INSTITUTE FOR SUSTAINABLE RESOURCES

The economic dynamics of climate change impacts, mitigation and adaptation: challenges and opportunities

Alvaro Calzadilla
UCL Institute for Sustainable Resources

Workshop on Pension Design, 7th November 2025

Outline

Climate change impacts, mitigation and adaptation

- Climate risks
- Investment needs
- Financial gaps
- Cost of inaction

Economy-wide impacts of decarbonisation

- Scenarios
- UCL – ENGAGE model
- Results

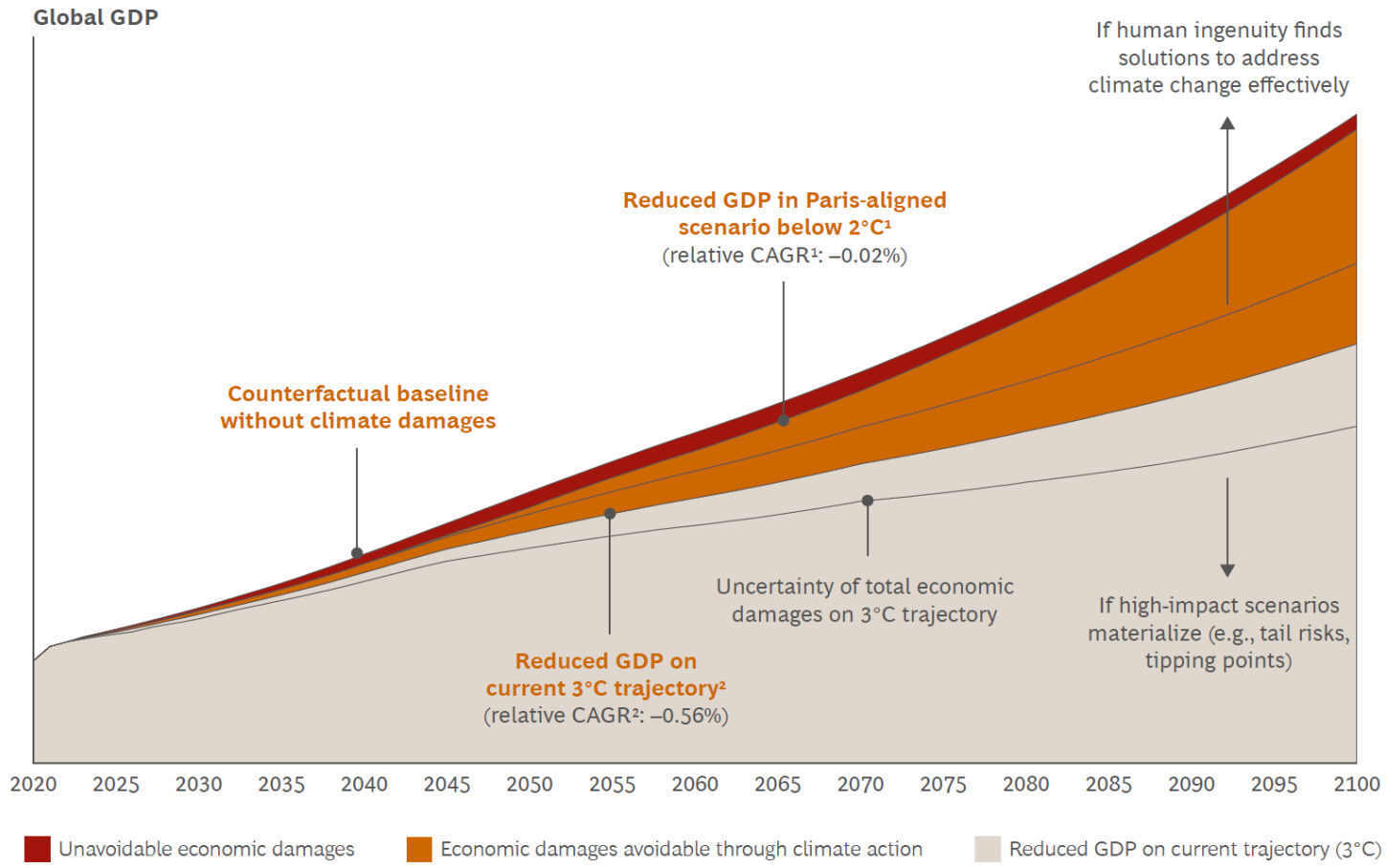
Conclusions

Climate change impacts, mitigation and adaptation

Climate change risks

- Extreme heat
- Drought/Floods
- Wildfire
- Damage to natural capital and ecosystem services
- Damage to capital stock
- Productivity loss
- Supply chain disruptions
- Financial instability
- …

