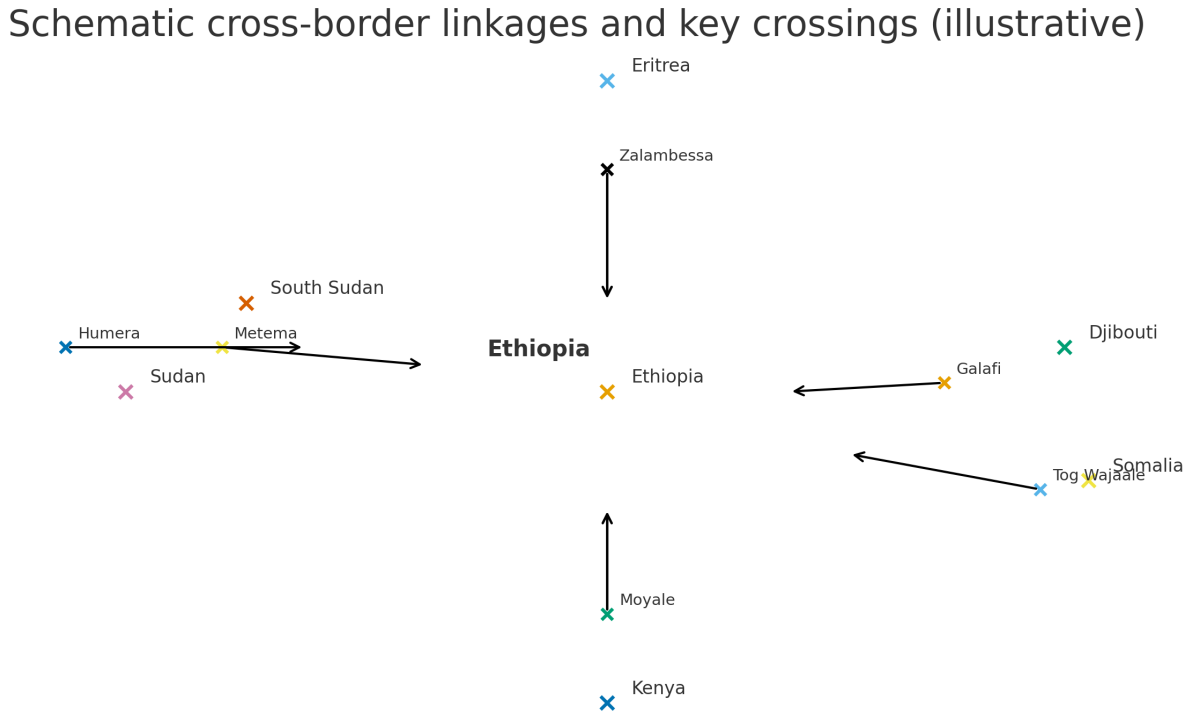


Figure.8¡.Major.corridors¿trade–mobility.intensity.(illustrative)

