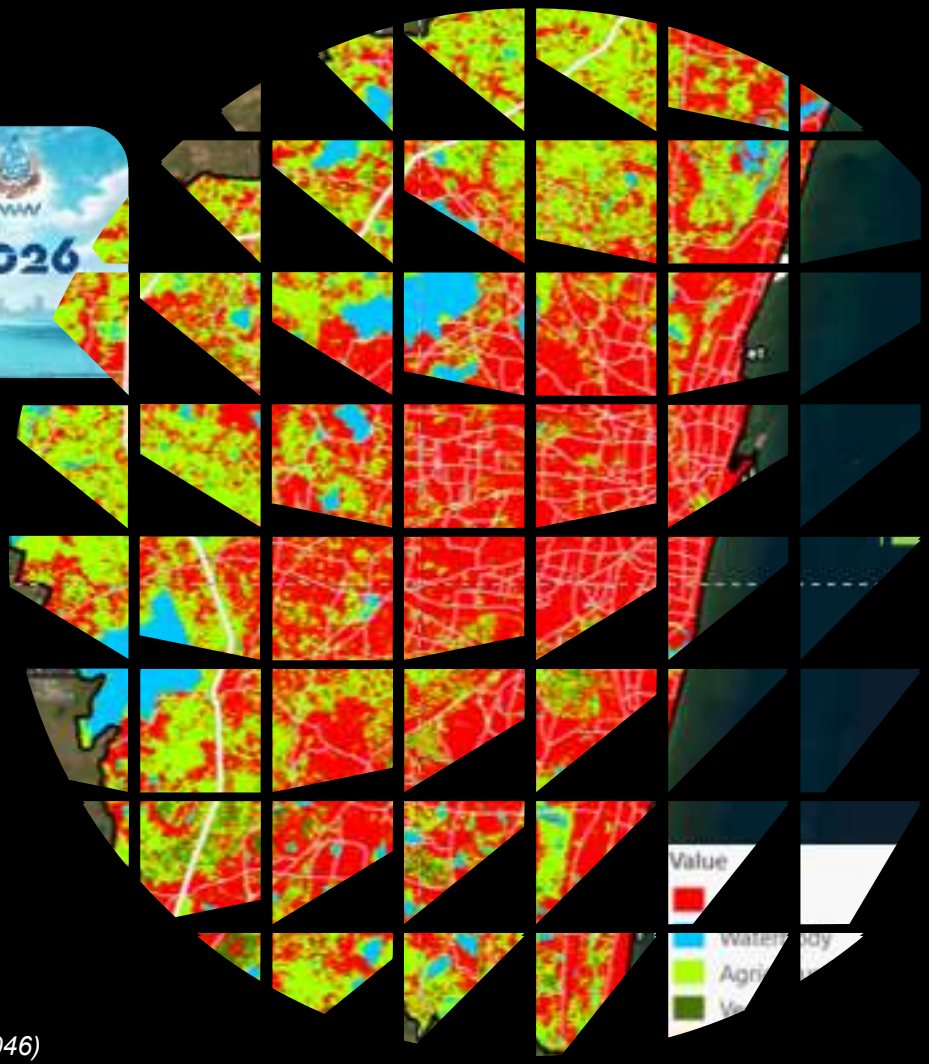




THEMATIC FORUM TF-7:

FORECASTING AND MODELLING FOR WATER SECURITY

Integrating Urban Growth Modelling and Blue-Green Infrastructure Safeguards for Water Security

Lessons and Spatial Planning Evidence from Chennai Metropolitan Area (CMA)

Authors: Shivani Yadav and Aakash Malik

Primary Research Paper submitted for IIWW-2026 Technical Session
Supported by: CMDA BGI Master Planning Study for Third Master Plan (TMP 2027–2046)

The Alluvium Group strives to solve the complex and systemic challenges facing our society and environment





Project: Integrating Blue Green Infrastructure in Urban Planning for Climate Change Adaptation and Mitigation in Chennai Metropolitan Area (CMA)
Client: World Bank, CMDA

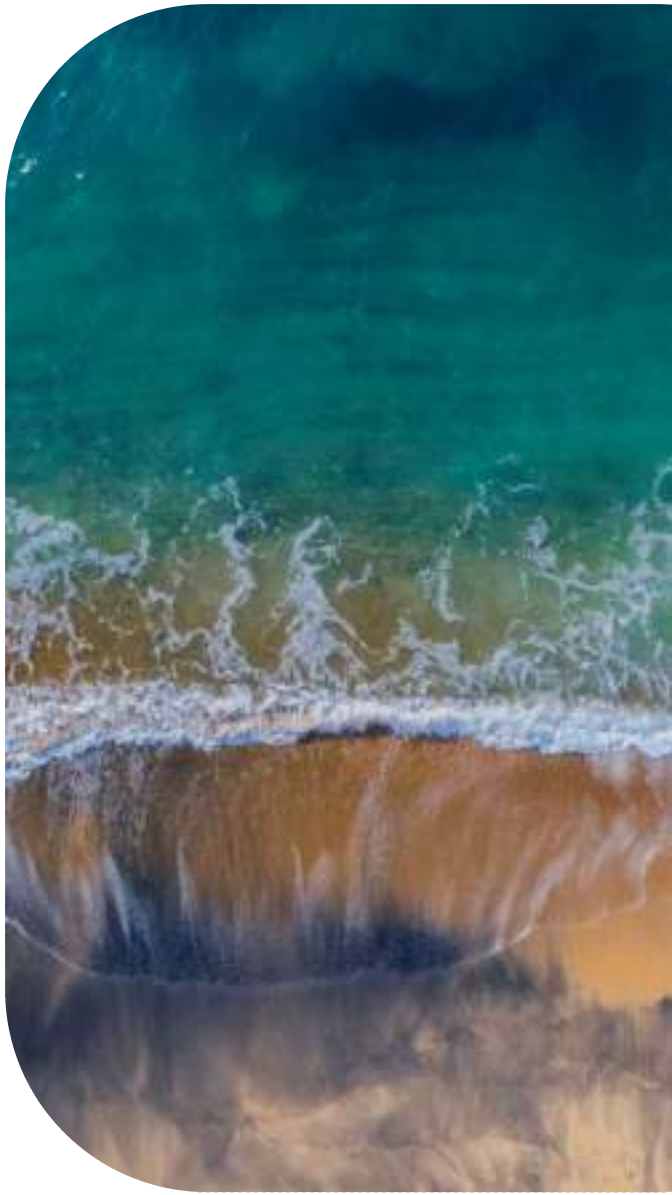
Objectives

1. **Forecast future urban growth**
   Project CMA's urban expansion for 2030 and 2050 under two scenarios: Business as Usual (BAU) and Safeguarding BGI.