Economic damages of climate change on a 3°C trajectory



Source: Benayad et a. 2025

Climate change impacts, mitigation and adaptation

Paris Agreement

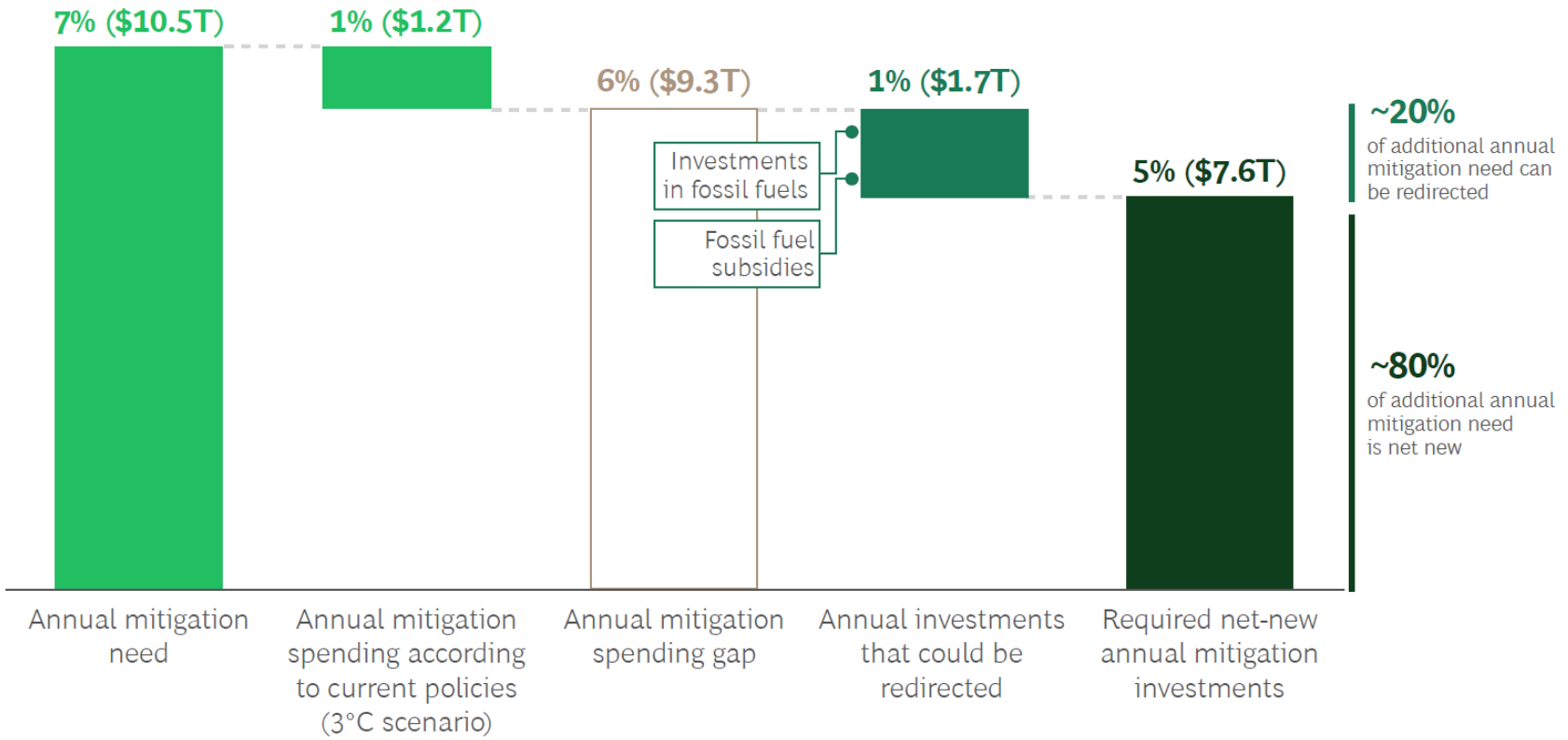
To limit warming below 2°C, global annual GHG emissions need to decrease:

From ~50 Gt today

To ~30 Gt by 2030

To carbon neutrality in 2050

Annual mitigation need and spending by 2050 (cumulative GDP)



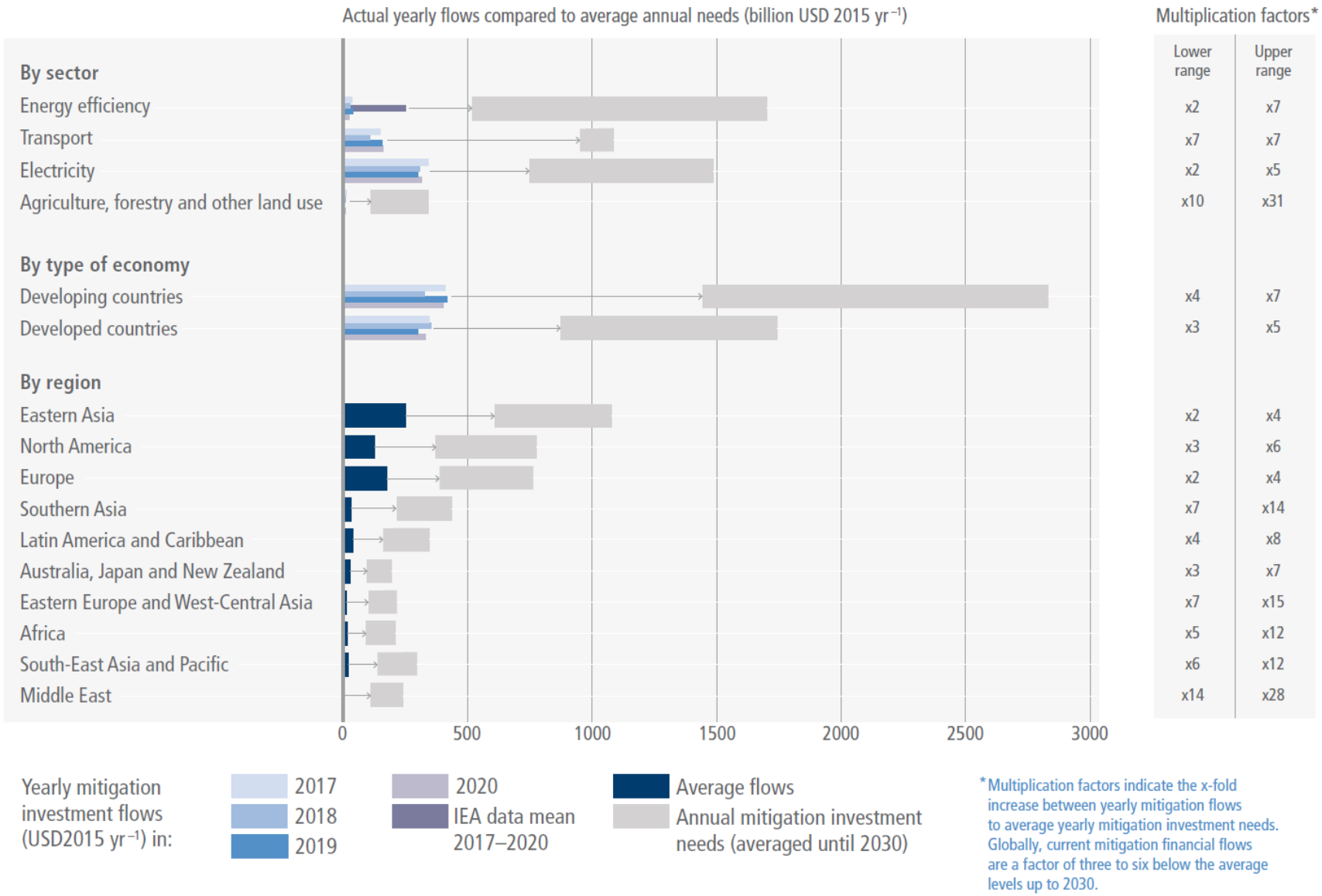
Source: Benayad et a. 2025

Climate change impact

Financial gaps

Globally, yearly climate finance flows have to increase by a factor between 3 and 6 to meet average annual needs between 2020 and 2030