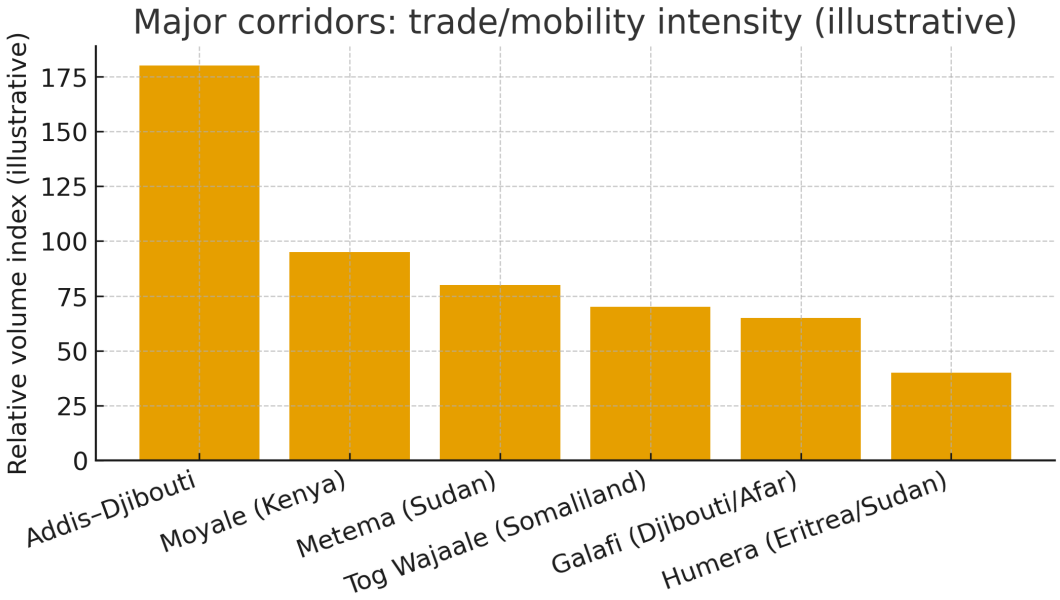


Figure.9¡.Cumulative.population.near.international.borders.(illustrative)

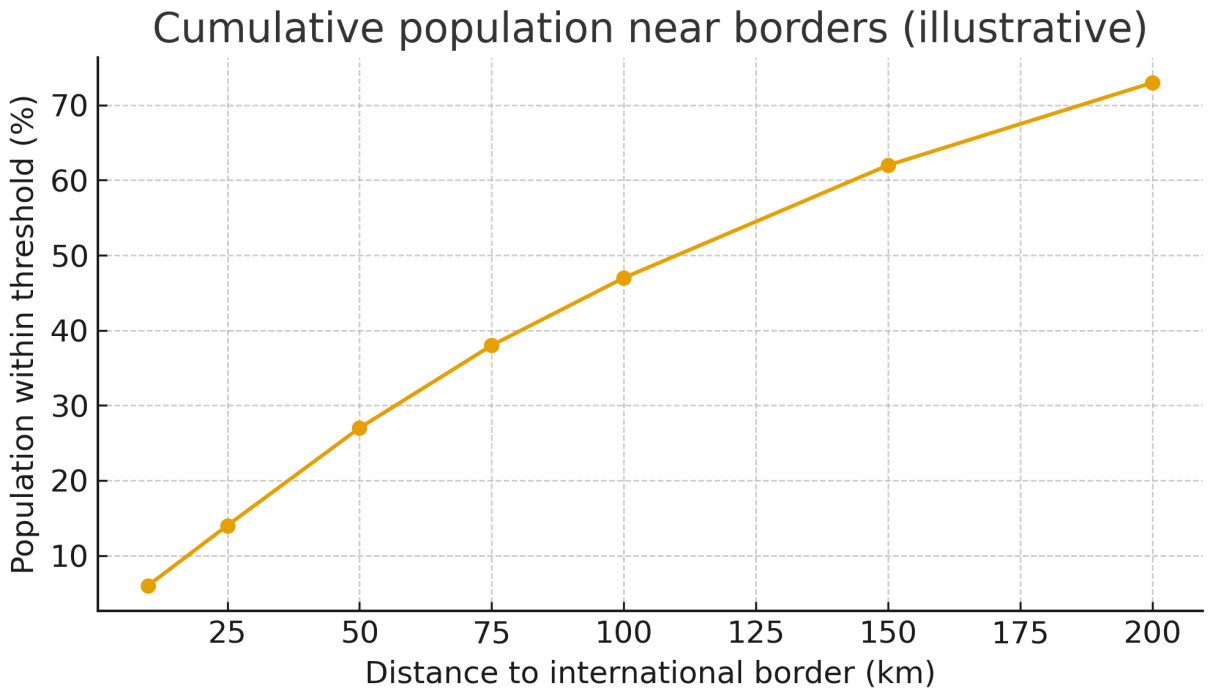


Figure.0¡.Refugee.populations.by.country.of.origin?867❹8680.(illustrative)

