

Nature Heals: Mangroves, Mental Health, and Cognitive Functions

Amanda Guimbeau¹, Xinde James Ji², Nidhiya Menon³ and Firman Witoelar⁴

¹ Université de Sherbrooke

² University of Florida & University of Guelph

³ Brandeis University & Harvard University

⁴ Australian National University

Heartland Environmental Economics Workshop
UIUC October 2025

Motivation: The Value and Threat to Mangroves

- ▶ Mangrove forests: keystone species in coastal ecosystems
 - ▶ Rich biodiversity, supports fisheries
 - ▶ High potential for carbon sequestration
 - ▶ Natural barriers against storms, floods, and erosion
 - ▶ Cultural significance for coastal communities
- ▶ Indonesia: Home to world's most extensive & diverse mangroves (>20% global area)
- ▶ The threat: Significant loss over past decades (aquaculture, oil palm, climate pressures)
 - ▶ Indonesia is a major contributor to global mangrove decline



Mangrove forest in Bali. Source: World Bank



Mangrove Distribution. Source: Global Mangrove Watch

The Incentive Problem

The missing quantification of social co-benefits highlights a central challenge in global forest conservation: incentive misalignment between local versus global benefits

- ▶ The Global/National Perspective
 - ▶ Governments (national and international, e.g., EU) prioritize climate benefits
 - ▶ Focus is on reducing national deforestation rates and securing carbon credits
 - ▶ Mangroves are valued primarily as immense 'blue carbon' sinks
 - ▶ Key benefits of mangrove conservation are global public goods
- ▶ The Local Perspective
 - ▶ Focus on livelihoods provided by mangroves/alternative land uses
 - ▶ Clearing mangroves for aquaculture (e.g., shrimp farms) offers tangible, short-term financial gains
 - ▶ Opportunity costs of conservation, such as foregone profits from aquaculture or palm production are borne locally (Glennerster and Jayachandran 2023)

FINANCIAL TIMES

US COMPANIES TECH MARKETS CLIMATE OPINION LEX WORK & CAREERS LIFE & ARTS HTSI

EU business regulation

+ Add to myFT

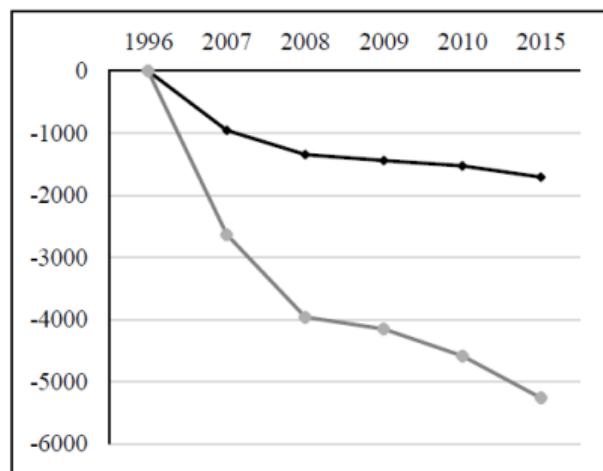
Indonesia says EU deforestation law is still unworkable

Jakarta's push for further postponement comes as EU countries call for 'onerous' rules to be simplified

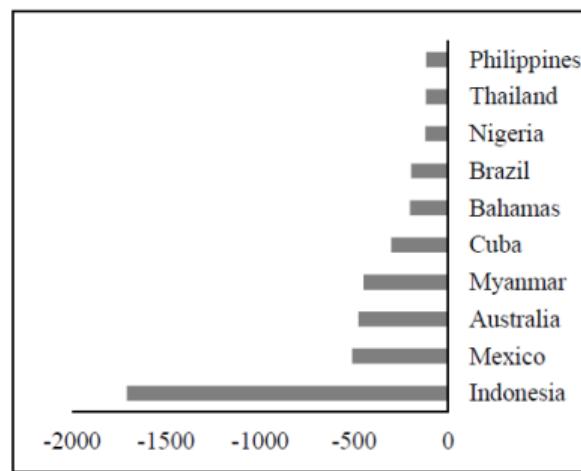


Net changes in mangrove habitat area from 1996 to 2015

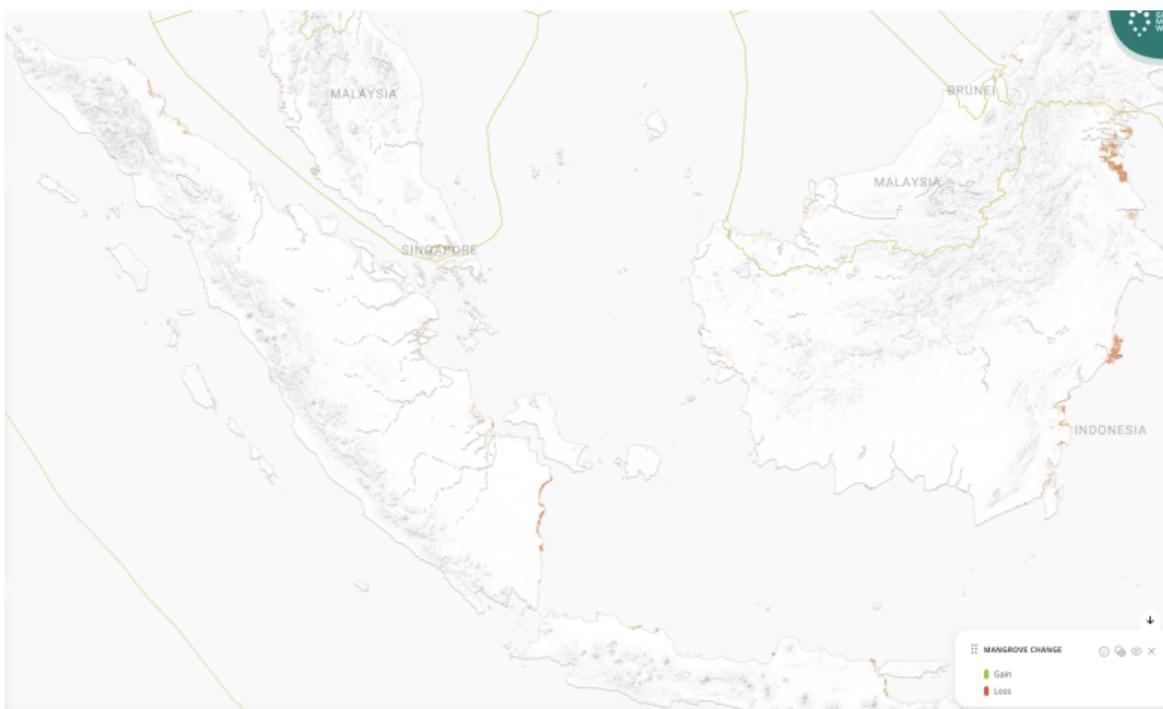
Panel A



Panel B



Notes: Panel A shows the global (in gray) and Indonesian (in bold) net change in areal extent of mangrove habitat (in km^2). Panel B shows the top 10 countries with the largest net change in areal extent of mangrove habitat between 1996 and 2015. Source: Global Mangrove Watch. For more details, see Bunting et al. (2022).



