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# Green Zoning as Structural Policy:

Ecological Protection, Disaster Resilience, and Local Growth  
in Indonesia

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ECOLOGY

RESILIENCE

GROWTH

# Nature loss is already a macroeconomic and fiscal issue

## Production systems

Forests, mangroves, watersheds, soils, and coastal ecosystems support agriculture, fisheries, water regulation, and carbon storage.

## Risk and public finance

Ecosystem decline can amplify flooding, erosion, livelihood losses, infrastructure damage, and public recovery spending.

## Regional development

Provincial spatial plans determine where development can occur and which ecological functions receive legal protection.

**Green zoning embeds natural capital into the rules governing land and sea use.**

# Policy architecture is ahead of its evidence base

## Policy momentum

- IBSAP 2025–2045 places integrated land–marine spatial planning at the centre of biodiversity protection.
- National Adaptation Plan 2026–2030 treats ecosystems as natural infrastructure for resilience.
- Provincial RTRW and RZWP3K translate national objectives into local zoning and development controls.

What the literature rarely tests together

**Ecological protection**

**Disaster burden**

**Economic performance**

within one comparable provincial framework

**The unresolved question is not whether planning matters—but where its associations are strongest.**

# One question across three outcome domains

**Are stronger, more biodiversity-inclusive spatial plans associated with lower degradation and disaster burden—without weaker economic growth?**

## 01 Ecology

Are stronger plans associated with lower forest and tree-cover loss?

## 02 Resilience

Are stronger plans associated with fewer events and lower realised disaster impacts?

## 03 Growth

Are stronger plans associated with weaker, similar, or stronger aggregate and sectoral growth?

# GZPI separates substantive zoning strength from data visibility

## Green Zoning Policy Index

**20%** Ecological-zone recognition and breadth

**20%** Legal protection strength

**20%** Spatial specificity

**20%** Implementation and accountability

**20%** Ecosystem diversity

## Data Visibility Score

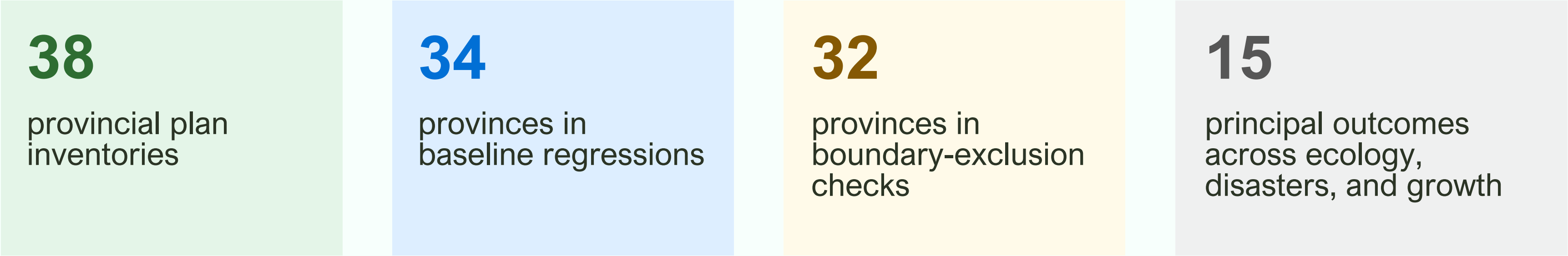
Area reporting · map availability · GIS readiness · traceable references · definition consistency · overlap disclosure · monitoring access

$$\text{GZPI}_i = 0.20 \times (\text{Breadth} + \text{Legal} + \text{Spatial} + \text{Implementation} + \text{Diversity})$$

**Applicability-adjusted: provinces are not penalised for ecosystems they do not have.**



The design combines national plan coverage with two empirical windows



Cross-section

Current plan package matched to 2021–2025 average outcomes

Annual panel data analysis

Plan regime by province-year 2014–2025; growth outcomes begin in 2015



## Two models test the same association from different angles

### Cross-sectional model

$$Y_i = \alpha + \beta \text{GZPI}_i + \delta \text{DVS}_i + \theta \text{PlanAge}_i + \gamma X_i + \varepsilon_i$$

- Compares 2021–2025 average outcomes across 34 provinces.
- OLS with heteroskedasticity-robust standard errors; Spearman correlations reported alongside.

