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Sustainable Development Key to Limiting Climate Change-Driven Wildfire Damages

Yi-Ling Hwong

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Los Angeles fires

Estimated cost of fire damage balloons to more than $250 billion

Background

- Climate change is causing wildfires to become more frequent, intense, persistent, and widespread
- Process-based fire models capable of simulating fire emission and burned areas (e.g., FireMIP)
- Climate-related factors ("fire weather") strongly correlated with burned areas
- However,
  - Economic loss modelling of wildfire damage in its infancy
  - Non-climate related predictors under-explored

Research objectives

1. Identify key drivers of global economic damages of wildfires
2. Project and compare future global wildfire damages under different climate and socio-economic scenarios (SSPs)

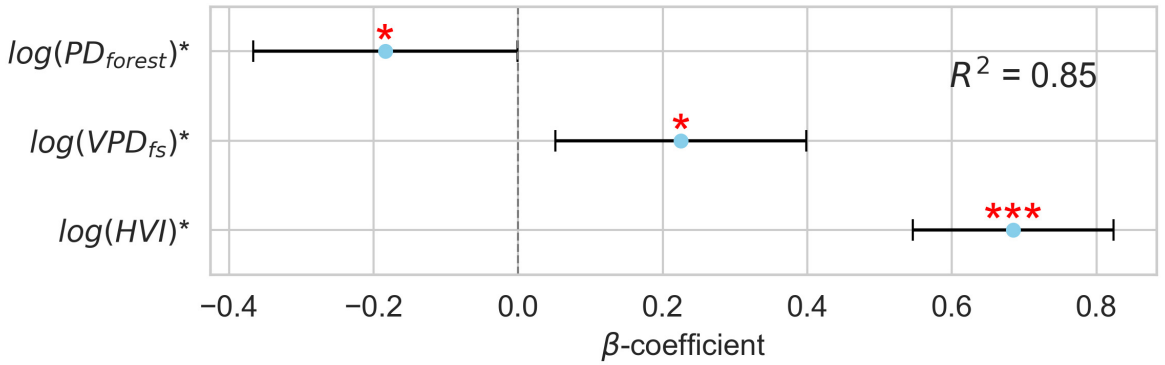
Methods

- Multiple regression analysis (generalised linear model)
- Outcome variable $\boldsymbol{y}$: wildfire economic damage data (EM-DAT), normalized by country GDP (%GDP)
- Independent variables $\boldsymbol{X}$:
  - Climatological: fire-season water vapour pressure deficit (VPD_{fs})(ISIMIP3a)
  - Anthropogenic: population density around forested area (PD_{forest})(GLOBIOM)
  - Socio-economic: human vulnerability index (HVI = 1 – HDI)(UNDP)
- Equation with standardised variables:

$$Z_{log(damage)} = \beta_0 + \beta_1 Z_{log(VPD_{fs})} + \beta_2 Z_{log(PD_{forest})} + \beta_3 Z_{log(\mathrm{HVI})} + \epsilon$$

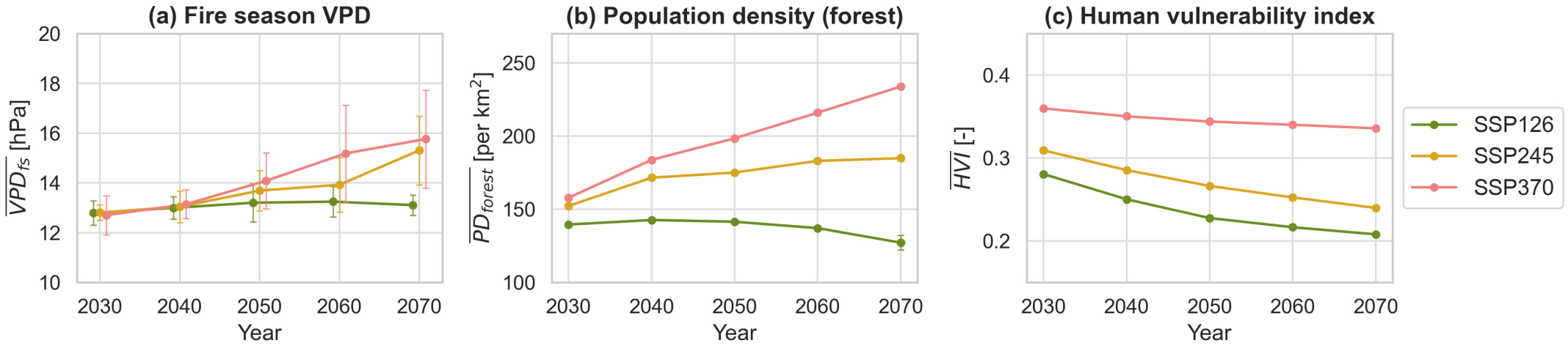
- Project future wildfire economic damages using β 's from fitted model