2. **Assess impacts on Blue-Green Infrastructure**
   Evaluate how projected growth affects blue and green infrastructure, particularly potential encroachment into hydrologically and ecologically significant areas.

3. **Identify growth zones and test spatial redistribution**
   Identify major future growth zones and assess whether BGI safeguards can redirect development pressure toward less-sensitive urban and peri-urban areas.

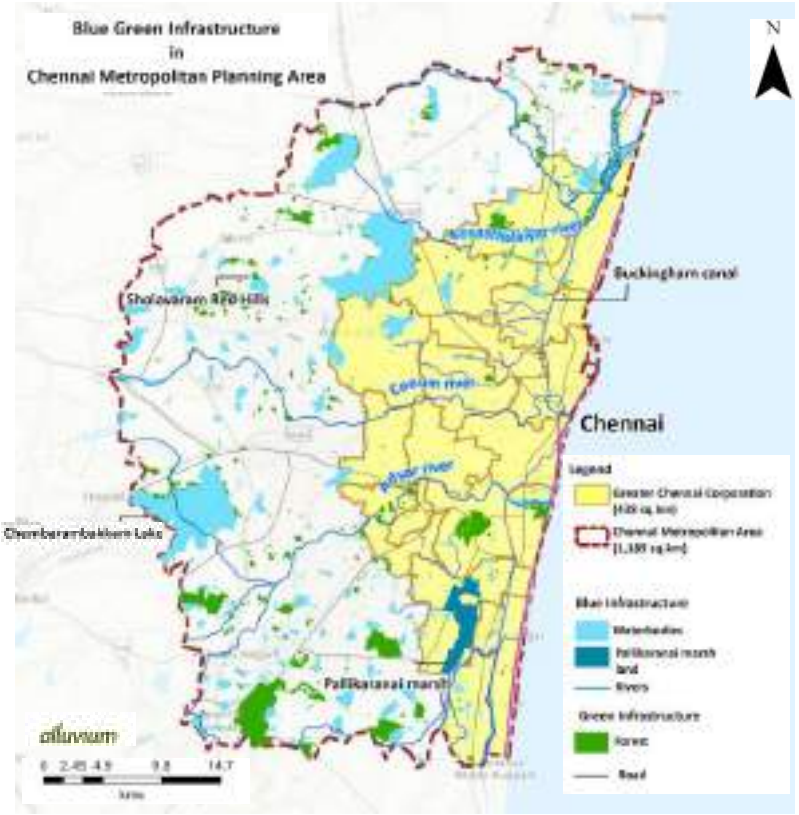




Blue-Green Infrastructure is part of the urban water system

Blue-Green Infrastructure (BGI) is the interconnected network of natural and semi-natural systems that support hydrological and ecological functioning (moderates runoff, stores water, enables recharge, filters pollutants and reduces heat exposure) in cities.





Blue Infrastructure in CMA → ~18%

Green Infrastructure in CMA → ~ 3.5% (excluding cropland)

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Urban Growth and Water Security in Chennai

Urban Growth Trend

3.5× Built Footprint Growth

Expanded from 168.5 km² in 1985 to ~600 km² in 2019 (59,120 ha in 2022)