Mangrove Change. Source: Global Mangrove Watch



Mangrove conversion in Kalimantan. Source: Global Mangrove Watch

Motivation: social impacts of mangrove ecosystems

What we know so far:

- ▶ In Florida, Mangrove buffers flood (Sheng et al., 2021, 2022), increase property values (Kajaria et al. 2023, Liu et al. 2025)
- ▶ In India, mangrove mitigates short-run cyclone impacts on economic activities (Zhu et al. 2023)
- ▶ In Indonesia, fishery households lose income (Yamamoto 2023), substitute with more labor, less food, and earlier marriage for girls (Yamamoto and Shigetomi, 2022)

This paper

Research questions:

- ▶ What are the effects of mangrove coverage on mental health and cognitive functions?
- ▶ Do these impacts vary across the life-cycle and other demographic characteristics?
- ▶ How do ecosystem stability and land use dynamics relate to these outcomes?
- ▶ Through which channels do these effects operate, and how contextual factors shape the strength of the mangrove-welfare relationship?

To answer these questions, we exploit

- ▶ high-resolution satellite data on mangrove coverage from Clark Labs
- ▶ panel variation in mental health and cognitive function from the Indonesian Family Life Survey (IFLS)

Contributions to the literature

- ▶ The effects of ecosystem degradation, particularly deforestation, on human health and well-being (Balboni et al. 2023; Berazneva and Byker 2017, 2024; Garg 2019; Kishida et al. 2024)
 - ▶ We find that mangrove loss significantly worsens mental health and cognitive function in Indonesia
- ▶ Social value of natural capital (Damania et al. 2023; Deutsch 2003; Fenichel and Abbott 2014; Liu et al. 2025; Muller et al. 2025; Polasky and Daly 2021)
 - ▶ We find that natural capital loss affects human well-being through multiple channels
- ▶ Environmental conditions and mental health (Burke et al. 2018; Carias et al. 2022; Evans et al. 2025; Hua et al. 2023; Mullins and White 2019; Rosales-Rueda 2018)
 - ▶ Most studies focus on sudden shocks (flooding, extreme heat, air pollution exposure); we focus on long-term natural capital disturbance

Data Sources

- ▶ **Welfare Data:** Indonesian Family Life Survey (IFLS) - Waves 4 (2007) & 5 (2014/15) [IFLS Coverage](#)
 - ▶ Rich individual/household panel data
 - ▶ Geocoded at the village level; tracks most migration across waves
- ▶ **Key Outcomes:** [Details on outcomes](#)
 - ▶ Mental Health: CESD-10 Depression Score
 - ▶ Cognition:
 - ▶ Episodic Memory (immediate + delayed word recall)
 - ▶ Fluid Intelligence (Raven's Progression Matrices + numeracy test)
- ▶ **Linking:** IFLS geocodes matched to land cover data → Mangrove cover within 30km radius

[Summary Statistics](#)

Measuring Mangrove Exposure

- ▶ High-resolution spatial data on coastal land use from Clark University's Center for Geospatial Analytics
- ▶ Two data products at 15-meter resolution
 - ① A land cover product that identifies distinct coastal land cover types of mangrove, wetland, pond aquaculture in 1999, 2014, 2018, 2020, and 2022
 - ② A land use change product that tracks whether mangroves and aquaculture ponds persist or transition into or out of other land use types between 1999 and 2022
- ▶ Measure 1: **Mangrove Coverage**
 - ▶ Percentage of land covered by mangroves within 30km of community c in year t
 - ▶ Measures natural capital endowment
- ▶ Measure 2: **Land Use Change**
 - ▶ Persistent mangrove cover between 1999-2022
 - ▶ Mangrove converted into other land uses (e.g., aquaculture)
 - ▶ Mangrove restored from other land uses