Important predictors of wildfire damages



- $R^2 = 0.85$
  - 10-fold CV $R^2 = 0.83$
- All three predictors statistically significant ($p < .05$)
- Predictor importance ranking:
  1. HVI ($\beta = 0.68$)
  2. VPD_{fs} ($\beta = 0.23$)
  3. PD_{forest} ($\beta = -0.18$)
- PD_{forest} negatively correlated with wildfire damages

Trends in predictor evolution



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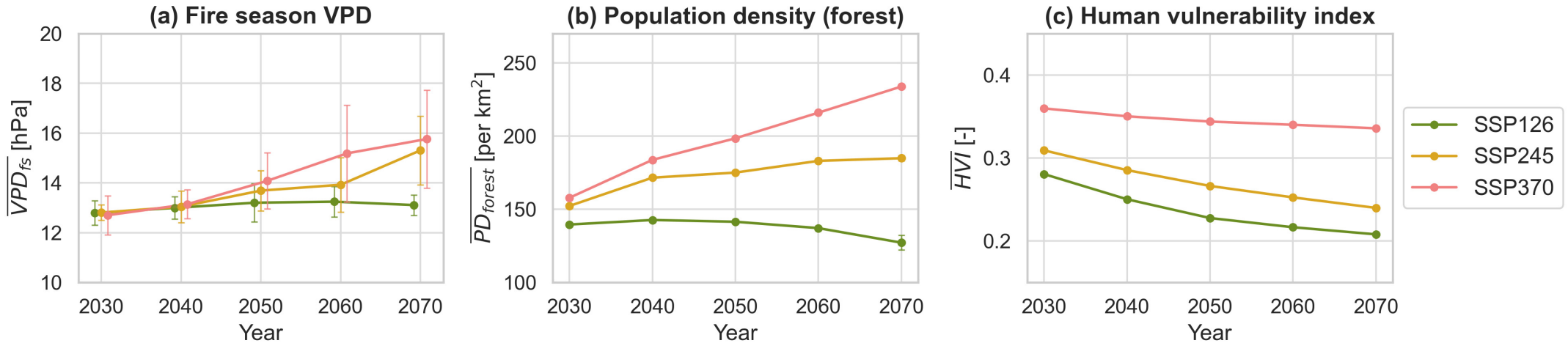
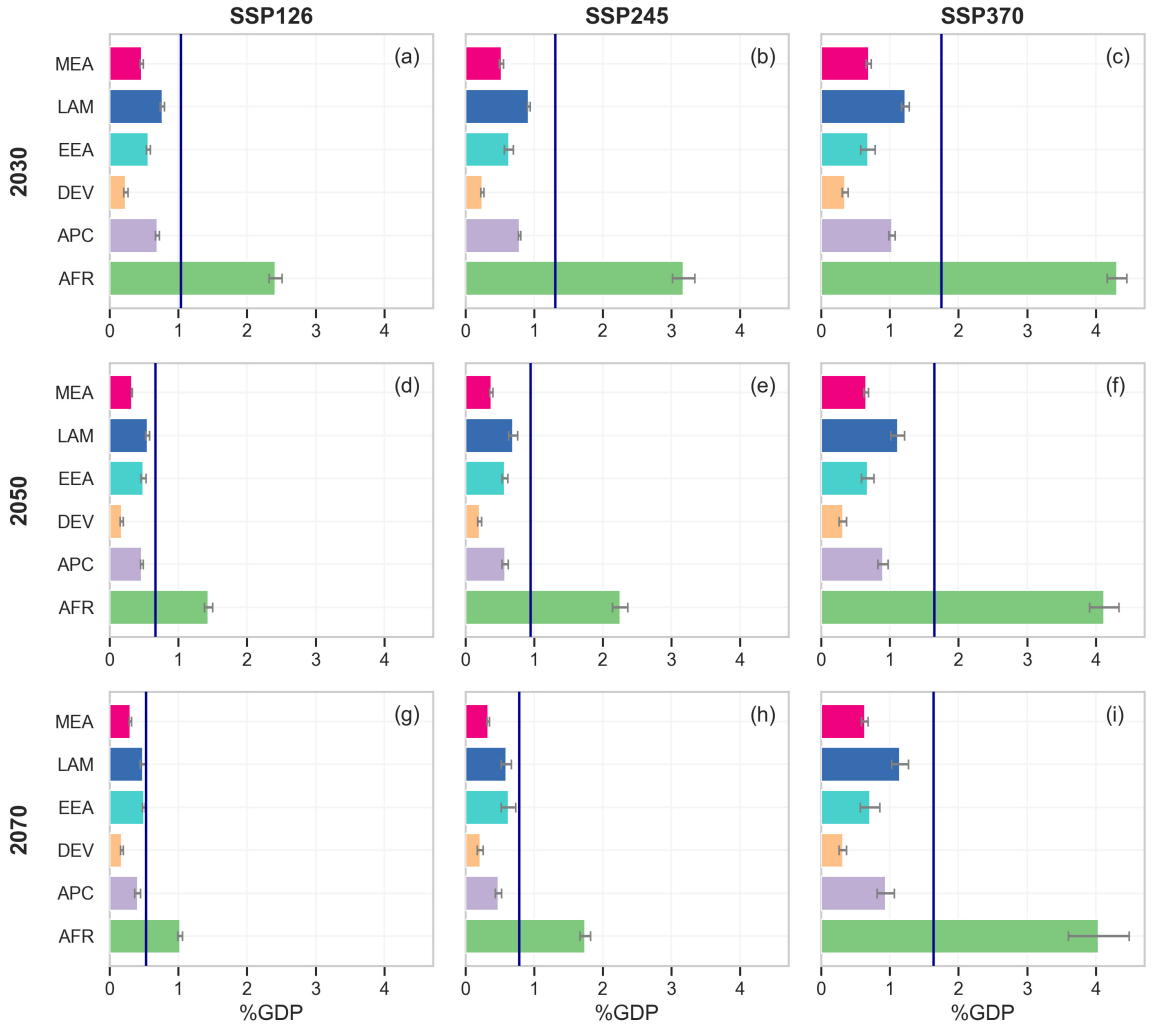