Breakdown of recent average (downstream) mitigation investments and model-based investment requirements for 2020–2030 (USD billion) in scenarios that likely limit warming to 2°C or lower

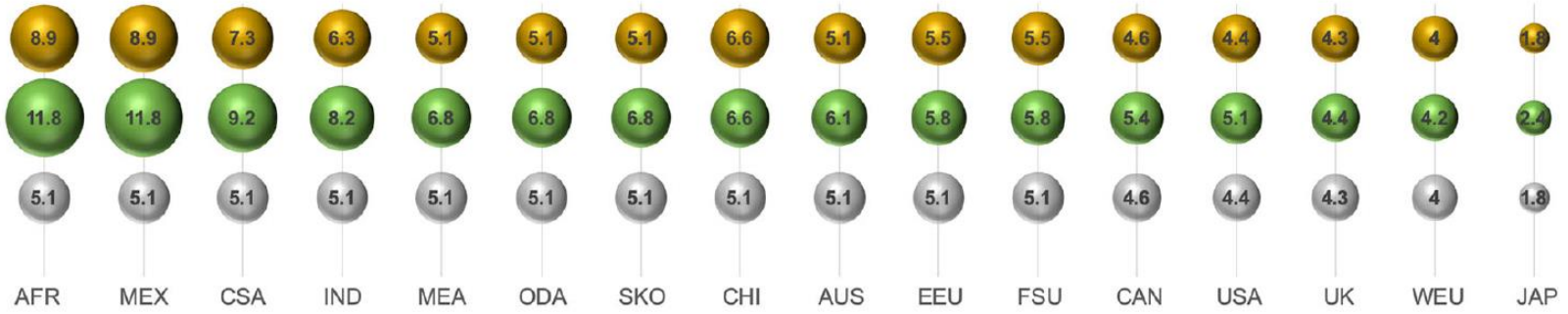


Source: IPCC 2022

Climate change impacts, m

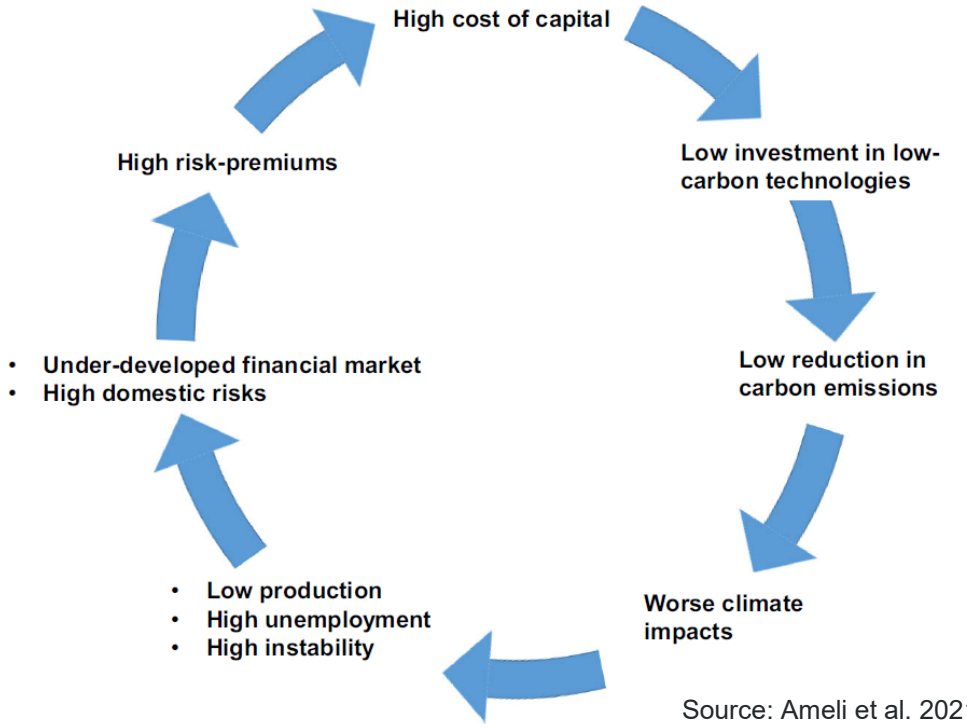
Cost of finance

The weighted average cost of capital (WACC, weighted average cost of raising funding for a specific project from different sources) is generally higher for low-carbon technologies and in developing economies



Low-carbon (green), high-carbon (brown) and reduced (grey) WACC values across regions