Impact

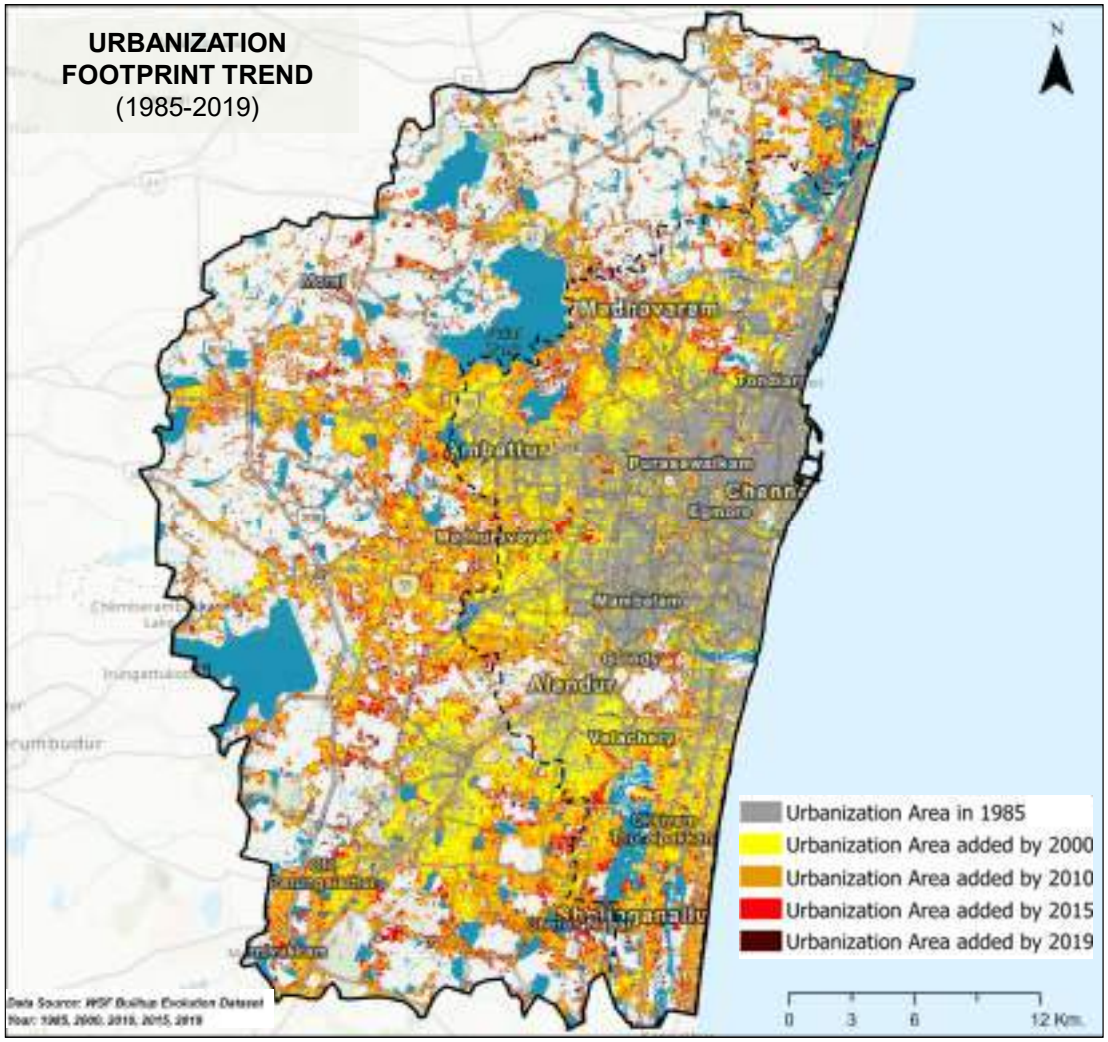
Blue-Green Infrastructure Baseline

29.5% (1,178 ha) of designated Green Infrastructure is already built over.

20.7% (4,403 ha) of designated Blue Infrastructure is already built over.

Climate Vulnerability

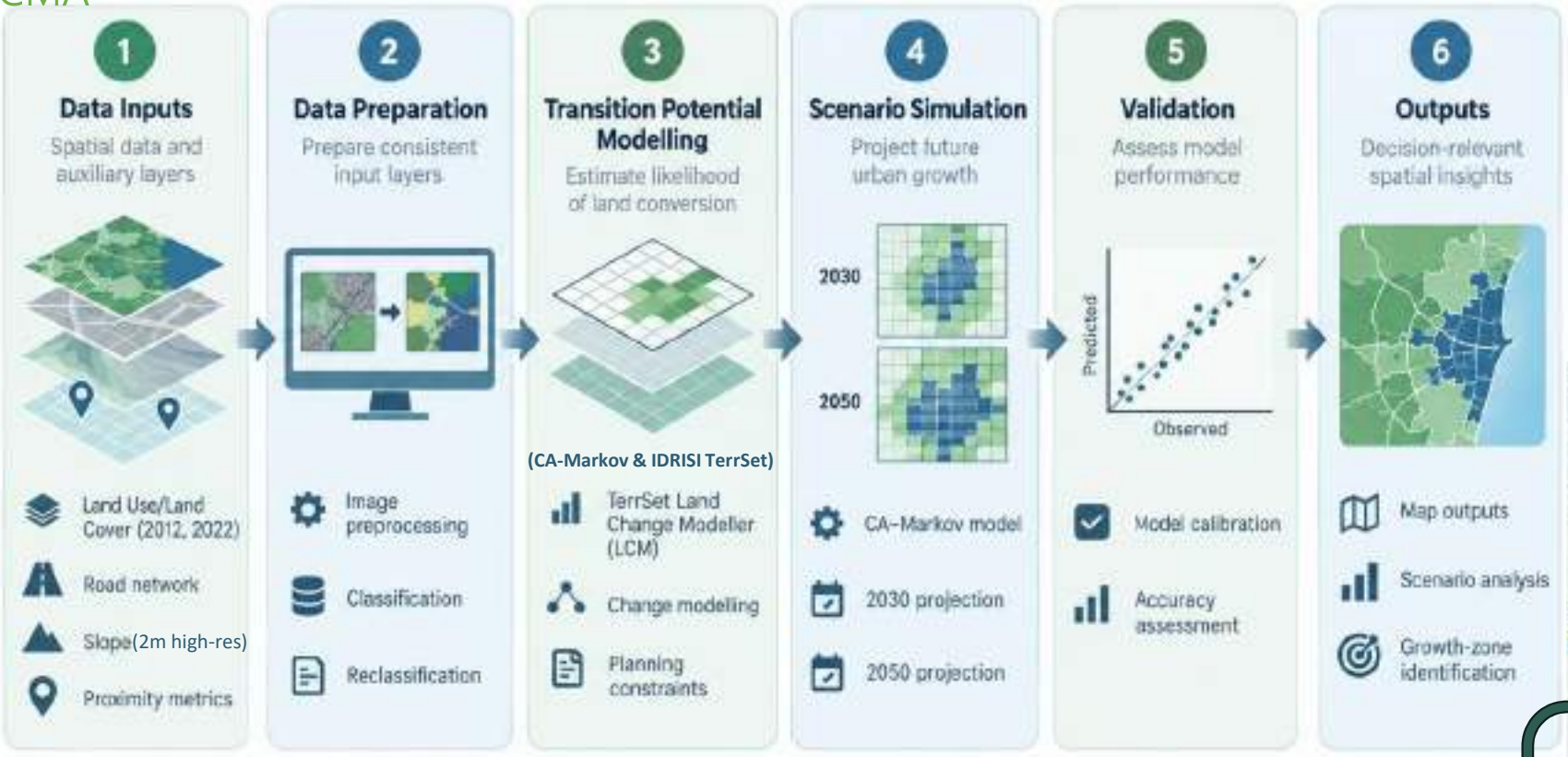
- **348 mm** rainfall in 24 hours (2015 floods)
- Coastline receded up to **560m** near Ennore
- Projected annual water deficit of **4,872 MCM** by 2050
- High frequency of **5-9** year drought cycles



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Modelling Urban Futures and BGI Integration

Method: scenario-based CA-Markov modelling for CMA





Rationale for 3km x 3km Grid:
Captures landscape-scale hydrological networks (flood dynamics) while retaining resolution for local ecological nuances (urban heat island mitigation).

Constraint Note: Analytical grid is defined at 3km x 3km to perfectly balance neighborhood-scale thermal variation with broader hydrological basin processes.

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Modelling Urban Futures and BGI Integration

Two alternative planning conditions for future growth tested in the model

Defining the 2030 and 2050 scenario pathways



Same demand for growth. Different spatial rules.