Empirical Strategy: Mangrove Cover

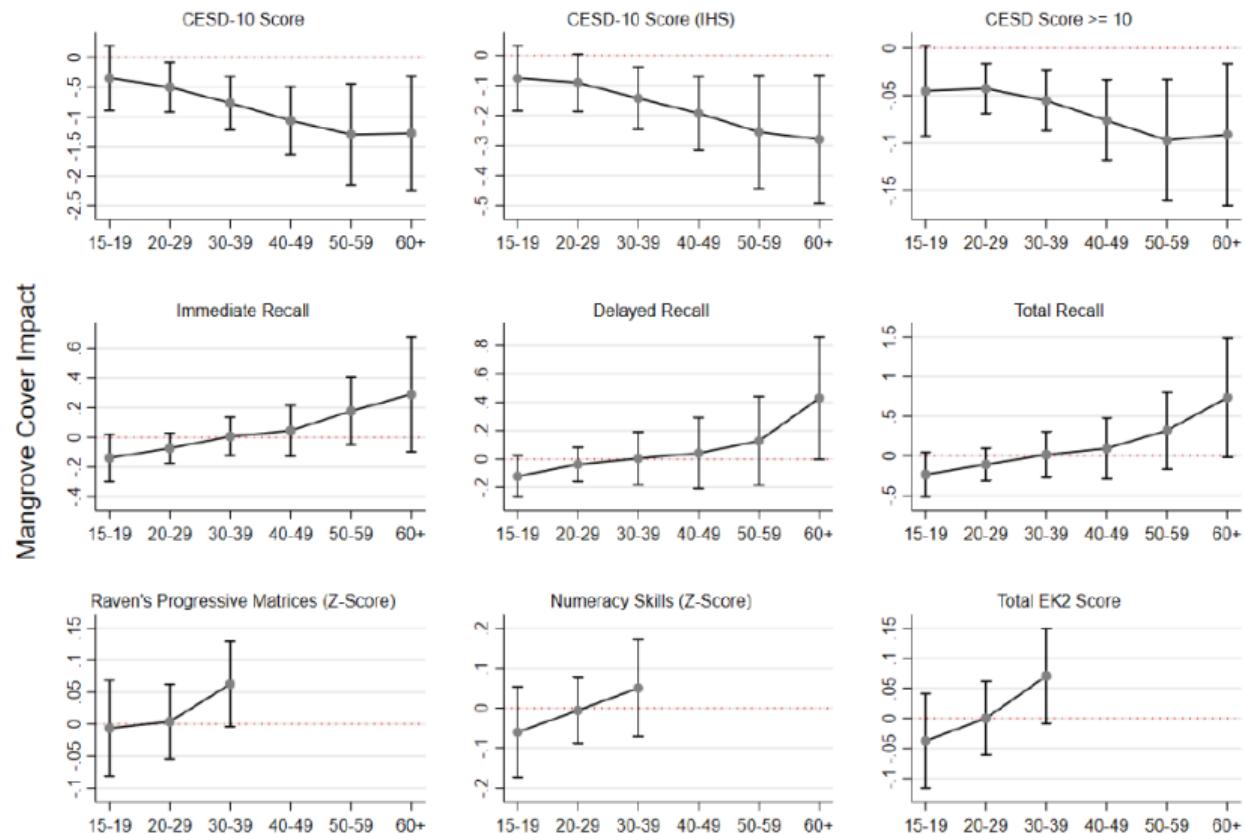
$$y_{ihct} = \beta \text{MangroveExposure}_{ct} + \gamma' X_{ihct} + \mu_i + \nu_t + \epsilon_{ihct}$$

- ▶ y_{ihct} : Mental health or cognitive outcome (individual i , household h , community c , time t)
- ▶ $\text{MangroveExposure}_{ct}$: Mangrove coverage within 30km of community c in year t
- ▶ X_{ihct} : Time-varying controls (age, marital status, education, etc.)
- ▶ Individual and survey wave fixed effects

The effects of mangrove coverage on mental health and cognitive ability

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Mental health						
	CESD-10	CESD-10 (log)	CESD-10 (inhs)	> median CESD-10	>=10 cutoff	
% Mangrove cover (within 30km of community location)	-0.663*** (0.236)	-0.104** (0.042)	-0.126** (0.051)	-0.035 (0.023)	-0.055*** (0.016)	
Mean of dependent variable	4.79	1.476	1.884	0.409	0.134	
Observations	36,948	36,948	36,948	36,948	36,948	
R-squared	0.637	0.623	0.619	0.604	0.583	
Panel B: Cognitive ability						
	immediate recall	delayed recall	total recall	general reasoning (Raven's z-score)	numeracy skills (z- score)	overall intelligence
% Mangrove cover (within 30km of community location)	-0.026 (0.058)	-0.021 (0.082)	-0.047 (0.130)	0.002 (0.031)	-0.021 (0.046)	-0.010 (0.035)
Mean of dependent variable	4.907	3.879	8.793	0.3	0.199	0.299
Observations	36,084	36,084	36,084	13,982	13,982	13,982
R-squared	0.748	0.721	0.759	0.691	0.674	0.721
Individual FE	✓	✓	✓	✓	✓	✓
Wave FE	✓	✓	✓	✓	✓	✓
Individual and household controls	✓	✓	✓	✓	✓	✓

Effects of mangrove coverage by age groups



Drivers of land use change

We are also interested in:

- ▶ The effect of mangrove endowment
- ▶ The effect of different land use change drivers; effects of persistent mangrove ecosystems as well as transitions between mangrove and aquaculture landscapes
- ▶ The land use transition data is in first-differenced form (LUC from 1999 to 2020), so we pair this with a first-difference estimation strategy

We specify a first-difference model (equivalent to TWFE since T=2):

$$\begin{aligned}\Delta y_{ihc} = & \beta_1 \text{MangrovePersistence}_c + \beta_2 \text{PondPersistence}_c \\ & + \beta_3 \text{Mangrove to Pond}_c + \beta_4 \text{Pond to Mangrove}_c + \gamma' \Delta X_{ihc} + \Delta \epsilon_{ihc}\end{aligned}$$

The effects of land use change on mental health and cognitive ability

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Mental health						
	CESD-10	CESD-10 (log)	CESD-10 (inhs)	> median CESD-10	>=10 cutoff	
% Mangrove persistence	-0.269*** (0.099)	-0.026 (0.022)	-0.029 (0.028)	-0.017 (0.011)	-0.023*** (0.006)	
% Aquaculture persistence	0.107** (0.047)	0.012 (0.011)	0.014 (0.015)	0.016*** (0.005)	0.008*** (0.003)	
% Mangrove converted to aquaculture	2.12*** (0.515)	0.264** (0.120)	0.308** (0.155)	0.144*** (0.053)	0.174*** (0.030)	
% Aquaculture converted to mangrove	-4.72*** (0.745)	-0.740*** (0.183)	-0.891*** (0.235)	-0.509*** (0.076)	-0.332*** (0.043)	
Panel B: Cognitive ability						
	episodic memory			fluid intelligence		
	immediate recall	delayed recall	total recall	general reasoning (Raven's z-score)	numeracy skills (z-score)	overall intelligence
% Mangrove persistence	0.060* (0.034)	0.104*** (0.040)	0.161** (0.067)	0.035* (0.020)	0.067** (0.034)	0.057** (0.025)
% Aquaculture persistence	-0.021 (0.018)	-0.096*** (0.024)	-0.116*** (0.036)	-0.019* (0.011)	-0.013 (0.017)	-0.016 (0.013)
% Mangrove converted to aquaculture	0.085 (0.210)	-0.082 (0.194)	-0.016 (0.366)	-0.001 (0.114)	0.116 (0.129)	0.069 (0.115)
% Aquaculture converted to mangrove	0.578** (0.292)	1.77*** (0.404)	2.37*** (0.629)	0.153 (0.185)	-0.184 (0.367)	-0.012 (0.257)