Source: Ameli et al. 2021



Source: Ameli et al. 2021

The climate investment trap at the macroeconomic level

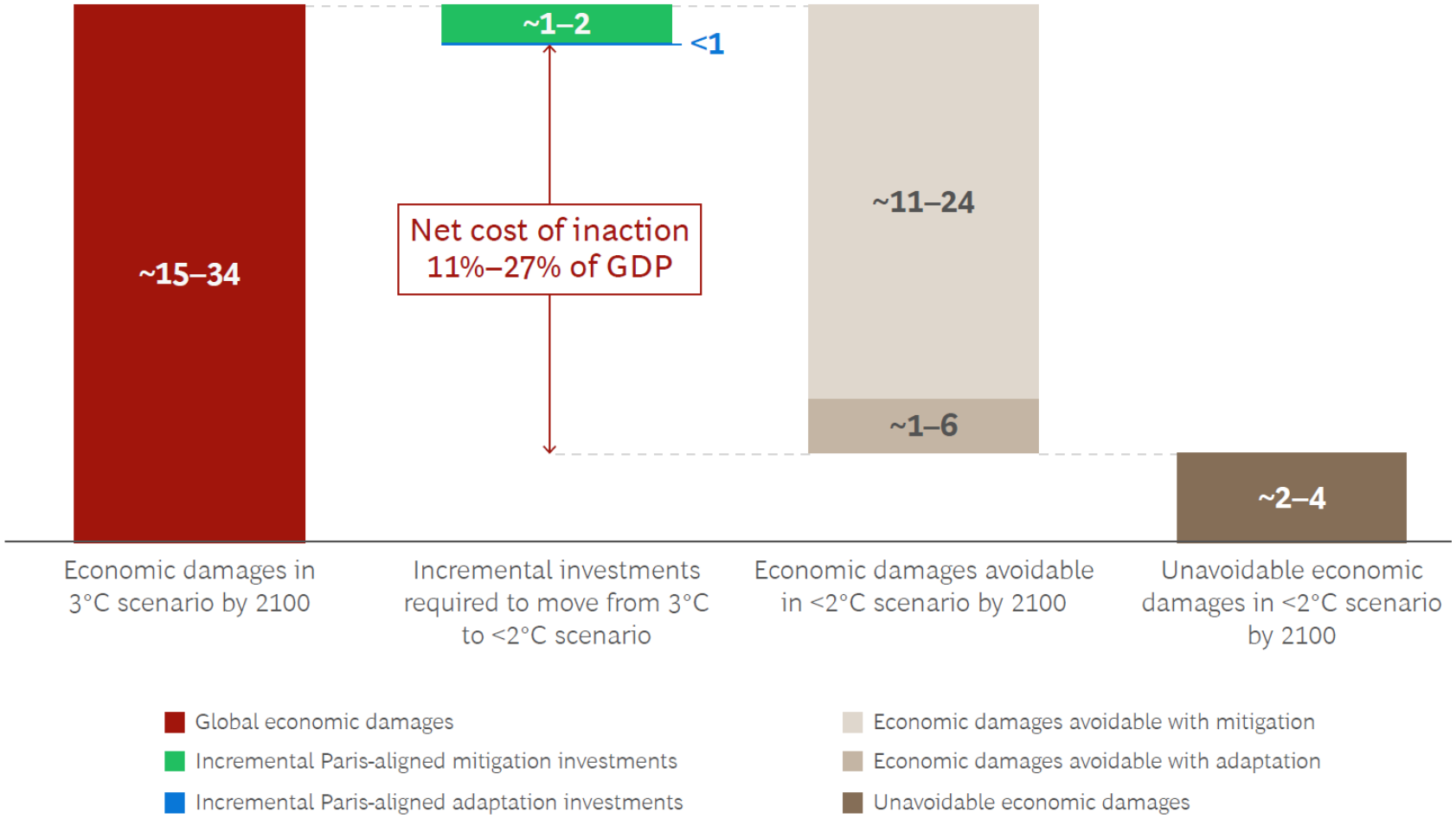

nature COMMUNICATIONS
ARTICLE
https://doi.org/10.1038/s41467-021-24305-3 OPEN
Higher cost of finance exacerbates a climate investment trap in developing economies
Nadia Ameli[1✉], Olivier Dessens[1,2], Matthew Winning[1,2], Jennifer Cronin[2], Hugues Chenet[1,3], Paul Drummond[1], Alvaro Calzadilla[1], Gabrial Anandarajah[2] & Michael Grubb[1]

Climate change impacts, mitigation and adaptation

Economic cost of inaction

The cost of inaction is around 11% to 27% of global GDP in 2100

Climate change costs and investments by 2100 (cumulative GDP, %)

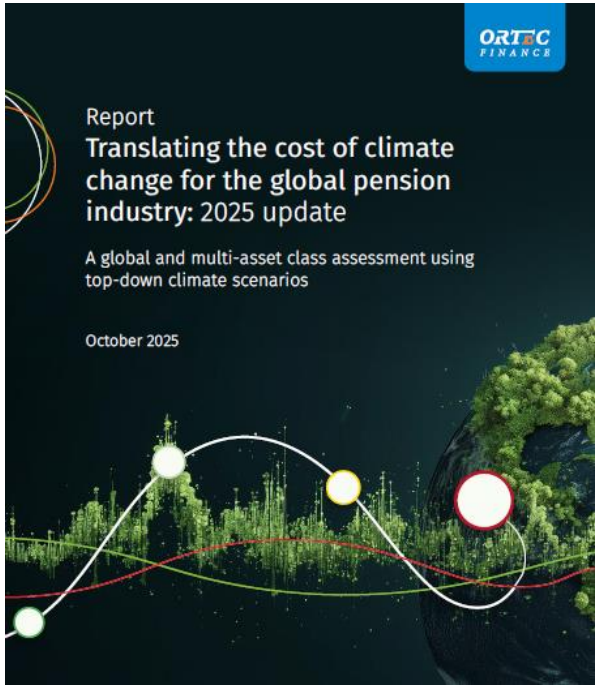


Source: Benayad et a. 2025

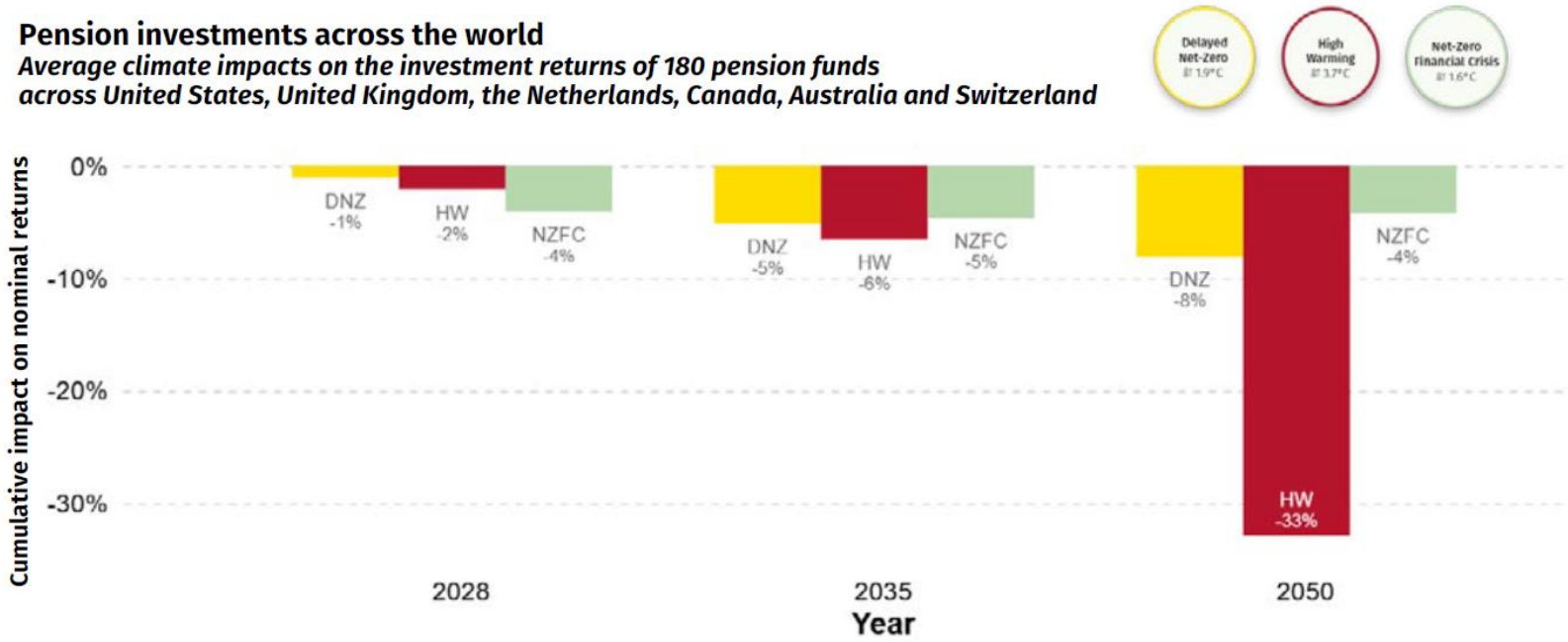
Climate change impacts, mitigation and adaptation