- VPD_{fs} worst under SSP370, slightly improves under SSP126
- PD_{forest} decreases under SSP126, grows fastest under SSP370 due to greater population growth
- HVI drops under SSP126, remains high and stagnates under SSP370

Future wildfire damage projections



MEA (Middle East), LAM (Latin America & Caribbean), EEA (Eastern Europe & West-Central Asia), DEV (Developed countries), APC (Asia & Developing Pacific), AFR (Africa)

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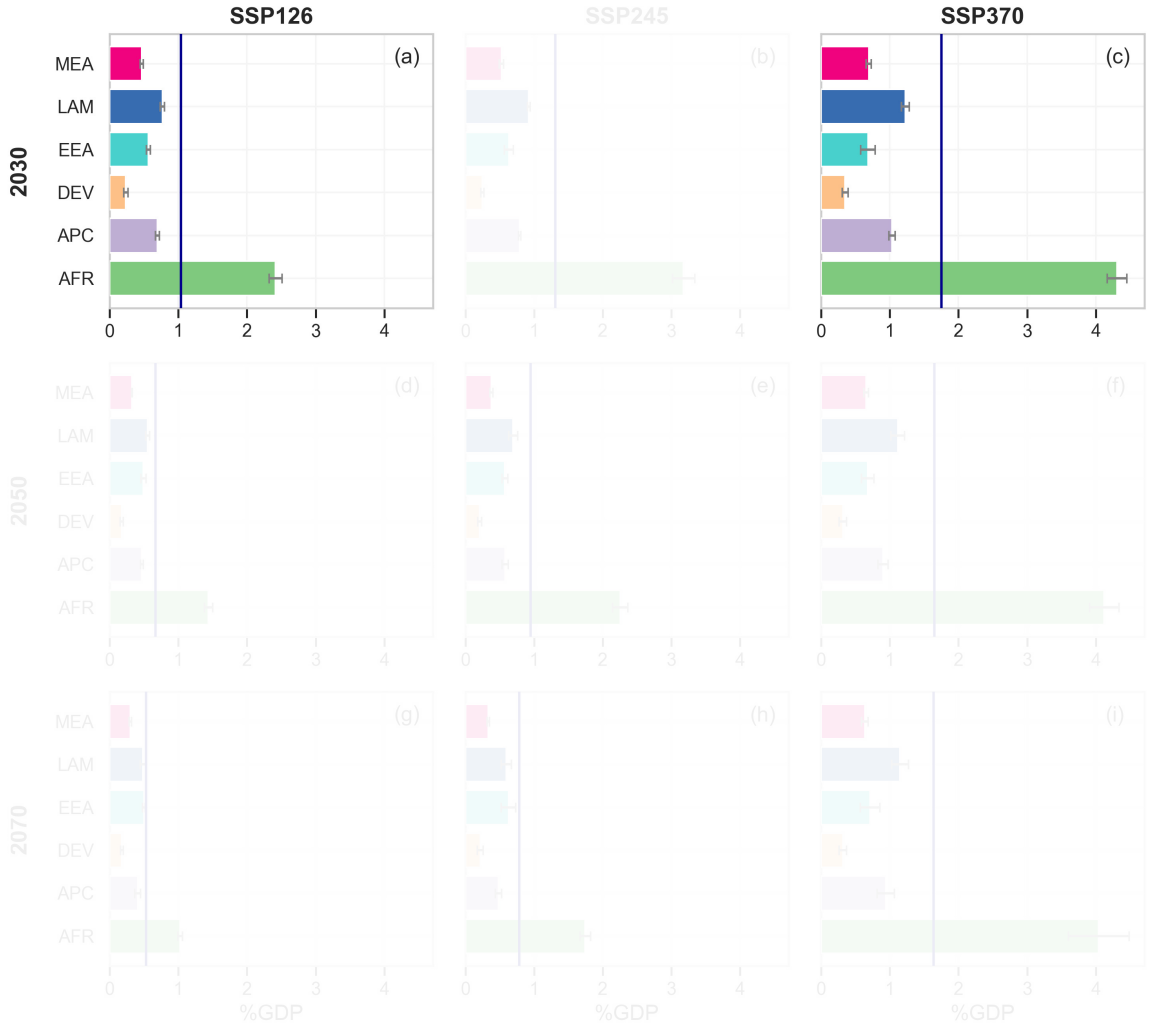