Robustness Checks

- ▶ Checks for data quality and matching process, using the Global Mangrove Watch (1996, 2007-2009, 2015-2020 at a 25-meter resolution)
- ▶ Alternative specifications of fixed effects
- ▶ Alternative clustering methods
- ▶ Additional controls (media, amenities, childhood conditions)
- ▶ Restricting sample based on migration status; addressing endogenous sorting

Discussion and results

We conducted additional checks on:

- ▶ Choice of buffer distance Results
- ▶ Heterogeneity across gender, education level, and food security status

Mechanisms

Potential Pathways:

① Hazard Exposure

- ▶ Reduced coastal protection
- ▶ Increased flood/storm risk

② Cultural and Perceptions

- ▶ Lower perceived mobility
- ▶ Bleaker economic future
- ▶ 'Ecological grief'

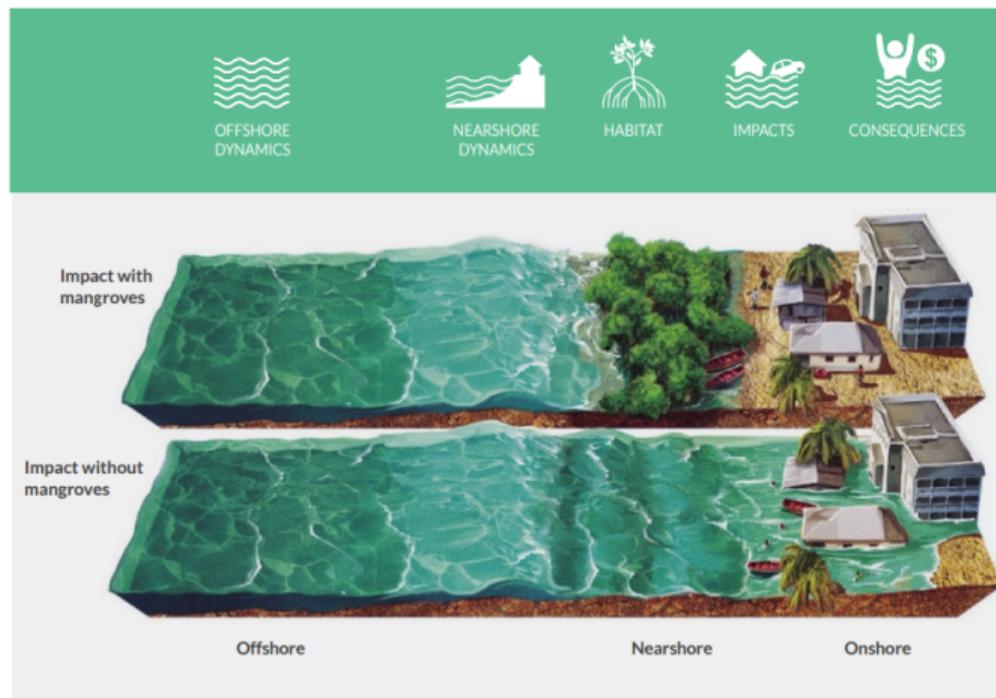
③ Livelihood and Income

- ▶ Income loss/Lower wages
- ▶ Compensating labor supply increase
- ▶ Reduced consumption
- ▶ Lower local economic activity

Flooding and Mangroves

FIGURE 8.1

Key steps and data for estimating the flood protection benefits provided by mangroves



Source: Figure 2.1 in Menéndez et al. 2024.

Mangroves and exposure to floods and other disasters

	Dependent variables:						
	flood	household exposure (past 5 years)		community exposure (past 5 years)		community preparedness	
		flood	flood and windstorm	flood, windstorm and other disasters	community flooded	number of floods in community	community preparedness
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Land use cover							
% Mangrove cover (within 30km of community location)	0.005 (0.024)	0.002 (0.025)	0.006 (0.025)	-0.023 (0.218)	-0.310 (1.439)	0.474 (0.355)	0.497 (0.505)
% Aquaculture ponds (within 30km of community location)	0.013 (0.008)	0.017* (0.009)	0.018* (0.009)	0.024 (0.178)	-0.655 (0.777)	0.179 (0.195)	0.371 (0.262)
Observations	36,924	36,924	36,924	26,418	26,418	26,418	26,418
R-squared	0.617	0.606	0.630	0.725	0.606	0.601	0.596
Panel B: Land use change							
% Mangrove persistence (1999-2022, within 30 km buffer)	-0.073*** (0.027)	-0.085*** (0.024)	-0.077*** (0.026)	-0.137** (0.059)	-1.89*** (0.696)	0.001 (0.047)	0.168*** (0.063)
% Aquaculture persistence (1999-2022, within 30 km buffer)	-0.002 (0.011)	-0.004 (0.011)	-0.002 (0.011)	0.009 (0.024)	-0.033 (0.086)	0.016 (0.035)	0.048 (0.039)
% Mangrove converted to aquaculture (1999-2022, within 30 km buffer)	0.199** (0.082)	0.259*** (0.086)	0.217** (0.087)	0.309 (0.339)	6.64 (5.34)	-0.146 (0.384)	-0.216 (0.580)
% Aquaculture converted to mangrove (1999-2022, within 30 km buffer)	-0.013 (0.171)	0.035 (0.169)	-0.014 (0.178)	-0.321 (0.391)	0.517 (1.55)	0.366 (0.576)	-0.095 (0.601)
Observations	18,462	18,462	18,462	13,209	13,209	13,209	13,209
R-squared	0.01142	0.01024	0.01123	0.04481	0.02830	0.01604	0.03671

Mangrove Loss, income and employment

	(1)	(2)	(3)	(4)	(5)
Panel A: Income and employment					
	income (last year)	worked for pay	employed last year	hours worked	
% Mangrove cover (within 30km of community location)	0.192*** (0.064)	0.025 (0.018)	0.018 (0.014)	-1.055 (1.126)	
% Aquaculture pond (within 30km of community location)	-0.001 (0.031)	0.010 (0.009)	0.023*** (0.008)	-0.224 (0.452)	
Observations	18,508	34,848	34,838	24,579	
R-squared	0.531	0.370	0.374	0.418	
Panel B: Consumption and nutrition					
	Whether household purchases		(log) expenditure on		
	fish	protein-rich food	healthy food	total food	non-food
% Mangrove cover (within 30km of community location)	0.014 (0.020)	0.014 (0.015)	0.128* (0.071)	0.086*** (0.033)	0.034 (0.039)
% Aquaculture pond (within 30km of community location)	0.017 (0.012)	0.012 (0.009)	0.033 (0.068)	0.019 (0.022)	0.047** (0.020)
Observations	34,816	34,816	34,816	34,816	34,816
R-squared	0.641	0.639	0.672	0.738	0.777
Household FE	✓	✓	✓	✓	✓
Wave FE	✓	✓	✓	✓	✓
Individual and household controls	✓	✓	✓	✓	✓