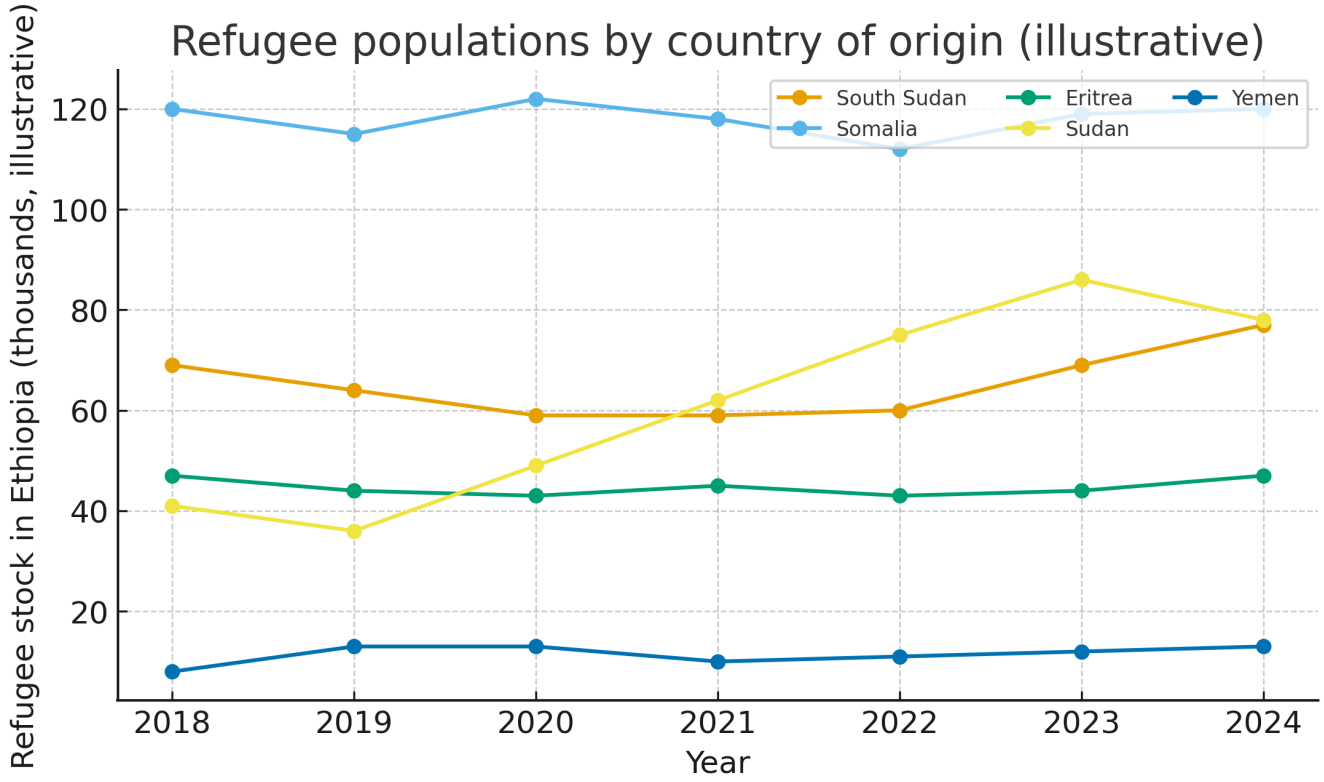


Table.8¡.Indicators.to.develop.for.Section.8¡70

Indicator	How to present / use
Border proximity	% population within 10/25/50/100 km of borders by region/woreda.
Corridor intensity	Composite index of traffic, night-lights, and facility density along corridors.
Border-town primacy	Share of regional urban population in top border towns.
Refugee/host ratios	Refugees per 1,000 host residents by woreda; service coverage overlay.
Trade/service catchments	Population within 60/120 minutes of each major crossing.