Hypothesis

The purpose of the comparison is to test whether excluding ecologically sensitive and hydrologically significant areas materially changes the direction, concentration and spatial spread of future built-up growth.

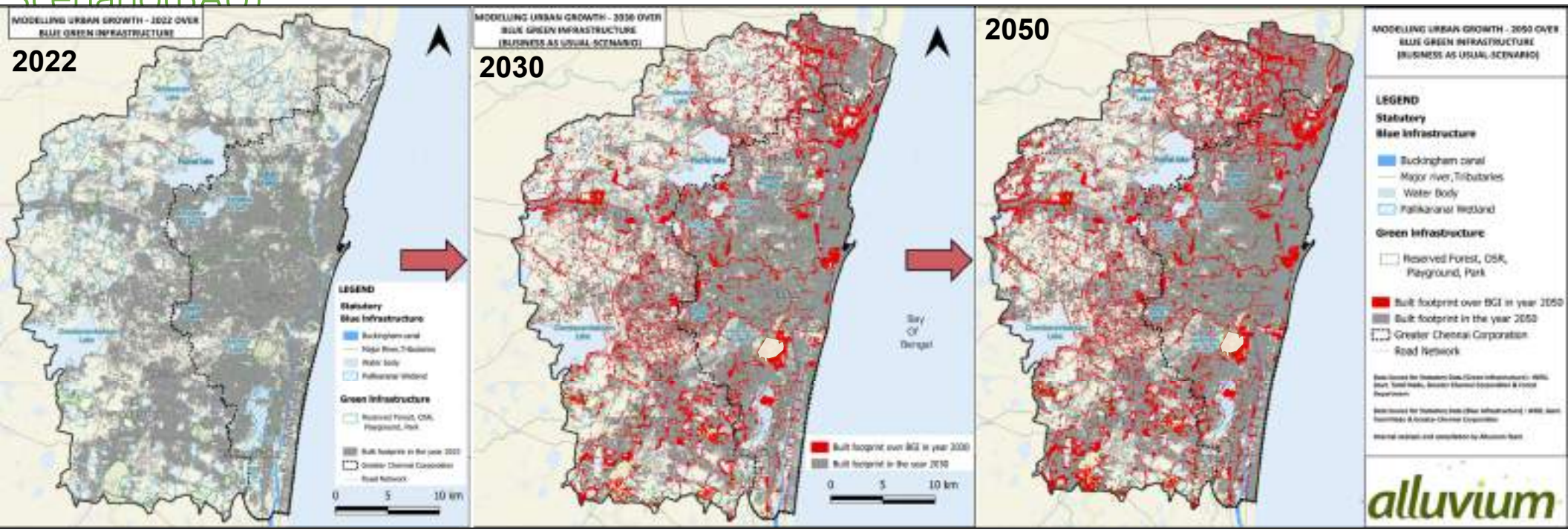
Interpretation rule: outputs are scenario tests, not deterministic land-conversion predictions.

Planning meaning: protecting BGI does not materially reduce projected urban growth; it changes the geography of development pressure.

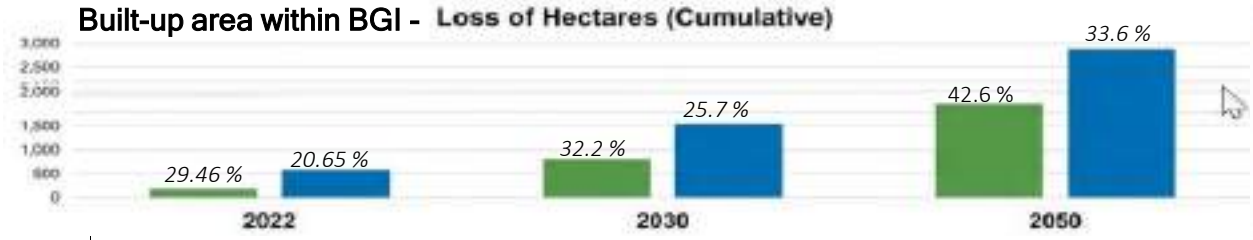
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Business As Usual Scenario(BAU)

Scenario Results: Urban Growth Impacts on BGI



**Note: During the urban growth modelling exercise, the 2022 baseline, integrated with BGI layers obtained from statutory sources (such as the Revenue Department, WRD, Forest Department, DMA, NCSCM, and SMP) – revealed significant built-up development within designated Green Infrastructure (29.5%) and Blue Infrastructure (20.7%) areas, indicating substantial levels of encroachment.*