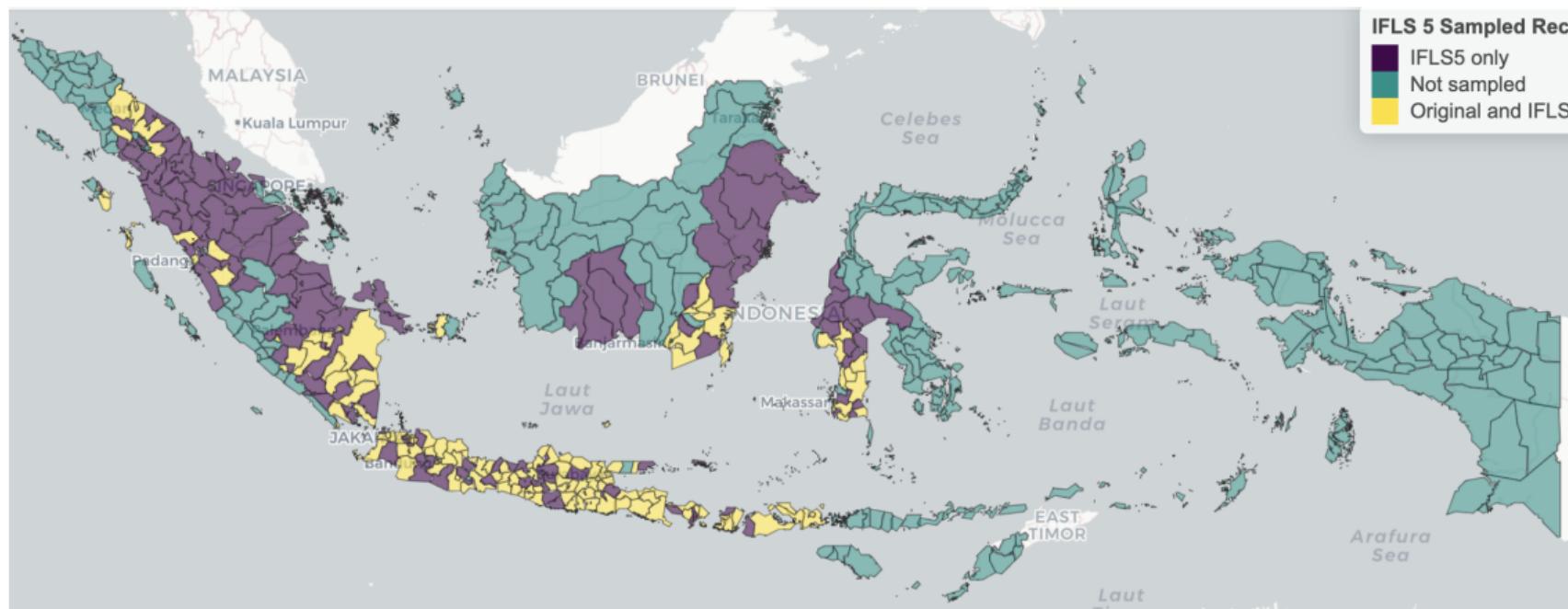
Contextual factors in the mangrove-welfare relationship

- ① Ecological Recovery Potential (feasibility of recovering mangrove ecosystems in a given area)
- ② Social Safety Nets (Unconditional cash transfers)
- ③ Social Capital (Community engagement)

Conclusion

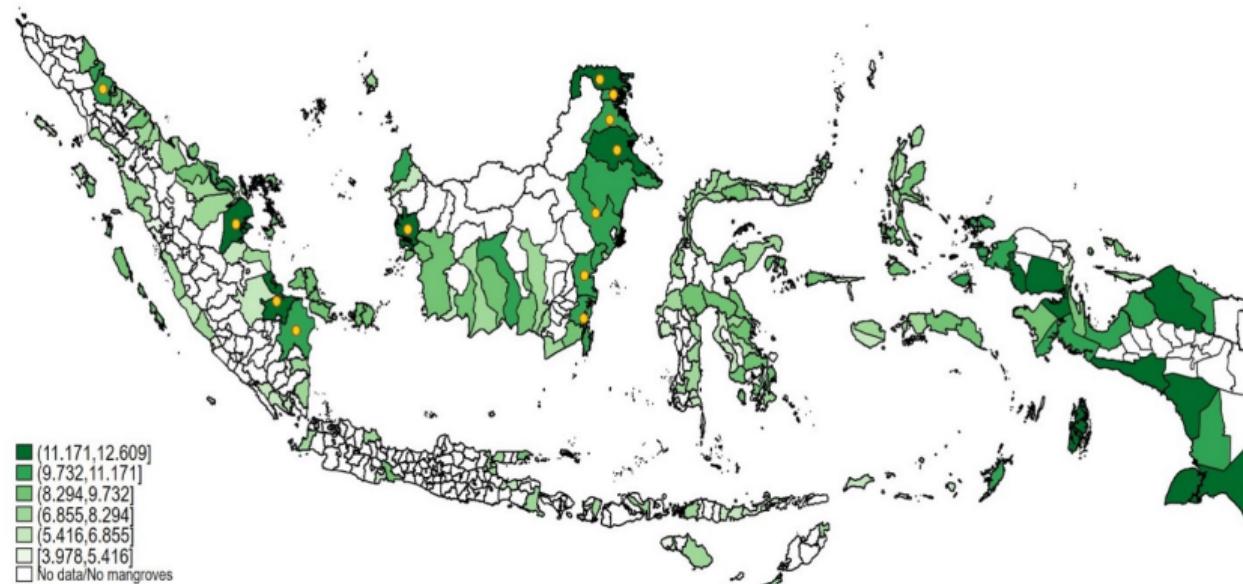
- ▶ Mangrove ecosystems improve mental well-being, extending their value beyond carbon storage and flood protection
- ▶ A persistent mangrove endowment has a clear positive effect on mental health, but the direction of land use change also matters
- ▶ Channels: reduced flood exposure, higher income, and improved dietary consumption partially explain these effects
- ▶ Mangrove conservation is not only an ecological and economic priority, but also a human capital investment, essential for climate resilience and population well-being