Pension portfolios return

A failed low-carbon transition could wipe 33% off pension fund returns worldwide by 2050 in a high warming climate scenario



Nominal pension portfolios returns



Source: Ortec Finance 2025

Economy-wide impacts of decarbonisation - Scenarios

CS-N0W WPE1 analysis

STEPS: Stated Policies Scenario

- Represents a BAU scenario
- SSP2 population growth, economic growth, and structural changes
- Provides a benchmark against which other scenarios are measured

APS: Announced Pledges Scenario

- Assumes that all commitments to act on climate change are fulfilled

Beyond SDS: Beyond Sustainable Development Scenario

- Goes beyond the SDS scenario described above and brings the global energy-related CO2 emissions to net zero by 2050.

Economy-wide impacts of decarbonisation – ENGAGE model

UCL - Environmental Global Applied General Equilibrium (ENGAGE) model

- Multi-region, multi-sector dynamic CGE model of the world economy
- Based on the GTAP10-Power latest database (141 countries/regions, 76 sectors)
- Represents the global economy in 2011
- Based on gtap9ingams model in MPSGE (Lanz and Rutherford 2016)
- Recursive dynamic model 2011-2050 (extendable)
- Models 16 regions, 27 sectors (4 crops, 13 energy sectors) and 4 factors of production

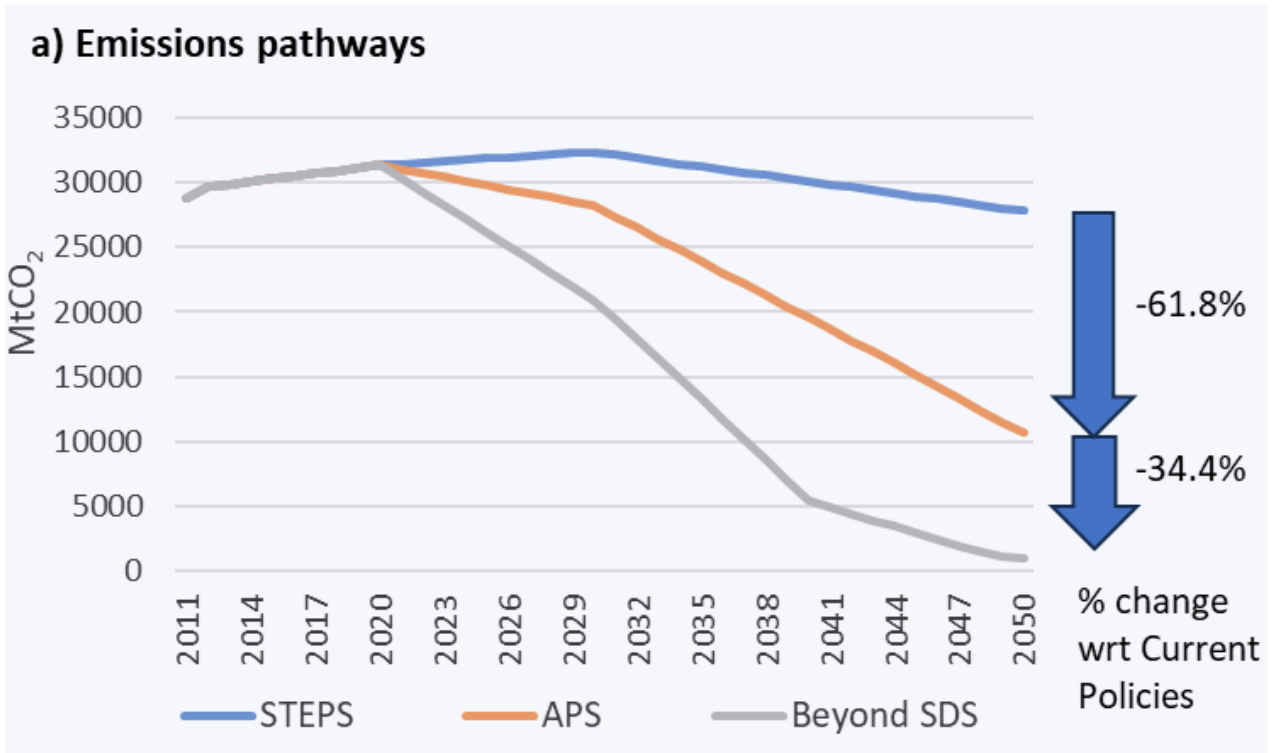
16 Regions	
AFR	Africa
AUS	Australia
CAN	Canada
CSA	Central and South America
CHI	China
EEU	Eastern Europe
FSU	Former Soviet Union
IND	India
JAP	Japan
MEA	Middle-east
MEX	Mexico
ODA	Other Developing Asia
SKO	South Korea
UK	United Kingdom
USA	USA
WEU	Western Europe

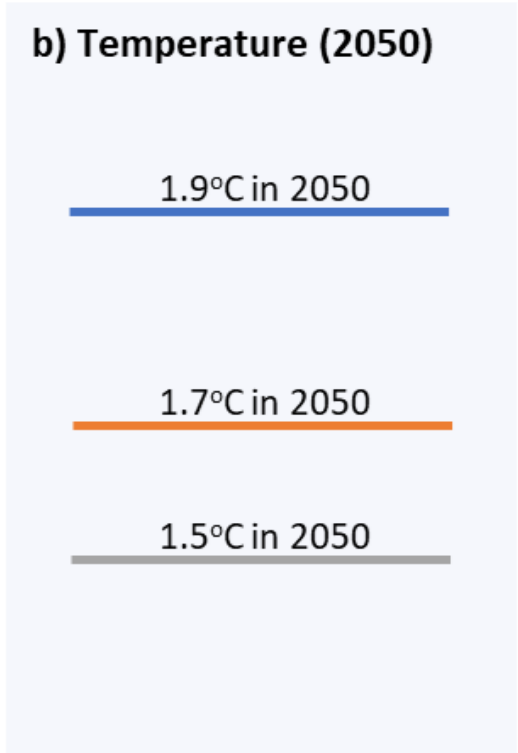
4 Factors of production	
LND	Land
LAB	Labour
CAP	Capital
RES	Natural resources