### Pooled annual model

$$Y_{it} = \alpha + \beta \text{GZPI}_{it} + \rho \text{DVS}_{it} + \theta \text{PlanAge}_{it} + \gamma' X_{it} + \lambda_t + \varepsilon_{it}$$

- Adds year fixed effects and province-clustered standard errors.
- No province fixed effects because GZPI has limited within-province variation.

**$\beta$  is a conditional association—not a causal policy effect.**



## Robustness tests target small-sample inference and structural sensitivity

### **2000** bootstrap replications

Normal p-values, percentile intervals, and bias-corrected intervals.

### **5000** outcome permutations

Two-sided Monte Carlo inference while retaining the covariate structure.

### **34×** leave-one-province-out

Tests whether a single province drives the cross-sectional GZPI coefficient.

### **5 + 3** annual sensitivity families

Alternative windows, boundary exclusion, five structural controls, and thematic combinations.

A finding is strongest when conventional, resampling, and sensitivity evidence point in the same direction.



# Substantive scores are high; visibility is much less even

91.24

mean GZPI  
range 75.70–97.90

72.69

mean DVS  
range 35.71–92.86

2.94 years

average plan age at end of  
outcome window

Areas are designated for ecological protection in  
the spatial plans:

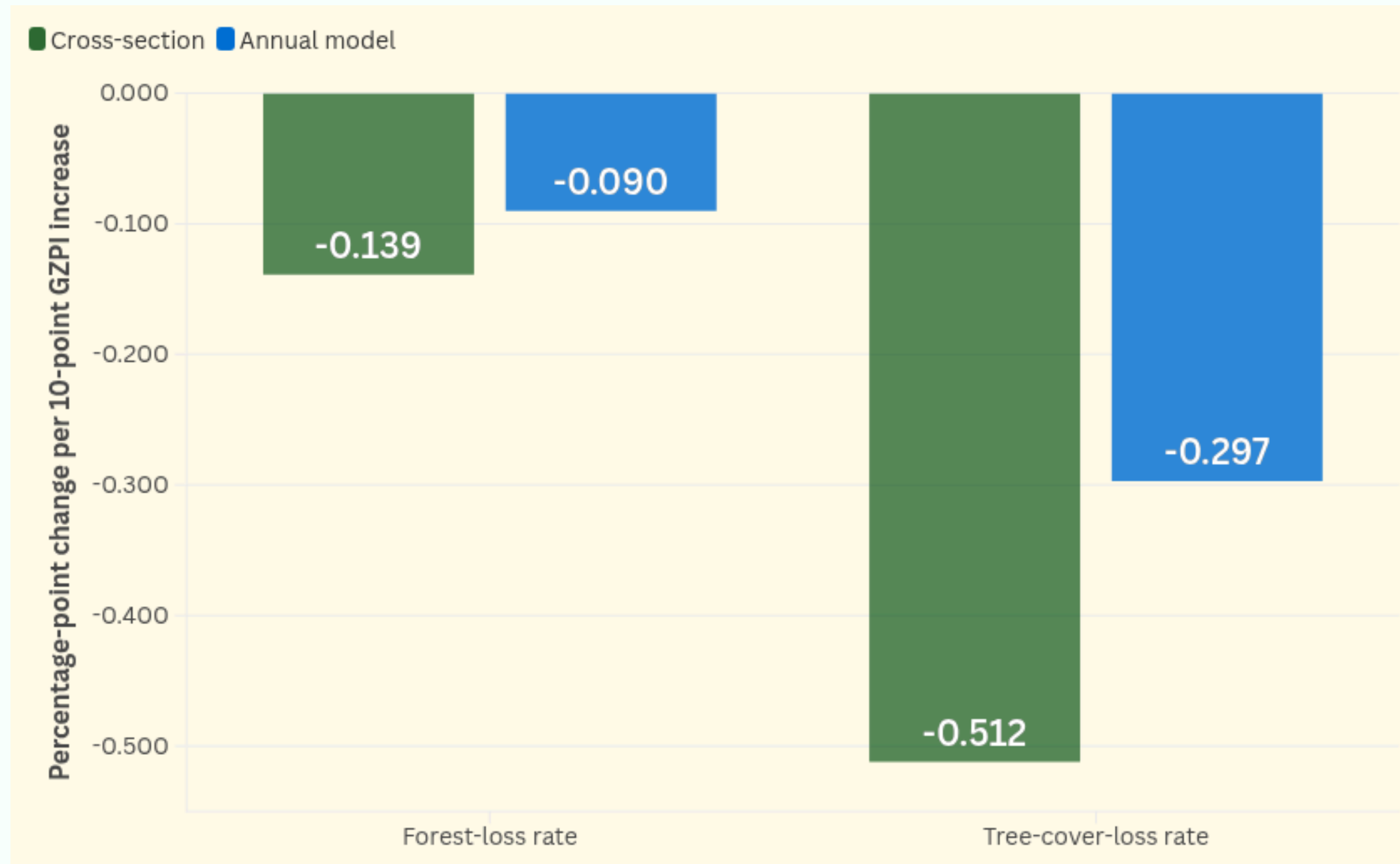
23.15% land

10.87% marine

## Why it matters

GZPI is concentrated near the top, while document visibility varies widely—limiting statistical separation and reinforcing the need to keep the two indices distinct.