IFLS Coverage

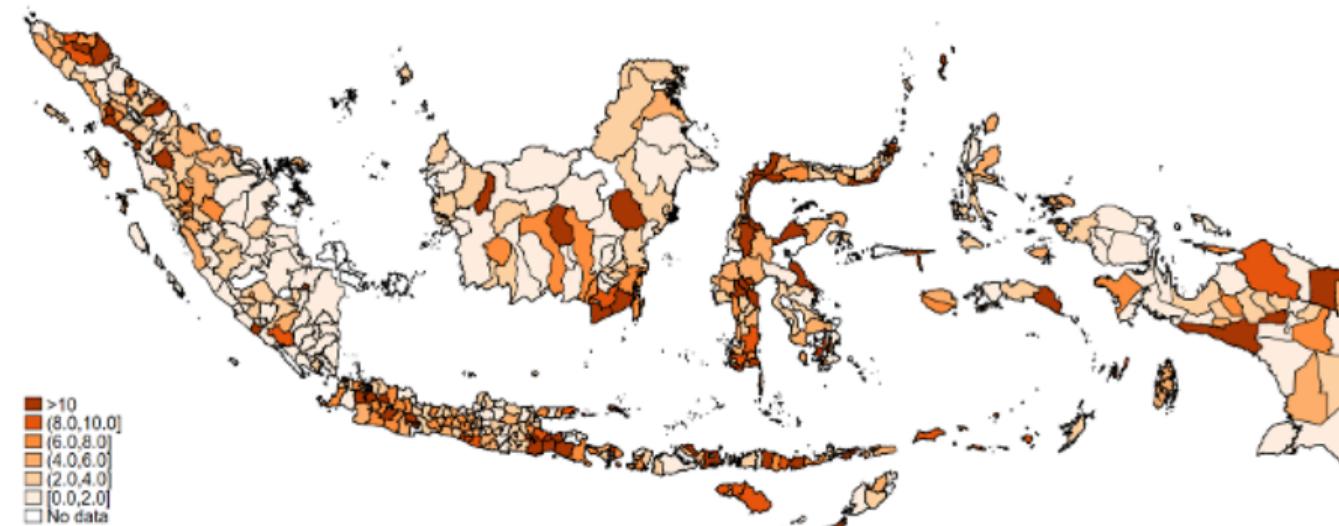


Back

Mangrove Coverage and Restoration Potential



Mental Health Conditions in Indonesia (SQR-20 score)



Summary statistics

Table 1: Summary statistics of selected variables

	Mean (1)	SD (2)	Min (3)	Max (4)
Panel A: Mental health outcomes (CESD-10)				
Total CESD-10 score	4.790	4.315	0.000	28.000
Log of CESD-10 score	1.476	0.787	0.000	3.367
Inverse hyperbolic sine of CESD-10	1.884	0.977	0.000	4.026
Binary: CESD-10 > median score	0.409	0.492	0.000	1.000
Binary: CESD-10 >= 10 (clinical cutoff)	0.134	0.341	0.000	1.000
Panel B: Cognitive outcomes				
Immediate word recall	4.907	1.872	0.000	10.000
Delayed word recall	3.879	2.044	0.000	10.000
Total episodic memory (immediate + delayed)	8.793	3.666	0.000	20.000
Raven's progression matrices test (z-score)	0.300	0.830	-2.359	1.452
Numeracy skills test (z-score)	0.199	0.995	-1.216	2.527
Overall intelligence (Raven + Numeracy, z-score)	0.299	0.855	-2.205	2.077
Panel C: Mangrove variables				
% Mangrove coverage (within 30km of community location)	0.240	0.866	0.000	10.880
% Aquaculture pond coverage (within 30km of community location)	0.764	1.911	0.000	16.536
% Persistent mangrove coverage across 1999-2022 (within 30 km of community location)	0.173	0.717	0.000	8.524
% Persistent aquaculture pond coverage across 1999-2022 (within 30 km of community location)	0.588	1.680	0.000	15.002
% Mangrove converted to aquaculture pond between 1999-2022 (within 30 km of community location)	0.037	0.182	0.000	4.923
% Aquaculture pond converted to mangroves between 1999-2022 (within 30 km of community location)	0.039	0.106	0.000	0.935

Back

Appendix: Outcome Variable Details

► Mental Health (CESD-10):

- ▶ Standard 10-item scale measuring depressive symptoms in past week
- ▶ Score range 0-30, higher scores indicate worse mental health
- ▶ Items cover feelings like sadness, hopelessness, effort, happiness (reverse coded)
- ▶ Clinical cutoff at ≥ 10 for depression screening

► Cognition: Episodic Memory

- ▶ Immediate & delayed recall of 10-word list
- ▶ Total score range 0-20.

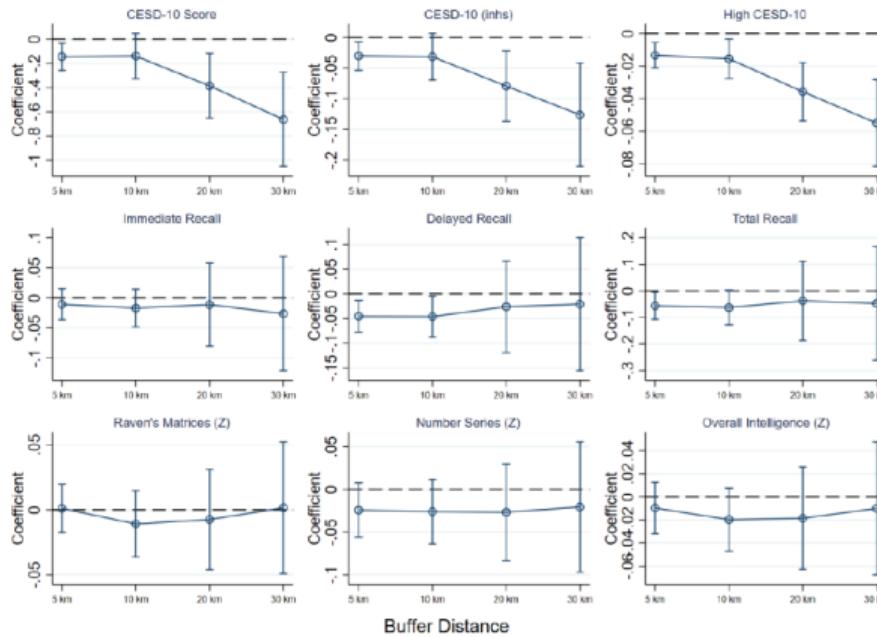
► Cognition: Fluid Intelligence Proxy

- ▶ Based on Raven's Progressive Matrices (pattern completion)
- ▶ Combined with numeracy test score
- ▶ Used to create binary indicators for 'top quartile' performance