Table.9¡.Data.sources.™.cautions

Source/component	Notes
Customs/trade statistics	Port and border post flows; confidentiality and coverage issues.
IOM Flow Monitoring Points (FMP)	Directional movement counts and profiles at key crossings.
UNHCR	Refugee site data and operational statistics for Ethiopia.
Night-time lights & OSM	Corridor intensity proxies; road quality and connectivity.
ESS/admin datasets	Population denominators; facility masterlists for service catchments.
Cautions	Security sensitivity; avoid exposing informal routes; align boundary/vintage.

Table.0¡.Illustrative.border.region.summary

Region	International neighbor(s)	Key crossing(s)	Notes (illustrative)
Afar	Eritrea/Djibouti	Galafi	Corridor to Djibouti port; arid lowlands
Somali	Somaliland/Somalia	Tog Wajaale	Trade and pastoral mobility; corridor links
Oromia (Borena)	Kenya	Moyale	Gateway to Nairobi; livestock and market flows
Amhara	Sudan	Metema	Trade and seasonal labor; recent shocks affect flows
Tigray	Eritrea	Zalambessa (periodic)	Border dynamics and sensitivity
Benishangul-Gumuz	Sudan/South Sudan	Kurmut/others	Riverine access; lower volumes

Sidebar: Practical workflow for border-focused analysis

• Map 60/120-minute catchments to major crossings; compute host–refugee ratios and service capacity.

• Use night-lights and OD traffic counts as corridor intensity proxies; cite vintages and versions.

• Coordinate with authorities to avoid publishing sensitive informal routes; aggregate results.

References — Section 2.14 (Cross-Border Linkages & Regional Context)

- IOM Flow Monitoring Points (FMP) — movement data at major border crossings in the Horn of Africa.

- UNHCR Operational Data — refugee and returnee statistics for Ethiopia and neighbors.

- National customs/transport authorities — corridor volumes (where accessible).

- NOAA VIIRS night-lights — corridor intensity proxy; pair with OSM roads/rail.

- ESS administrative data — denominators; facility masterlists for border regions.

2.15) Policy Implications & Planning Use-Cases

What this section does. Translates Chapter 2 evidence into action for Ethiopia—showing how accessibility, settlement patterns, hazards, and mobility inform concrete investments and sequencing.

Table.7¡.Planning.use_cases.and.targeting.logic.(Ethiopia_focused)

Use-case	Decision logic / targeting rule
Primary health expansion	Target kebeles >60 min to nearest health post; site upgrades for highest coverage gain.
School access (upper primary)	Identify 60/120-min gaps and prioritize school construction or transport.
Rural connectivity	Feeder roads to high-density, low-access cells; costed by terrain and flood risk.
Urban service catch-up	Infill WASH/electricity in fast-growing urban peripheries.
Lowland resilience	Pastoral water points and mobile services aligned with seasonal routes.
Border development	Service hubs in high-flow crossings; host–refugee ratio planning.

Figure.7¡.Prioritizing.policy.options.by.impact.vs.cost.(illustrative)