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- Global mean wildfire damages greater under SSP370, with LDC experiencing larger damages
- Disparity widens by 2070: damages 3x larger under SSP370 vs. SSP126

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- More even damage distribution under SSP126

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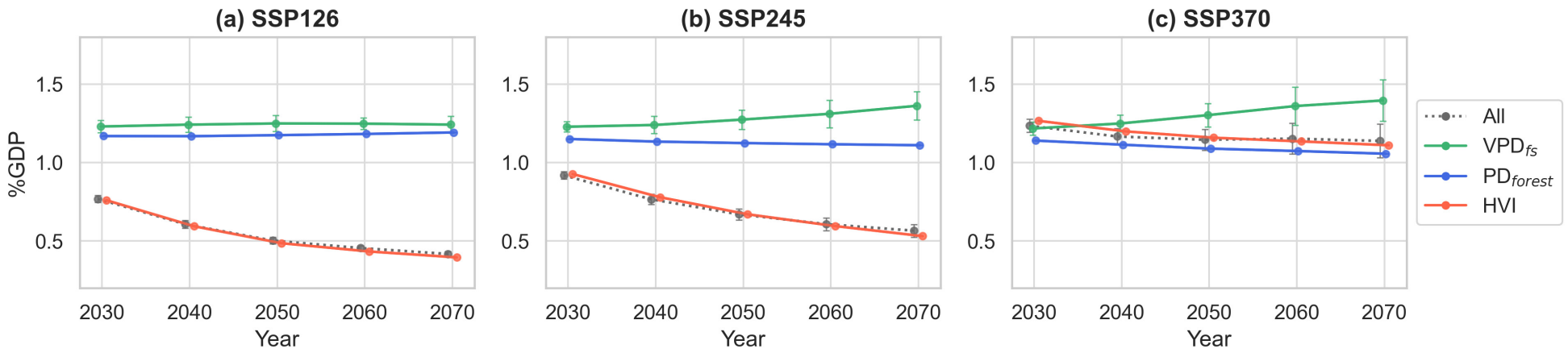
Predictor contributions to future wildfire damages