Back

Buffer distance

Figure A3: The effects of mangrove coverage by distance bands



Back

Table 3: Heterogeneous effects of mangrove coverage

	(1)	(2)	(3)	(4)
Panel A: By gender				
	CESD-10	CESD score >= 10	total recall	overall intelligence
% Mangrove cover x female	-0.708** (0.280)	-0.060*** (0.022)	-0.009 (0.164)	-0.027 (0.043)
% Mangrove cover x male	-0.619** (0.253)	-0.050*** (0.017)	-0.083 (0.139)	0.004 (0.041)
Observations	36,948	36,948	36,084	13,982
R-squared	0.637	0.583	0.759	0.721
Panel B: By highest education level				
	CESD-10	CESD score >= 10	total recall	overall intelligence
% Mangrove cover x no formal education	-0.188 (0.445)	-0.022 (0.028)	-0.290 (0.337)	-0.111 (0.148)
% Mangrove cover x primary school	-0.642 (0.390)	-0.051* (0.027)	0.011 (0.220)	-0.145 (0.099)
% Mangrove cover x junior high school	-0.798** (0.369)	-0.063** (0.031)	0.017 (0.178)	-0.002 (0.061)
% Mangrove cover x senior high school	-0.563*** (0.187)	-0.052*** (0.015)	-0.113 (0.129)	-0.010 (0.028)
% Mangrove cover x college or above	-0.961** (0.398)	-0.065** (0.028)	0.030 (0.155)	0.084 (0.055)
Observations	36,948	36,948	36,084	13,982
R-squared	0.637	0.583	0.759	0.722
Panel C: By food insecurity status				
	CESD-10	CESD score >= 10	total recall	overall intelligence
% Mangrove cover x not food insecure	-0.665*** (0.234)	-0.054*** (0.016)	-0.072 (0.118)	-0.009 (0.037)
% Mangrove cover x food insecure	-0.622** (0.275)	-0.063*** (0.019)	0.184 (0.159)	-0.016 (0.042)
Observations	36,934	36,934	36,070	13,978
R-squared	0.637	0.583	0.760	0.721
Individual FE	✓	✓	✓	✓
Wave FE	✓	✓	✓	✓
Individual and household controls	✓	✓	✓	✓

Migration

- ▶ Selective migration can bias the relationship between environmental quality and welfare.
 - ▶ Healthier or more resilient individuals may stay in areas with better environmental amenities.
- ▶ Stratifying the sample by migration status allows us to examine differences in well-being between movers and non-movers.
- ▶ Two purposes of the analysis:
 - ▶ Test if findings are robust to endogenous sorting.
 - ▶ Understand how ecosystems affect well-being through different sources of variation.
- ▶ For non-movers: Effect is identified from changes in mangroves within the same community.
- ▶ For movers: Effect is identified from differences in mangrove cover between origin and destination communities.

Migration

- ▶ Non-movers experience significantly larger mental health benefits from mangrove cover:
- ▶ For movers, effects are smaller, although still statistically significant.
- ▶ Implications of larger benefits for non-movers:
 - ▶ Mental health benefits may result from cumulative exposure and long-term integration.
 - ▶ Benefits accumulate over time as individuals build a sense of place and stable, nature-linked livelihoods.
- ▶ Smaller effects for movers may indicate selective migration, possibly due to unobserved heterogeneities.
- ▶ Results suggest in-situ conservation and restoration initiatives could be effective for protecting well-being.

Table 4: Impacts of mangrove cover by migration status

	full sample (1)	Migration status			
		HH stayed in community (2)	HH stayed in subdistrict (3)	HH moved out of community (4)	HH moved out of subdistrict (5)
Panel A: CESD-10					
% Mangrove cover	-0.663***	-1.308***	-1.094**	-0.454*	-0.504**
(within 30km of community location)	(0.236)	(0.425)	(0.435)	(0.243)	(0.216)
Observations	36,948	28,468	32,602	8,238	4,104
Panel B: CESD score >= 10					
% Mangrove cover	-0.126**	-0.093***	-0.080***	-0.042**	-0.048***
(within 30km of community location)	-0.051	(0.029)	(0.029)	(0.017)	(0.017)
Observations	36,948	28,468	32,602	8,238	4,104
Panel C: Total recall					
% Mangrove cover	-0.047	0.021	-0.106	-0.096	-0.010
(within 30km of community location)	(0.130)	(0.321)	(0.284)	(0.110)	(0.093)
Observations	36,084	27,722	31,778	8,120	4,064
Panel D: Overall intelligence					
% Mangrove cover	-0.010	-0.141*	-0.138*	-0.006	0.006
(within 30km of community location)	(0.035)	(0.083)	(0.072)	(0.036)	(0.038)
Observations	13,982	9,500	11,202	4,314	2,612

Back

Table A1: Mangrove coverage, mental health and cognitive ability - additional controls and alternative sets of fixed effects

	baseline (Ind + wave FE)	additional controls	household + wave FE	household + wave FE + childhood controls	individual + province + wave FE	community + wave FE	sub-district + wave FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: CESD-10							
% Mangrove cover	-0.663***	-0.648***	-0.782***	-0.843***	-0.783***	-1.305***	-1.259***
(Mangrove coverage within 30 km buffer)	(0.236)	(0.233)	(0.251)	(0.257)	(0.273)	(0.493)	(0.367)
Panel B: CESD score >= 10							
% Mangrove cover	-0.061***	-0.054***	-0.062***	-0.068***	-0.096***	-0.089***	-0.017**
(Mangrove coverage within 30 km buffer)	(0.017)	(0.016)	(0.019)	(0.018)	(0.032)	(0.024)	(0.007)
Panel C: Total recall							
% Mangrove cover	-0.047	-0.052	-0.044	-0.021	-0.010	-0.137	-0.144
(Mangrove coverage within 30 km buffer)	(0.130)	(0.130)	(0.147)	(0.156)	(0.152)	(0.314)	(0.249)
Panel D: Overall Intelligence							
% Mangrove cover	-0.010	-0.010	-0.019	-0.012	-0.031	-0.207**	-0.172***
(Mangrove coverage within 30 km buffer)	(0.035)	(0.035)	(0.043)	(0.043)	(0.042)	(0.089)	(0.063)