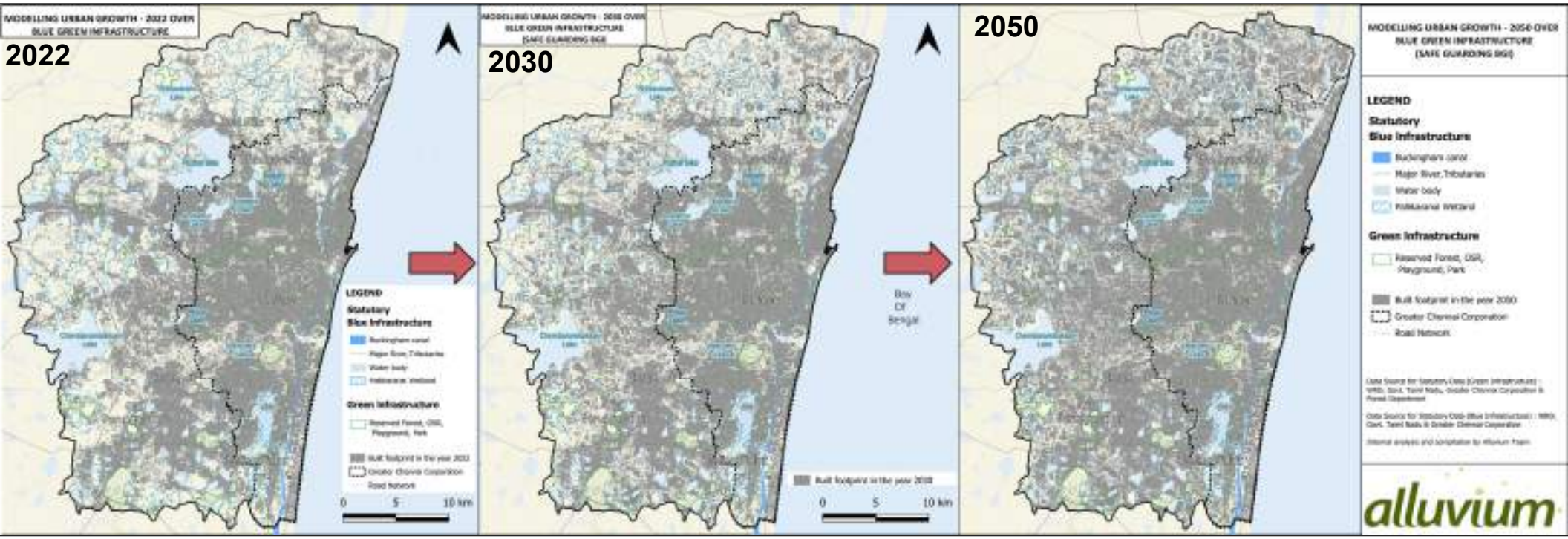


Green Infrastructure Lost:
42.6% (1,705 ha).

Blue Infrastructure Lost:
33.6% (7,167 ha).