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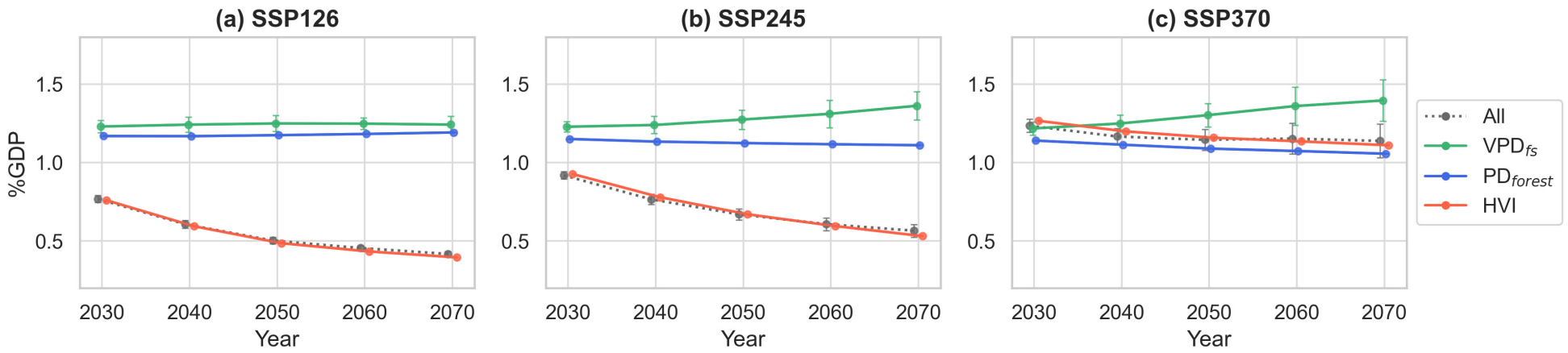

- Damage reduction due to improving socio-economic conditions can offset climate-driven damages, but less certain under SSP370

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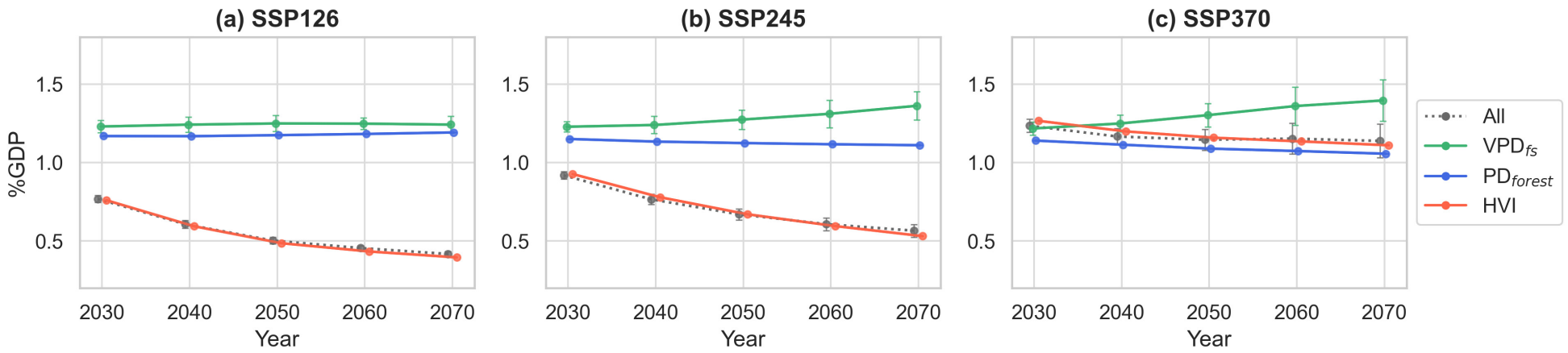