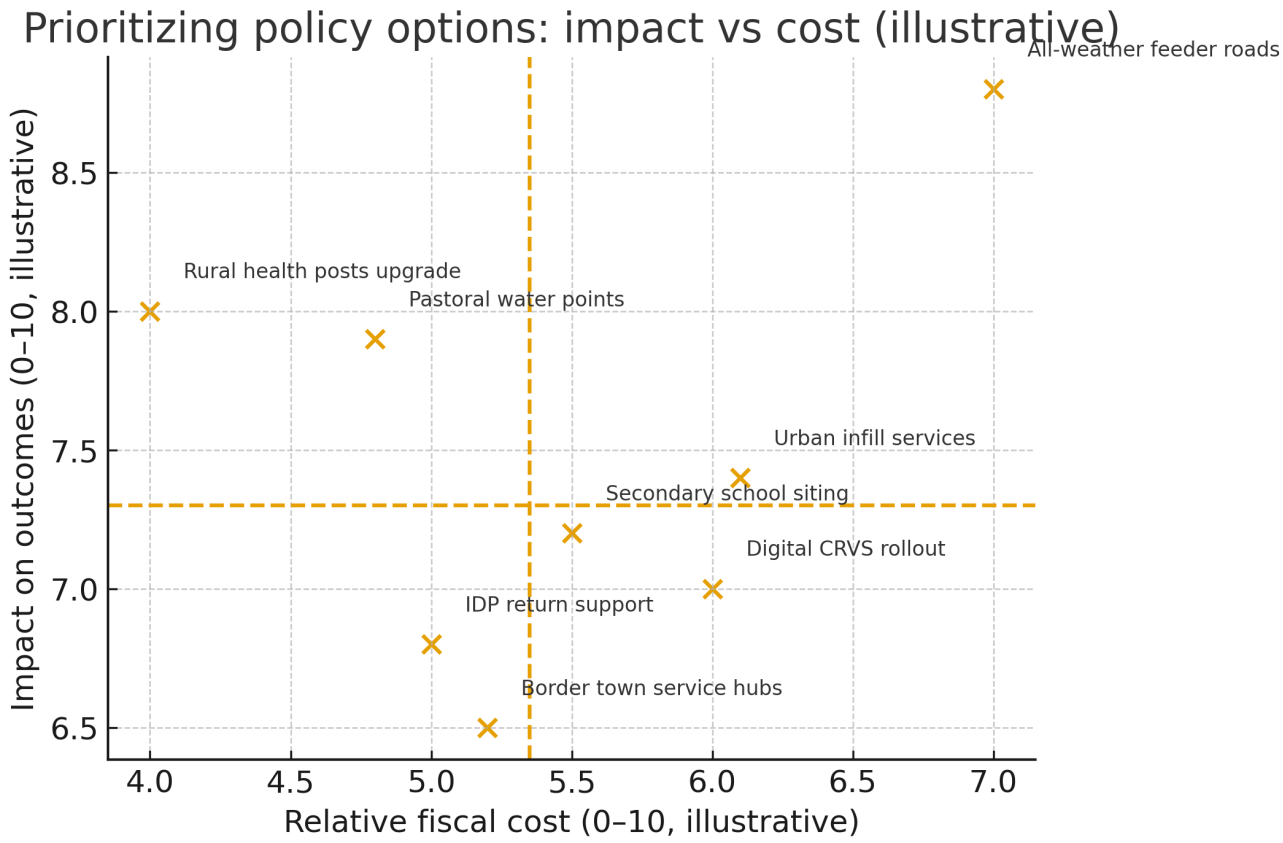


Figure.¡.Sequenced.roadmap.of.workstreams.to.8696.(illustrative)