Safe-guarding BGI

Scenario Results: Urban Growth Impacts on BGI

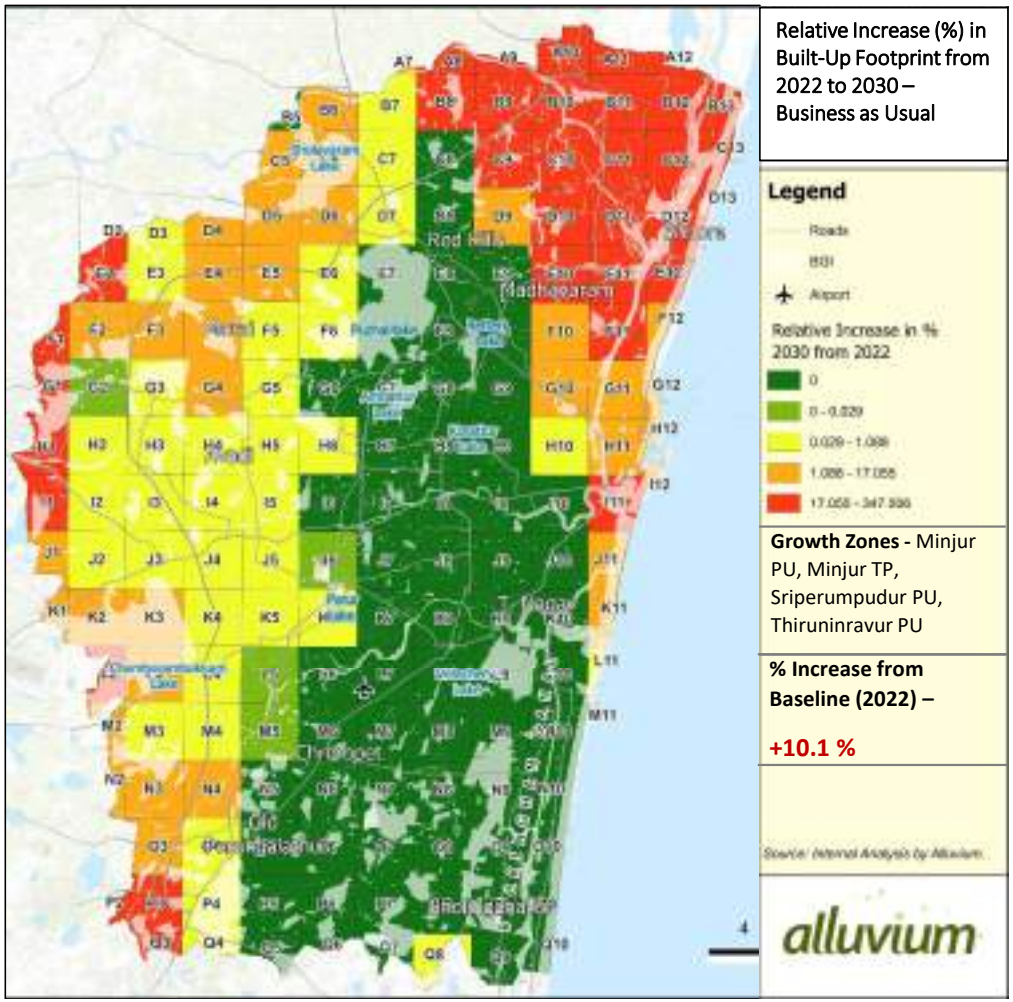


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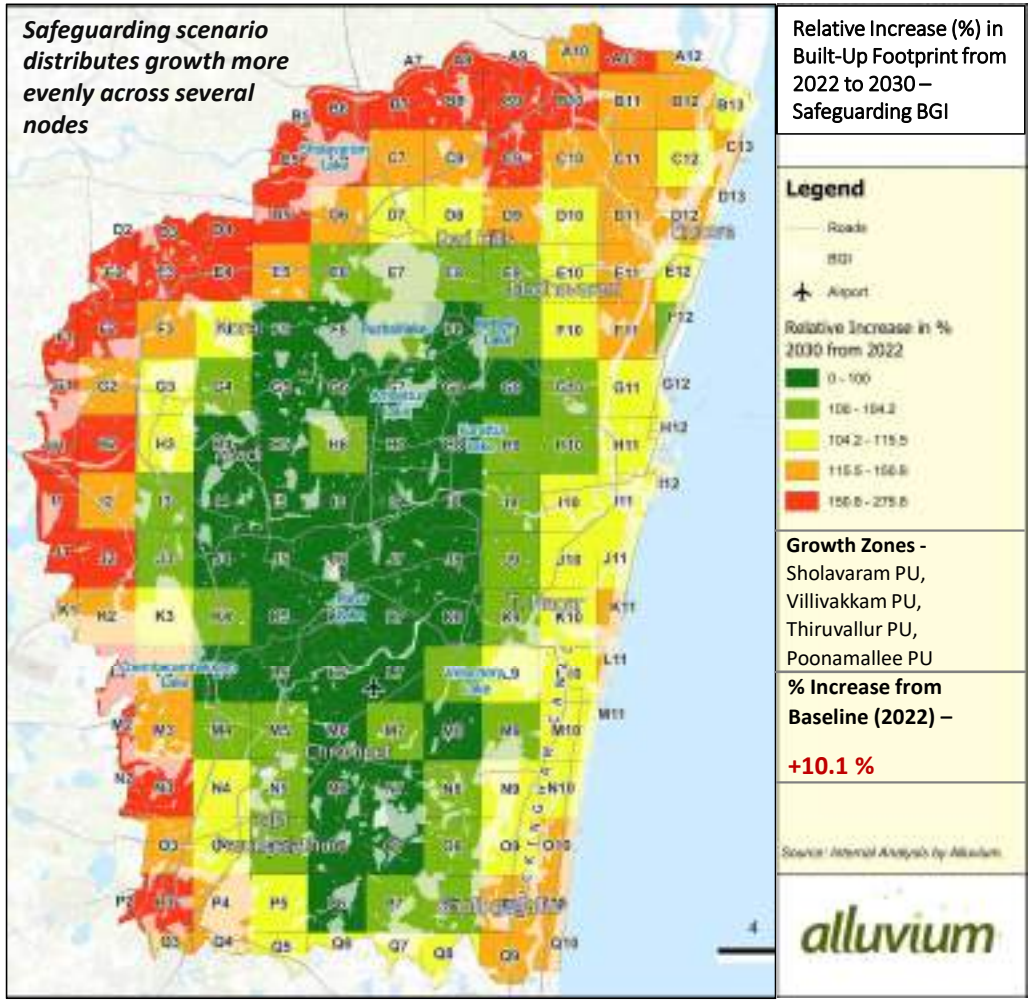
By safeguarding Blue-Green Infrastructure (BGI) through protective zoning (No development Zones) and planning policies, the same quantum of urban development can be accommodated while preserving over 13.14% of green and ~13% of blue infrastructure that would otherwise be lost under a business-as-usual scenario.