# The strongest evidence is lower ecological degradation



**Coefficients show conditional associations; they are not causal effects.**

## Tree-cover loss

Supported by OLS, bootstrap intervals, permutation inference, and every annual sensitivity test.

## Forest loss

Negative throughout; cross-sectional inference is method-sensitive, while annual evidence is stronger.

## Interpretation

Formal designations, restrictions, spatial detail, and implementation provisions may moderate land-cover conversion.

# Recorded disasters show no general protection effect

| Outcome             | Cross-sec. | Annual   | Integrated reading                 |
|---------------------|------------|----------|------------------------------------|
| Flood events        | +17.81**   | +10.67   | OLS signal fails resampling        |
| Tidal-flood events  | +0.761*    | +0.553** | Stable positive recorded frequency |
| Landslides          | +9.95      | +21.40   | Imprecise / null                   |
| Forest & land fires | -7.36      | +5.06    | Imprecise / null                   |
| People affected     | -1.11      | +0.23    | Imprecise / null                   |
| House damaged       | -188       | +124     | Imprecise / null                   |

**What can be concluded**

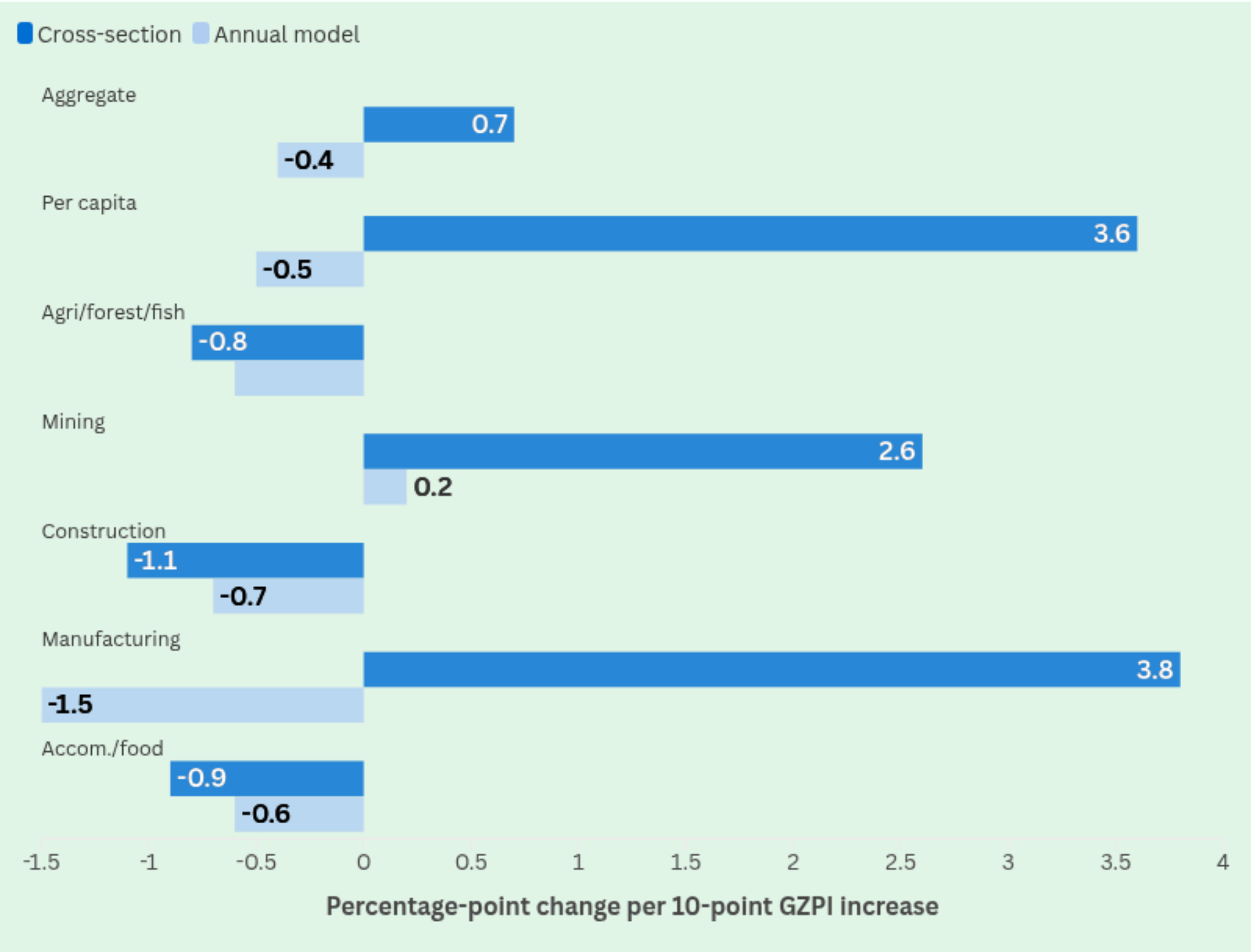
No robust evidence that higher GZPI reduces event frequency or realised impacts in the available data.