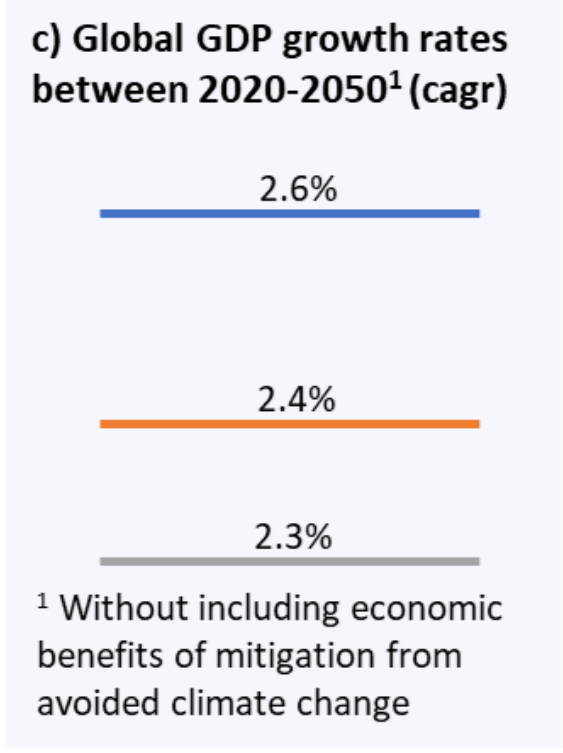
27 Sectors	
PDR	Paddy rice
WHT	Wheat
GRO	Cereal grains
OCR	Other crops
A_F	Agriculture and food
MIN	Minerals
PPP	Paper
CRP	Chemical
NMM	Non-metalic minerals
I_S	Iron and steel
MPR	Metal products
IND	Other industry
COA	Coal
OIL	Crude oil
GAS	Gas
P_C	Petroleum & Coke
NUP	Nuclear power
CFP	Coal-fired power
GFP	Gas-fired power
WIP	Wind power
HYP	Hydroelectric power
OFP	Oil-fired power
OTP	Other power
SOP	Solar power
TnD	Transmission and distribution
SER	Services
TRN	Transport

Economy-wide impacts of decarbonisation – Key results

Global CO_2 emissions, temperature and economic impacts by decarbonisation scenario