Scenario Results: Urban Growth Zones and Expansion areas - 2030

From 2022 to 2030 – Business as Usual

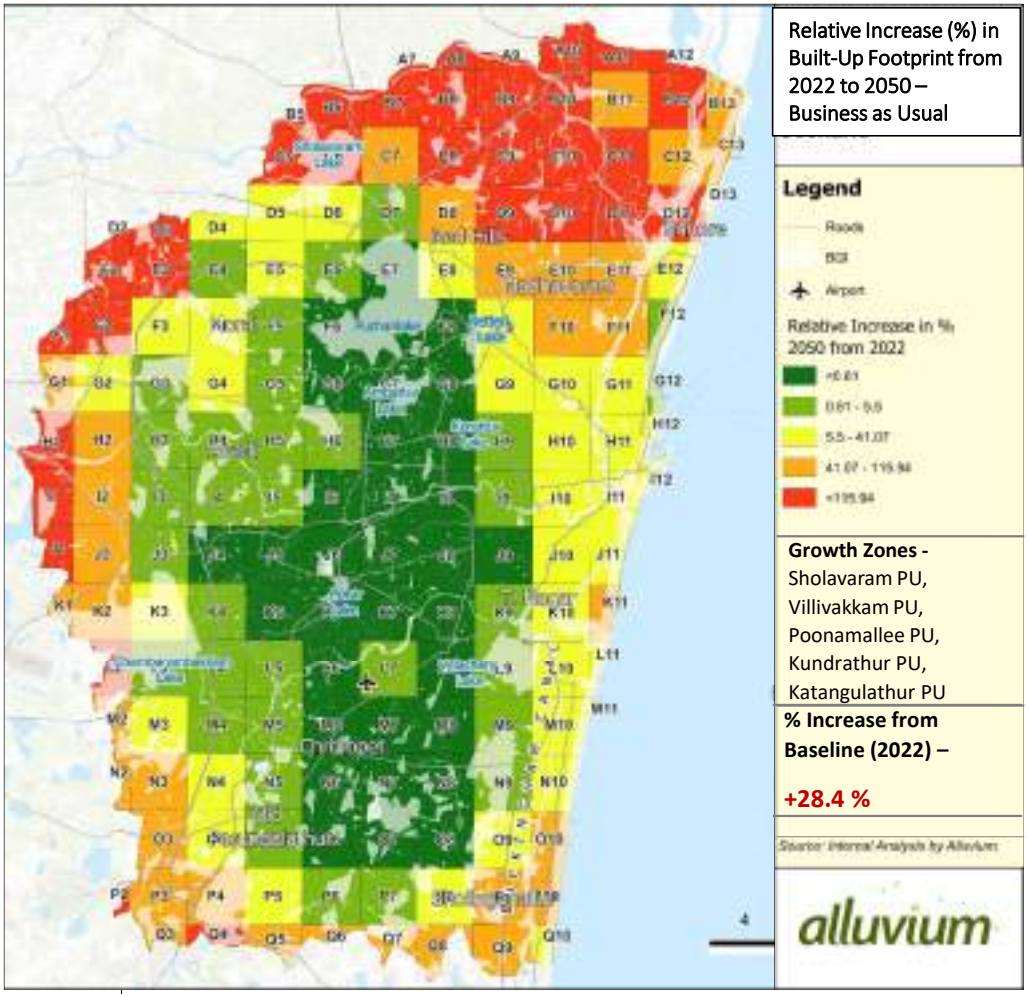


From 2022 to 2030 – Safeguarding BGI

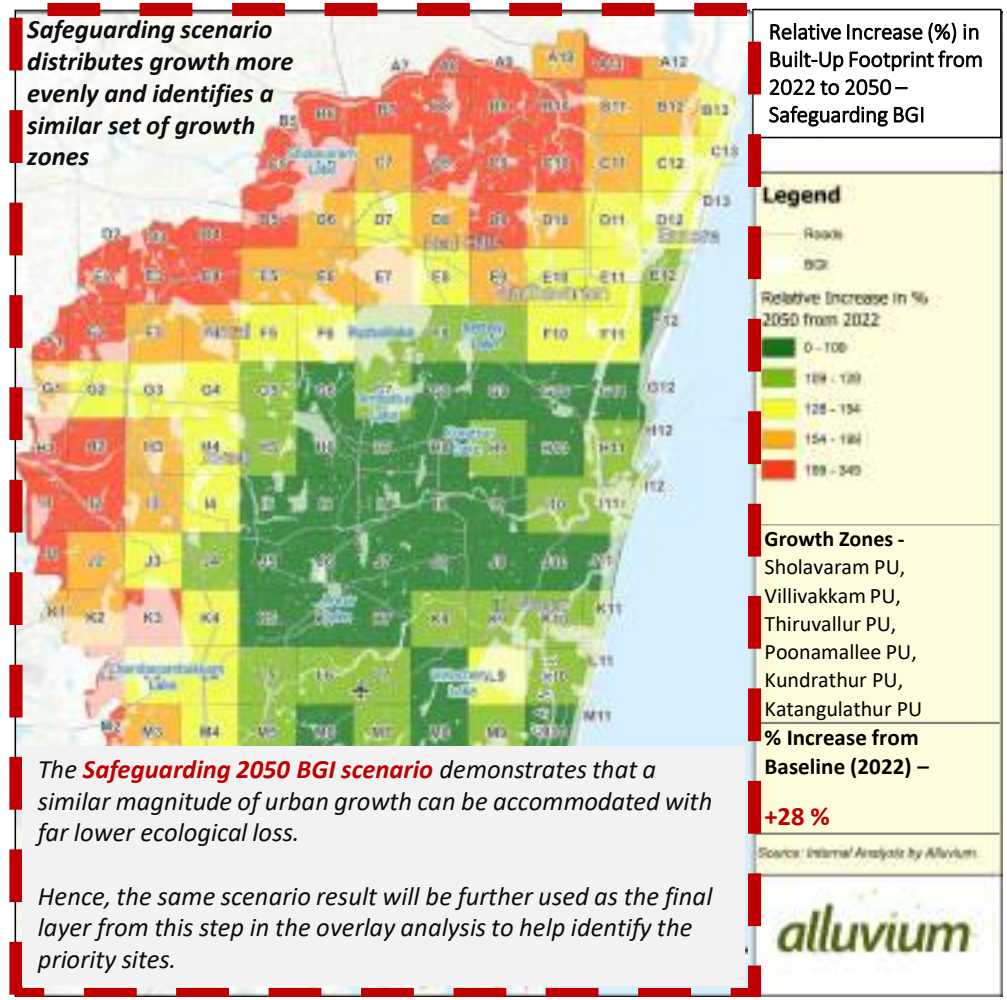


Scenario Results: Urban Growth Zones and Expansion areas - 2030

From 2022 to 2050 – Business as Usual



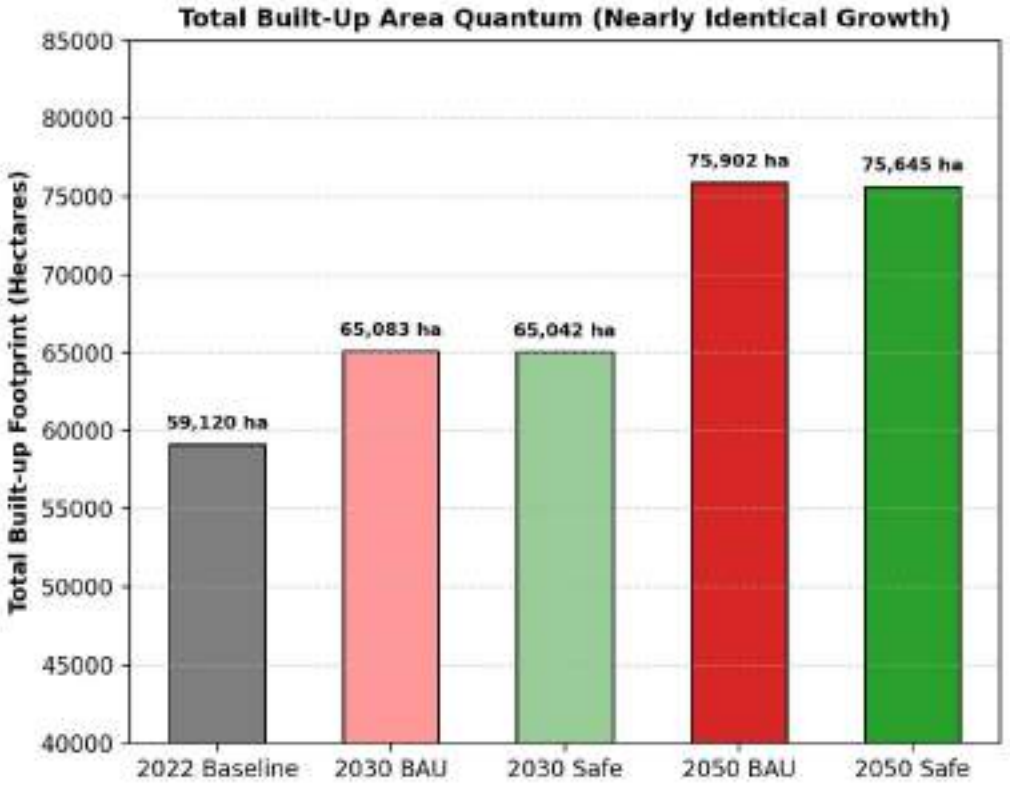
From 2022 to 2050 – Safeguarding BGI

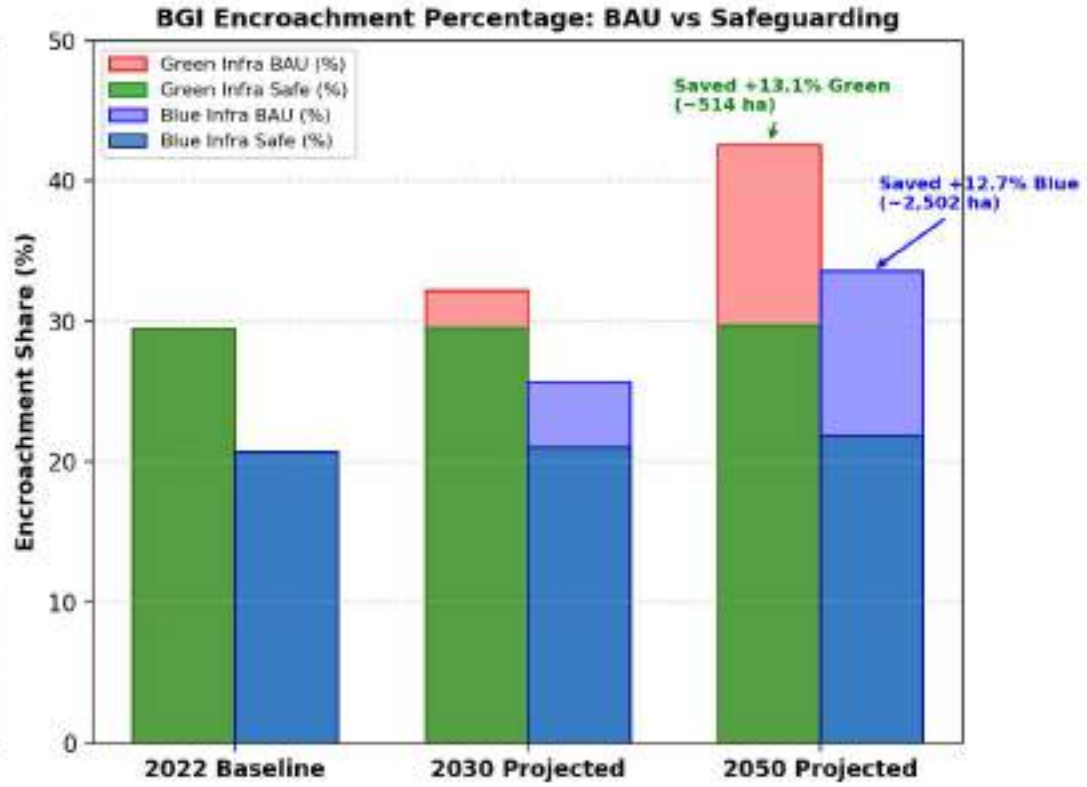


Results Summary: Urban Growth Model Outputs

Safeguarding BGI Accommodates the Same Urban Growth (+28% by 2050) While Saving 13% More Green & Blue Cover

Year	Scenario	Built-up (ha)	% Increase	Green Loss (%)	Blue Loss (%)	Major Growth Nodes
2022	Baseline	59,120 ha	—	1,178 ha (29.50%)	4,403 ha (20.70%)	Reference Year



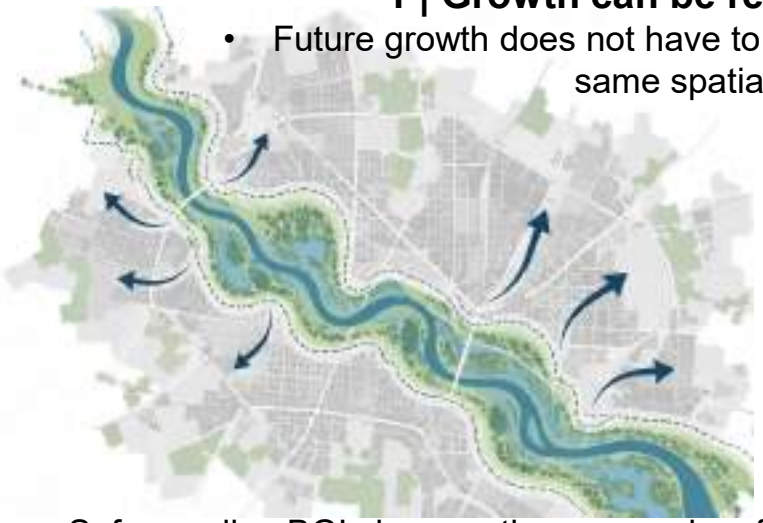


Conclusion: Steering urban growth to safeguard water security

Urban growth modelling as a first-step decision-support tool for metropolitan planning

1 | Growth can be redirected