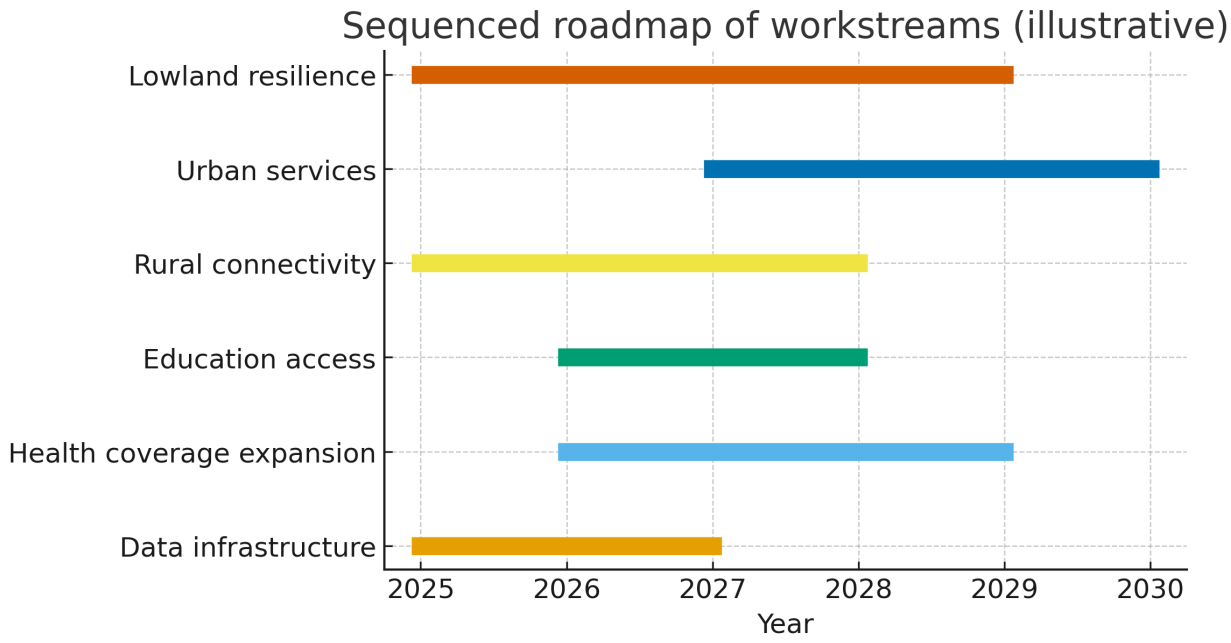


Figure.¡.Equity-efficiency.trade_offs.for.policy.options.(illustrative)

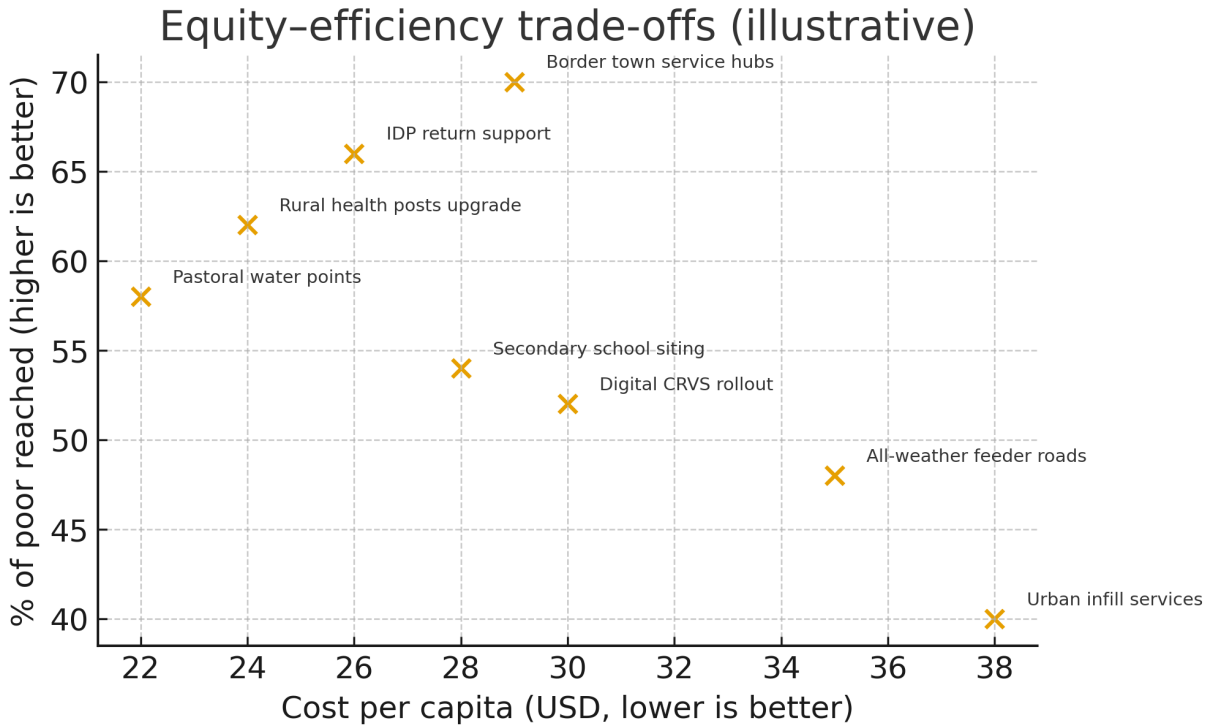


Table.8¡.Policy.levers.and.implementing.agencies.(examples)

Lever	Lead/partners
Health posts/centers upgrade	MoH & regional bureaus; leverage community health workers.
School construction & buses	Ministry of Education + regional offices; partnerships for transport.
Feeder roads & bridges	Roads Authority + local governments; climate-resilient standards.
Urban basic services (WASH/power)	Municipal utilities; PPPs for distribution & metering.
Water points & corridors (lowlands)	MoWE, pastoral commissions; joint ops with humanitarian actors.
CRVS & admin data	Vital Events Agency; integrate with health & ID systems.