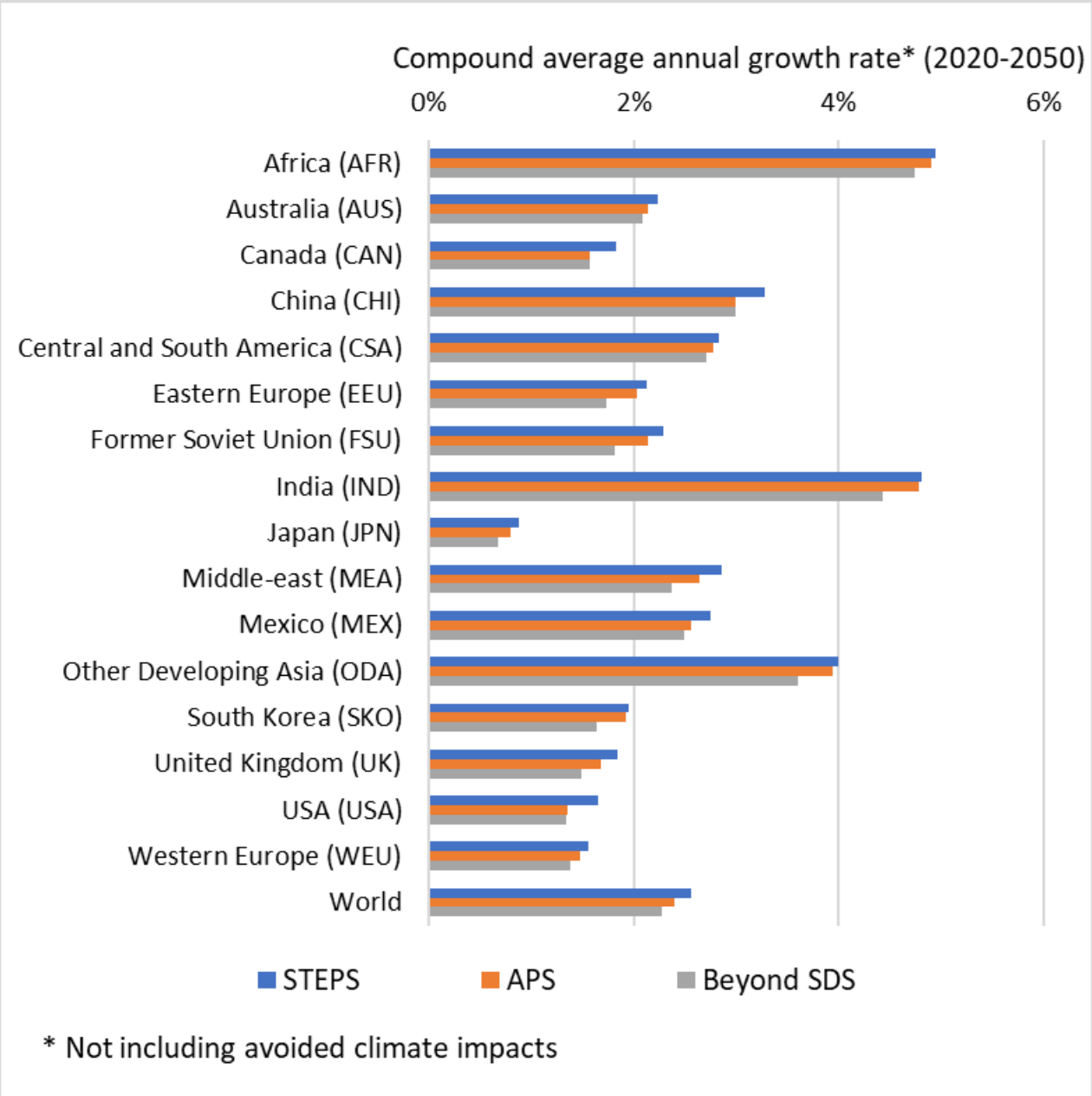






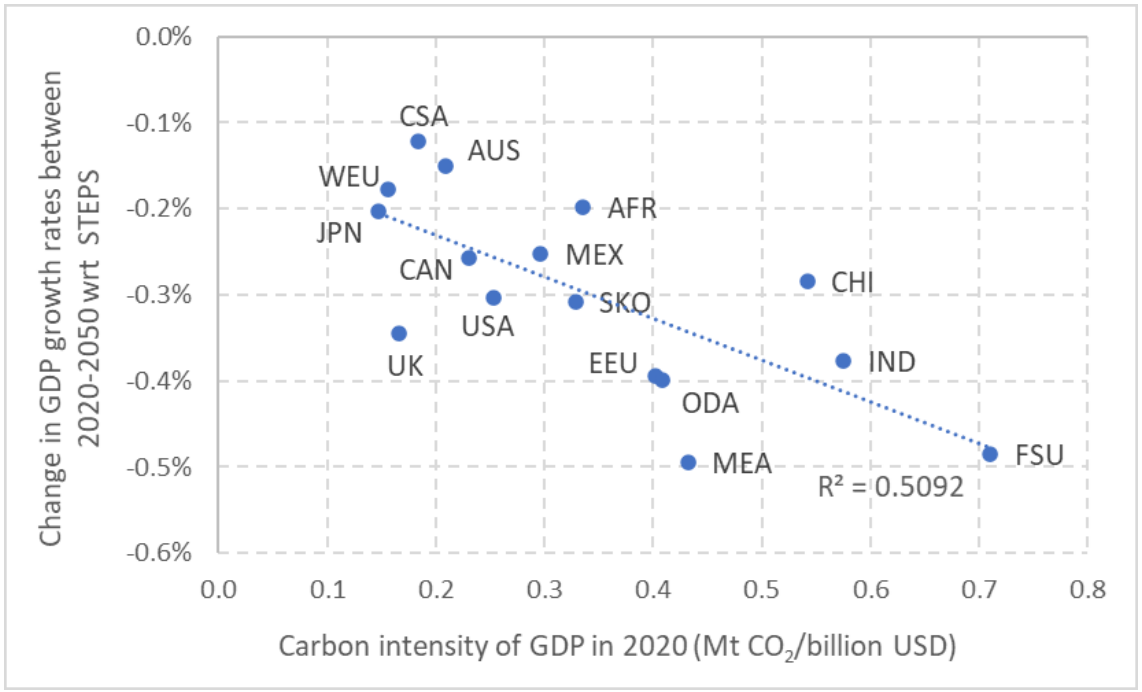
Economy-wide impacts of decarbonisation – Key results

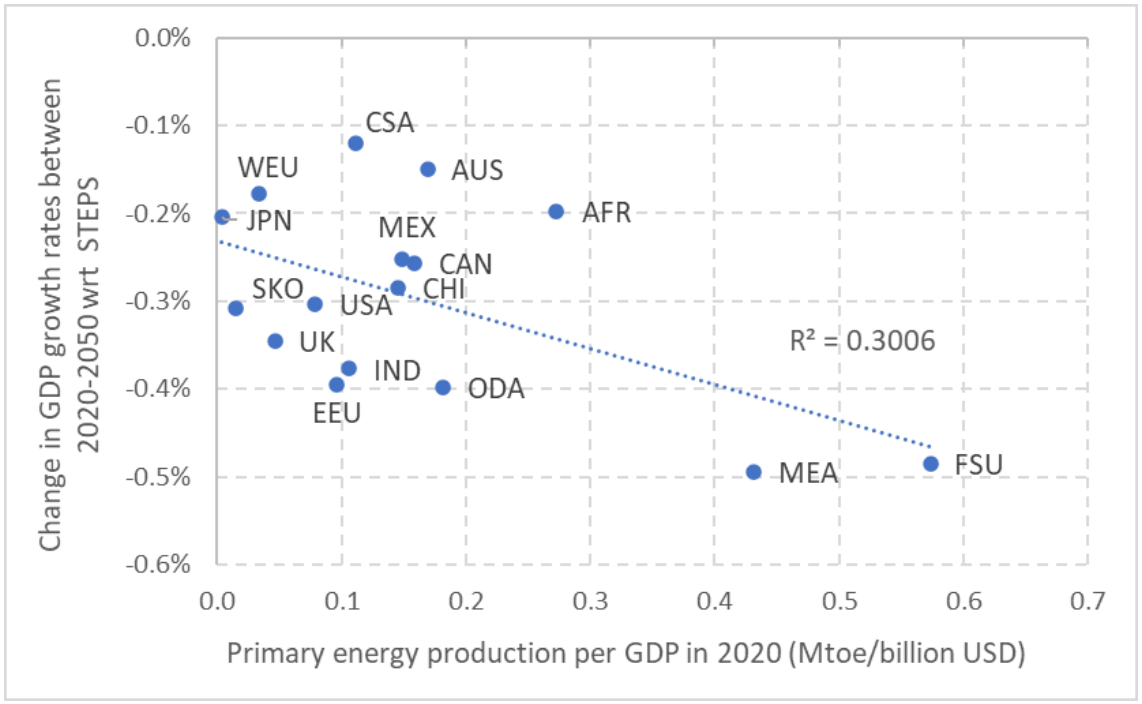
Regional GDP compound average annual growth rates between 2020-2050 by decarbonisation scenario