- Future growth does not have to follow the same spatial pathway.



- Safeguarding BGI changes the geography of development pressure **without materially reducing the projected scale of metropolitan growth**.

2 | Forecasting can inform where planning action is needed



Urban growth forecasting can identify **where future development is most likely to conflict with critical BGI**.



The **Safeguarding BGI scenario** can then provide a spatial basis for **priority BGI intervention areas**



Model interpretation

Use as a decision-support layer. Do not treat outputs as exact parcel-level predictions. Validation, data quality and field verification remain critical.

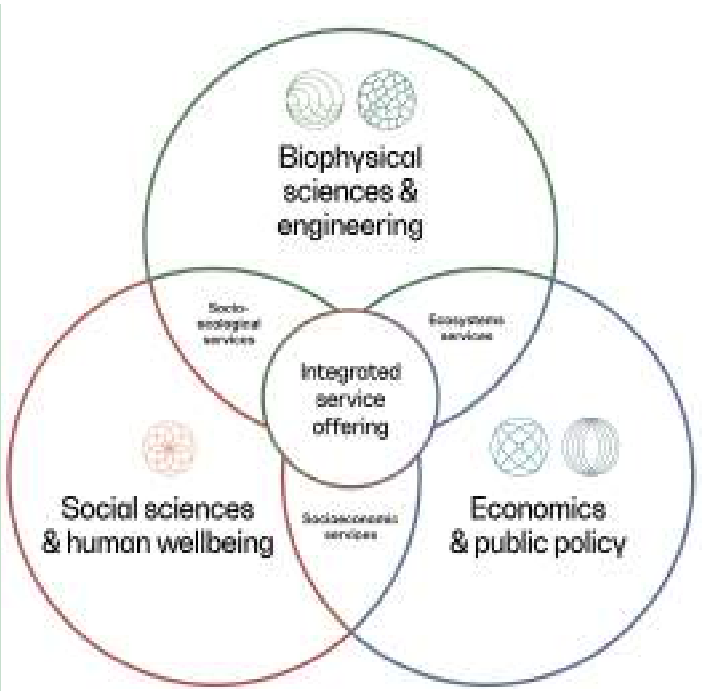
Policy entry points

✓ Master Plan zoning | Development control rules |
✓ Floodplain and wetland buffers | BGI restoration / DPR prioritisation

Growth cannot simply be stopped. But it can be steered and redirected from critical BGI.

Thank you

Questions?



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