Table.9¡.Data.products.to.support.planning

Product	Contents & notes
Travel-time coverage maps	30/60/120-min catchments by facility type with denominators.
Settlement & built-up layers	GHSL/WSF footprints + WorldPop/GHS-POP population grids (aligned years).
Equity tabs	Coverage by region, wealth, gender, disability (survey-aligned).
Hazard overlays	1-in-10/100-year flood, drought frequency, landslide susceptibility.
Monitoring dashboards	Quarterly updates with versioned data & reproducible methods.

Table.0¡.Monitoring.KPIs.for.annual.tracking.(examples)

KPI	Definition
Health – access within 60 min	% population within 60 min to primary health; disaggregated.
Education – access within 60/120 min	% 7–14 within thresholds to upper primary.
Road connectivity	% population within 2 km of all-weather road; travel-time index change.
Urban services	% households with piped water/electricity in priority peripheries.
Lowland resilience	% of pastoral households within 20 km of functional water points (seasonal).

Table.❶¡.Candidate.case.studies.to.add

Candidate case study	Focus of analysis
Addis–Adama corridor	Urban infill and school access program; lights-per-capita and density trends.
Afar border belt	Galafi hub: health & market catchments; refugee/host service balancing.
Borena (Oromia) lowlands	Pastoral water points; mobile health/schools along routes.
Metema–Gondar axis	Trade, seasonal labor, and flood risk in settlement planning.

Sidebar: Practical sequencing rules of thumb

• Start with data plumbing: boundaries, facility masterlists, denominators; publish versions.
• Early wins: target high-impact/low-cost quadrants; pair with operations pilots for ground truth.
• Scale with safeguards: formalize update cycles, uncertainty notes, and protection-by-design.

References — Section 2.15 (Policy Implications & Planning Use-Cases)

- UN DESA & UNSD guidance — translating demographic evidence into policy and SDG monitoring.

- Ministries of Health/Education/Roads Ethiopia — sector plans and service standards (for alignment).

- WorldPop, GHSL, WSF — spatial population & built-up layers underpinning coverage targeting.

- Weiss et al. — travel-time accessibility methods for siting and catchments.

- Humanitarian cluster guidance — protection-aware analysis for displacement contexts.

Chapter 2 — Population Distribution

Landing-Page Summary (Ethiopia-Focused)

What this chapter covers. How people are distributed across Ethiopia's highlands and lowlands; cities, towns and rural settlements; how accessibility, hazards and cross-border linkages shape where people live; and how to turn these insights into policy.

Ethiopia-Centered Takeaways

- Highland concentration drives demand for urban services; lowland mobility requires flexible service models.
- Travel time—not distance—best predicts practical access; prioritize 60-minute coverage gains.
- Dataset choice (WorldPop vs GHS-POP vs HRSL) and boundary vintage can change small-area conclusions.
- Hazard overlays (flood/drought/landslide) and displacement dynamics are essential for safe planning.
- Cross-border corridors (e.g., Addis–Djibouti) shape settlement and market access near frontiers.

How to Use This Chapter

1. Start with 2.1 for definitions and metrics, then scan 2.2–2.4 for the basic pattern of people and places.
2. Use 2.5–2.9 to model who can reach what within 30/60/120 minutes and to size catchments.
3. Consult 2.10–2.12 for data and risk layers; document versions and vintages.
4. Apply 2.13 to test sensitivity; design field validation to reduce key uncertainties.