Table A2: The effects of mangroves on mental health and cognitive ability – all land-use groups

	(1)	(2)	(3)	(4)
	Outcome variable:			
	CESD-10	CESD score >= 10	total recall	overall intelligence
% Mangrove persistence (1999-2022, within 30 km buffer)	-0.153** (0.074)	-0.015*** (0.005)	0.171*** (0.061)	0.078*** (0.014)
% Aquaculture persistence (1999-2022, within 30 km buffer)	-0.005 (0.055)	0.001 (0.003)	-0.148*** (0.048)	-0.015 (0.015)
% Mangrove converted to aquaculture (1999-2022, within 30 km buffer)	1.30*** (0.376)	0.131*** (0.023)	-0.350 (0.333)	0.148* (0.075)
% Mangrove converted to other land uses (1999-2022, within 30 km buffer)	-1.22*** (0.468)	-0.092** (0.040)	-0.045 (0.469)	-0.303** (0.121)
% Aquaculture converted to mangrove (1999-2022, within 30 km buffer)	-3.57*** (0.988)	-0.212*** (0.060)	3.35*** (0.842)	0.140 (0.313)
% Aquaculture converted to other land uses (1999-2022, within 30 km buffer)	-0.269 (0.246)	-0.039** (0.019)	-0.475** (0.205)	0.015 (0.058)
% Other land uses converted to aquaculture (1999-2022, within 30 km buffer)	1.48*** (0.392)	0.072*** (0.026)	0.491 (0.354)	-0.170* (0.092)
Observations	18,474	18,474	18,042	7,029
R ²	0.0105	0.007	0.005	0.01

Table A3: Mangrove coverage, perceived upward social mobility, and future economic outlook

	(1)	(2)	(3)
Panel A: Low perceived upward social mobility			
(based on subjective social status)			
	current and future	past and future	past, current, future
% Mangrove cover (within 30km of community location)	-0.024* (0.012)	-0.017 (0.011)	-0.017 (0.011)
Observations	32,734	32,734	32,734
R-squared	0.581	0.579	0.582
Panel B: Standard of living and future economic outlook			
bleak economic outlook			
	inadequate std of living (adults and children)	bleak economic outlook and low social mobility	
% Mangrove cover (within 30km of community location)	-0.022 (0.020)	0.011 (0.012)	-0.012 (0.009)
Observations	35,868	15,416	32,174
R-squared	0.614	0.596	0.571
Individual FE	✓	✓	✓
Wave FE	✓	✓	✓
Individual and household controls	✓	✓	✓

Table A4: Mangrove coverage, mental health, cognition, and unconditional cash transfers

	Dependent variables:					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Mental health						
	CESD-10	CESD-10 (log)	CESD-10 (inhs)	> median CESD-10	=>10 cutoff	
% Mangrove cover (within 30km of community location)	-0.650*** (0.235)	-0.103** (0.041)	-0.125** (0.051)	-0.034 (0.023)	-0.054*** (0.016)	
Received unconditional cash transfer (BCT/BLSM) (1 = Received BCT/BLSM in the past 5 years)	0.270* (0.145)	0.055** (0.025)	0.068** (0.031)	0.026 (0.016)	0.019 (0.012)	
% Mangrove cover x received cash transfer	-0.222 (0.172)	-0.024 (0.024)	-0.027 (0.029)	-0.029** (0.014)	-0.017 (0.017)	
Observations	36,948	36,948	36,948	36,948	36,948	
R-squared	0.637	0.624	0.619	0.604	0.583	
Panel B: Cognitive ability						
	episodic memory		fluid intelligence		overall intelligence	
	immediate recall	delayed recall	general reasoning (Raven's z-score)	numeracy skills (z-score)	numeracy skills (z-score)	overall intelligence
% Mangrove cover (within 30km of community location)	-0.026 (0.057)	-0.027 (0.082)	-0.052 (0.129)	-0.000 (0.032)	-0.017 (0.046)	-0.010 (0.036)
Received unconditional cash transfer (BCT/BLSM) (1 = Received BCT/BLSM in the past 5 years)	-0.010 (0.052)	-0.098* (0.056)	-0.108 (0.096)	0.011 (0.034)	-0.003 (0.048)	0.003 (0.038)
% Mangrove cover x received cash transfer	-0.001 (0.059)	0.098* (0.051)	0.097 (0.089)	0.027 (0.043)	-0.043 (0.066)	-0.001 (0.050)
Observations	36,084	36,084	36,084	13,982	13,982	13,982
R-squared	0.748	0.721	0.759	0.691	0.674	0.721

Table A5: Mangrove coverage, mental health, cognition, and social capital

	Dependent variables:			
	(1)	(2)	(3)	(4)
Panel A: CESD-10				
% Mangrove cover (within 30km of community location)	-0.663*** (0.236)		-0.658*** (0.235)	-0.657*** (0.236)
1 = High social capital (Trust public safety and participate in comm. meetings)		-0.254** (0.103)	-0.252** (0.103)	-0.251** (0.108)
Mangrove cover x high social Capital				-0.001 (0.081)
Panel B: Total recall				
% Mangrove cover (within 30km of community location)	+0.047 (0.130)		-0.047 (0.130)	-0.032 (0.132)
1 = High social capital (Trust public safety and participate in comm. meetings)		0.128* (0.068)	0.128* (0.068)	0.133* (0.071)
Mangrove cover x high social Capital				-0.026 (0.117)
Panel C: Overall intelligence				
% Mangrove cover (within 30km of community location)	-0.010 (0.035)		-0.010 (0.035)	0.009 (0.041)
1 = High social capital (Trust public safety and participate in comm. meetings)		0.032 (0.025)	0.033 (0.025)	0.040 (0.026)
Mangrove cover x high social Capital				-0.036 (0.027)
Individual FE	✓	✓	✓	✓
Wave FE	✓	✓	✓	✓
Individual and household controls	✓	✓	✓	✓