**Interpretation**

Formal designations, restrictions, spatial detail, and implementation provisions may moderate land-cover conversion.

Event frequency is not the same as avoided exposure, lower inundation depth, or avoided future losses.

# The strongest evidence is lower ecological degradation



## Aggregate output

Aggregate and per-capita annual coefficients are statistically insignificant.

## Sectoral adjustment

Annual agriculture and construction estimates are negative, but sensitive to boundaries or windows.

## Inference matters

The positive cross-sectional per-capita signal is not supported by bootstrap or permutation tests.

## The hierarchy of results is consistent with different policy channels

### Ecology

#### Direct channel

Zoning directly regulates conversion, protected functions, and permitted uses.

**Strongest evidence**

### Resilience

#### Indirect channel

Observed events also reflect hazard intensity, exposure, infrastructure, preparedness, and reporting.

**Weak/confounded evidence**

### Growth

#### Offsetting channels

Near-term restrictions can coexist with longer-run ecosystem services, certainty, and avoided losses.

**No aggregate penalty; qualified sector signals**

**Green zoning is structural policy—not a stand-alone disaster programme or a short-run growth engine.**



## Five limitations constrain interpretation

### 01 Design, not enforcement

GZPI measures published provisions—not permits, budgets, compliance, or actual land-use control.

### 02 Associational identification

Reverse causality and omitted governance or geography remain possible.

### 03 Small and concentrated sample

Only 34 provinces; with GZPI scores clustered near the upper end.

### 04 Limited within-province change

Annual models cannot use province fixed effects and remain mainly between-province comparisons.

### 05 Data comparability

Recent plans, Papua boundary changes, and incomplete disaster reporting constrain interpretation.

# Green zoning appears environmentally effective without a demonstrated aggregate growth penalty

## 01 Ecology

Lower tree-cover loss is the most robust finding; forest-loss evidence is negative but more method-sensitive.

## 02 Resilience

No general disaster-protection effect is demonstrated in recorded events or realised impacts.

## 03 Growth

No robust aggregate penalty; agriculture and construction may face concentrated short-run adjustment pressures.

### Policy priority

**Connect zoning to permits, budgets, enforcement, monitoring, ecosystem restoration, and sector-specific transition support.**





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# Thank you for listening!

questions and future collaborations  
are welcome

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