Glossary — Chapter 2 Terms

Alphabetical Glossary

Term	Plain definition
Accessibility	Effort/time to reach services or markets, accounting for terrain and transport modes.
Administrative boundary vintage	The year/edition of official boundaries; required for comparability across datasets.
Agglomeration	Spatial clustering of people and firms that yields scale economies and spillovers.
Ambient population	Average 24-hour population distribution (e.g., LandScan).
Built-up footprint (GHSL/WSF)	Satellite-inferred built structures; used to constrain population models.
Catchment (service area)	Population practically served by a facility given travel times and barriers.
Catchment load	Population per facility within a defined travel-time threshold.
CHIRPS	Gridded precipitation dataset for drought and rainfall anomaly analysis.
Corridor	Transport axis linking domestic and international nodes (road/rail/port).
CRVS	Civil Registration and Vital Statistics—records of births, deaths, and other vital events.
De facto / De jure	Present at enumeration vs usual residence concepts for population counts.
Degree of Urbanization (SMOD)	Global urban/rural classification framework (settlement model).
Density (population)	People per unit area; may be population- or grid-based.
Displacement (IDP/refugee/returnee)	Forced movement inside or across borders and subsequent returns.
DTM (IOM)	Displacement Tracking Matrix—assessments of IDP/returnee stocks and movements.
Equity gap	Difference in access or outcomes across groups (region, wealth, gender, disability).
Exposure	People/assets located where hazards may occur.
Friction surface	Raster of per-cell travel ‘cost’ (minutes per meter) used to compute travel time.
Functional urban area	Urban core plus commuting zone; reflects labor-market integration.

GHSL	Global Human Settlement Layer—built-up, population and urban classification products.
GHS-POP	Gridded population product from the European Commission's GHSL.
Gini (spatial/NTL)	Inequality measure; here, distribution across space or pixels.
Gridded population	Population estimates on a regular grid (e.g., 30 m–1 km cells).
Hazard	Potentially damaging physical event or process (flood, drought, landslide).
Hosting pressure	IDPs/refugees per 1,000 residents in a host community.
HRSL	High Resolution Settlement Layer—building-constrained population estimates.
IDP	Internally Displaced Person—forced to flee home but remaining within Ethiopia.
Isochrone	Area reachable within a travel-time threshold from a location (e.g., ≤60 minutes).
LandScan	Ambient (day–night) population distribution at ~1 km resolution.
Location-allocation	Optimization method to site facilities to maximize coverage/minimize travel time.
Lorenz curve	Graphical representation of concentration/inequality; paired with the Gini index.
Migration (internal)	Change of usual residence within national borders.
NDVI	Normalized Difference Vegetation Index—satellite greenness proxy, useful for mobility/hazards.
Net migration	In-migration minus out-migration for a region or zone.
Night-time lights (NTL)	Satellite-observed radiance used as a proxy for economic activity.
OD matrix (origin–destination)	Table of flows between origins and destinations (e.g., regional migration).
Pastoral mobility	Seasonal movement of livestock-keeping households to track pasture and water.
Population reclassification	Urban/rural status or boundary change that affects counts without physical moves.
Primacy (urban)	Dominance of the largest city relative to the urban system.
Reclassification (urban)	Change in administrative status or boundary that creates apparent growth.

Return period	Average interval between events of a given severity (e.g., 1-in-100-year flood).
Risk	Expected loss that reflects hazard × exposure × vulnerability.
Service coverage	Share of population within a travel-time threshold to a service.
SMOD	Settlement Model from GHSL used for Degree of Urbanization.
SPEI	Standardized Precipitation–Evapotranspiration Index, used for drought analysis.
Travel-time surface	Map of modeled time to traverse terrain/roads; basis for accessibility metrics.
VIIRS / DMSP-OLS	Night-lights sensors: VIIRS (current), DMSP (legacy).
Vulnerability	Propensity to suffer harm given exposure; includes sensitivity and adaptive capacity.
WorldPop	Set of gridded population products (top-down and bottom-up variants).
WSF (World Settlement Footprint)	DLR's global built-up product.