Economy-wide impacts of decarbonisation – Key results

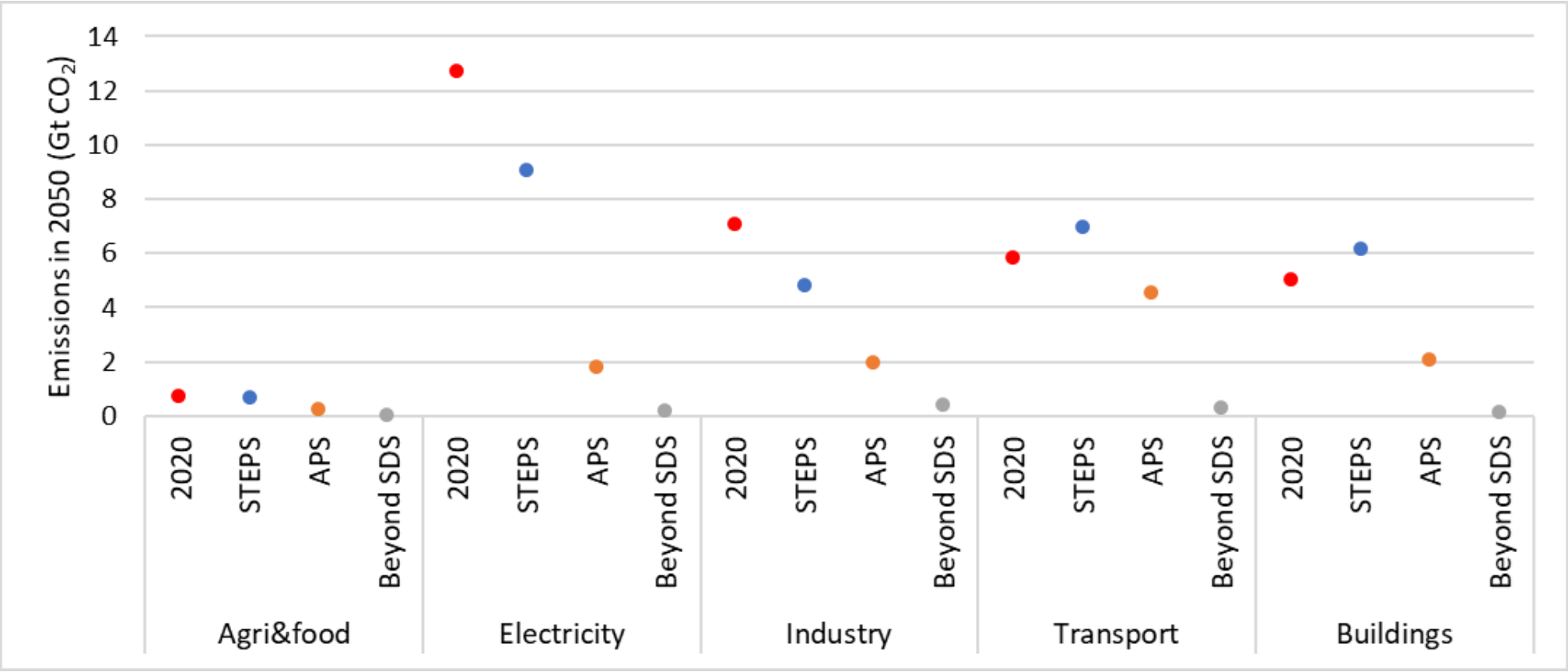
Changes in regional GDP growth rates between 2020-2050 compared to carbon intensity (left) and primary energy production (right) in 2020 under the beyond SDS scenario.





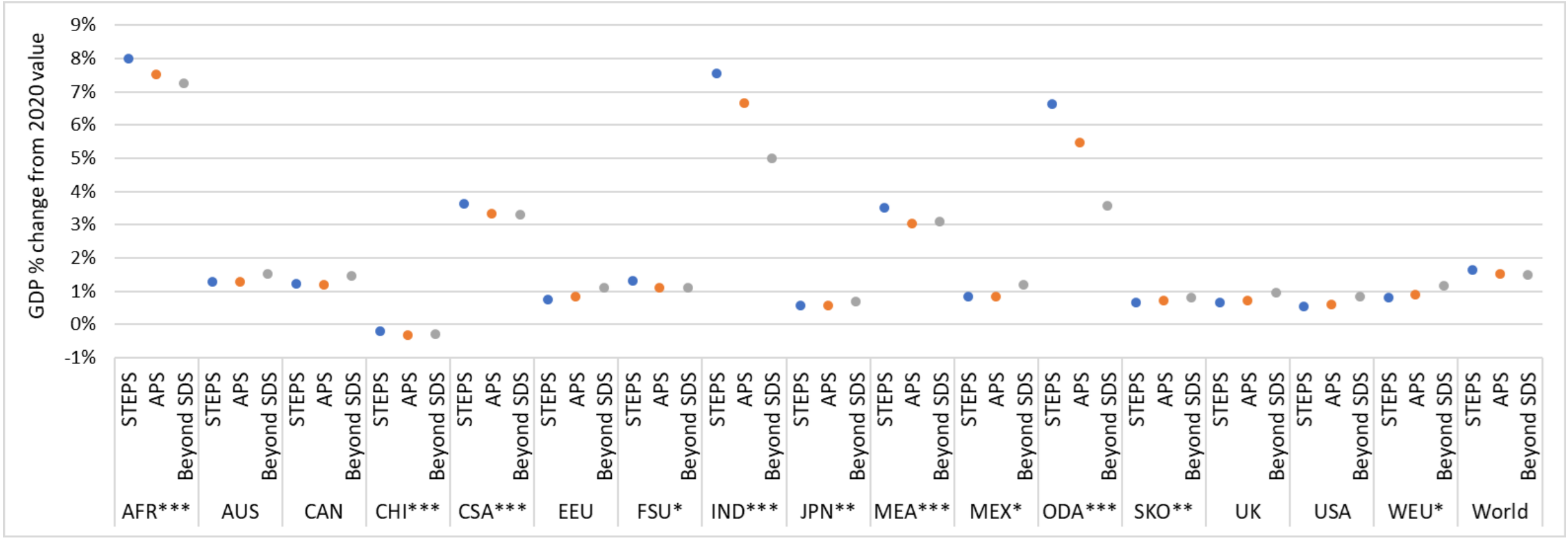
Economy-wide impacts of decarbonisation – Key results

Global sectoral CO_2 emissions in 2050 by decarbonisation scenario



Economy-wide impacts of decarbonisation – Key results

Regional economic costs of heat stress in 2050 by decarbonisation scenario



Conclusions

- Climate change imposes huge risks to economic development
- Significant investment gap delay the transition
- Cost of inaction could represent between 11% to 27% of global GDP
- Pension funds are affected by a reduced nominal returns and inflation

- Climate change mitigation requires restructuring the economic system, which comes with cost.
- However, the economic costs of mitigation scenarios are significantly lower than the economic cost of inaction

- The decline in GDP behind mitigation scenarios are explained mainly by the current level of carbon intensity, primary energy production and the climate induced changes in competitiveness

Q&A