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- VPD_{fs} (climate) related damages stabilise under SSP126, grow under SSP245 and SSP370
- Climate-driven damages highest for all three SSPs if socio-economic conditions remain stagnant at historical levels

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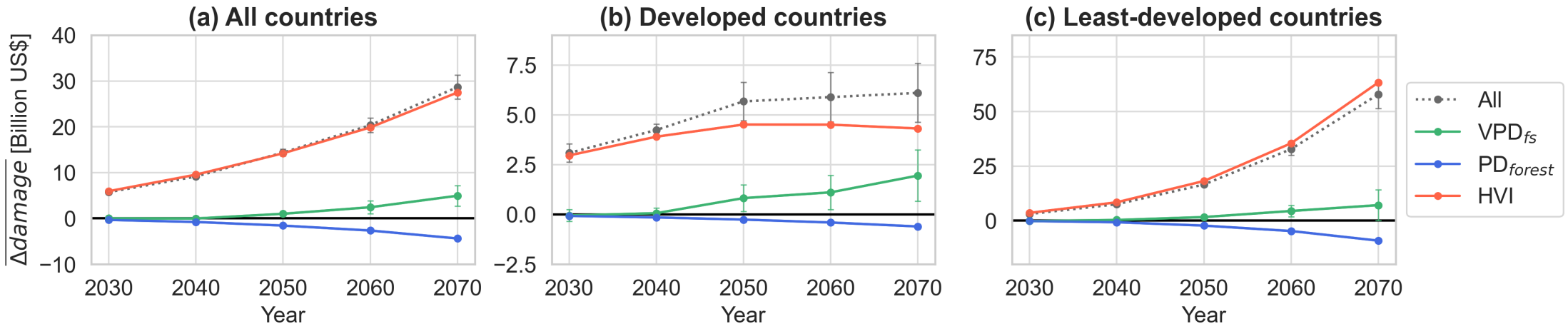
What do countries stand to gain by following a sustainable pathway?



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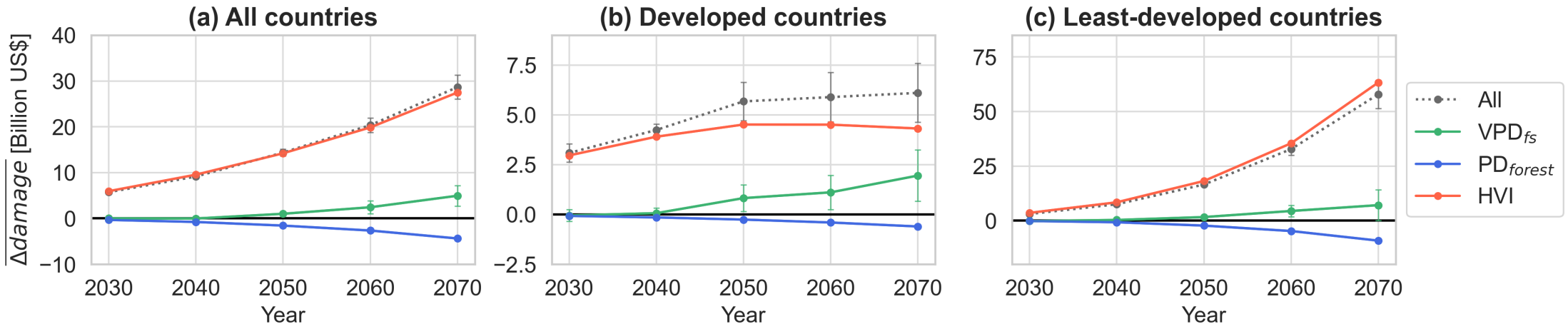

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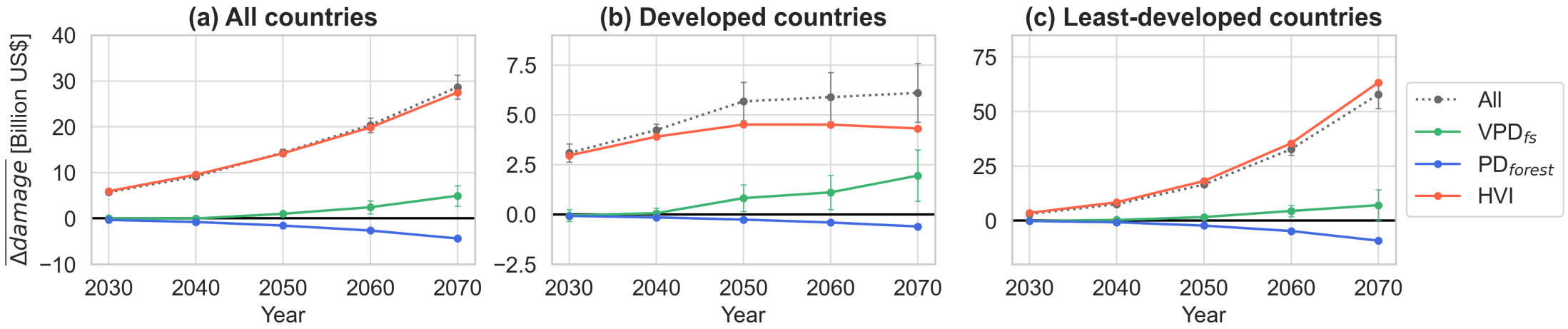

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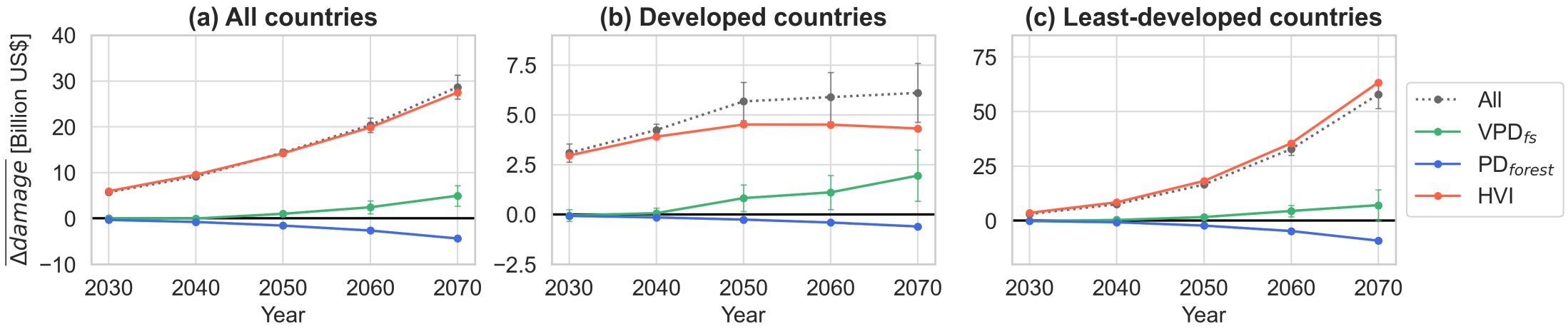

- Following SSP126 leads to damage reduction, except in PD_{forest}-only scenario
- Developed countries: climate hazard could become dominant driver if socio-economic conditions remain stable at current high levels
- LDCs: potential gains of following SSP126 up to 10x greater compared to developed countries

Conclusions

- Socio-economic factor (HVI) strongest predictor of historical wildfire damages, differs from predictions of burned areas where climatological factors more important

- A sustainable pathway (SSP126) leads to reduction and more even distribution in wildfire damages through more equitable socio-economic progress (lower HVI) and stronger climate actions (lower VPD_{fs})

- Robust socio-economic development can offset wildfire damages attributable to climate hazards, but this outcome not guaranteed under SSP370

preprint

Hwong et al. (submitted)