

Socioeconomic benefits of weather information

A development perspective

Paolo Avner
Senior Economist, World Bank

**WMO – ITU conference, Geneva, September 28
– 30 2026**



GFDRR
Global Facility for Disaster Reduction and Recovery



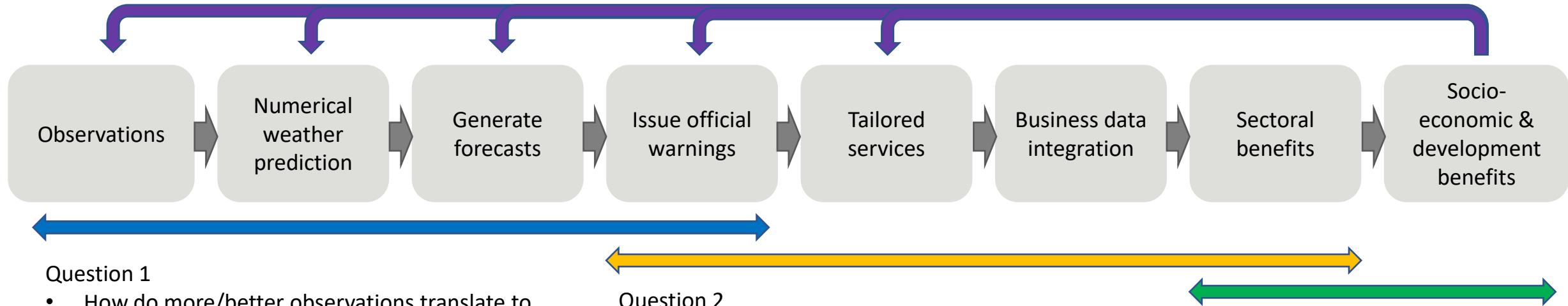
Administered by
THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP



From observations to value for people and economies...

Question 4

- How to prioritize interventions along the value chain, including expanding and improving climate and weather services to maximize socio-economic benefits under deep uncertainty?



Question 1

- How do more/better observations translate to better forecasts and information?

Question 2

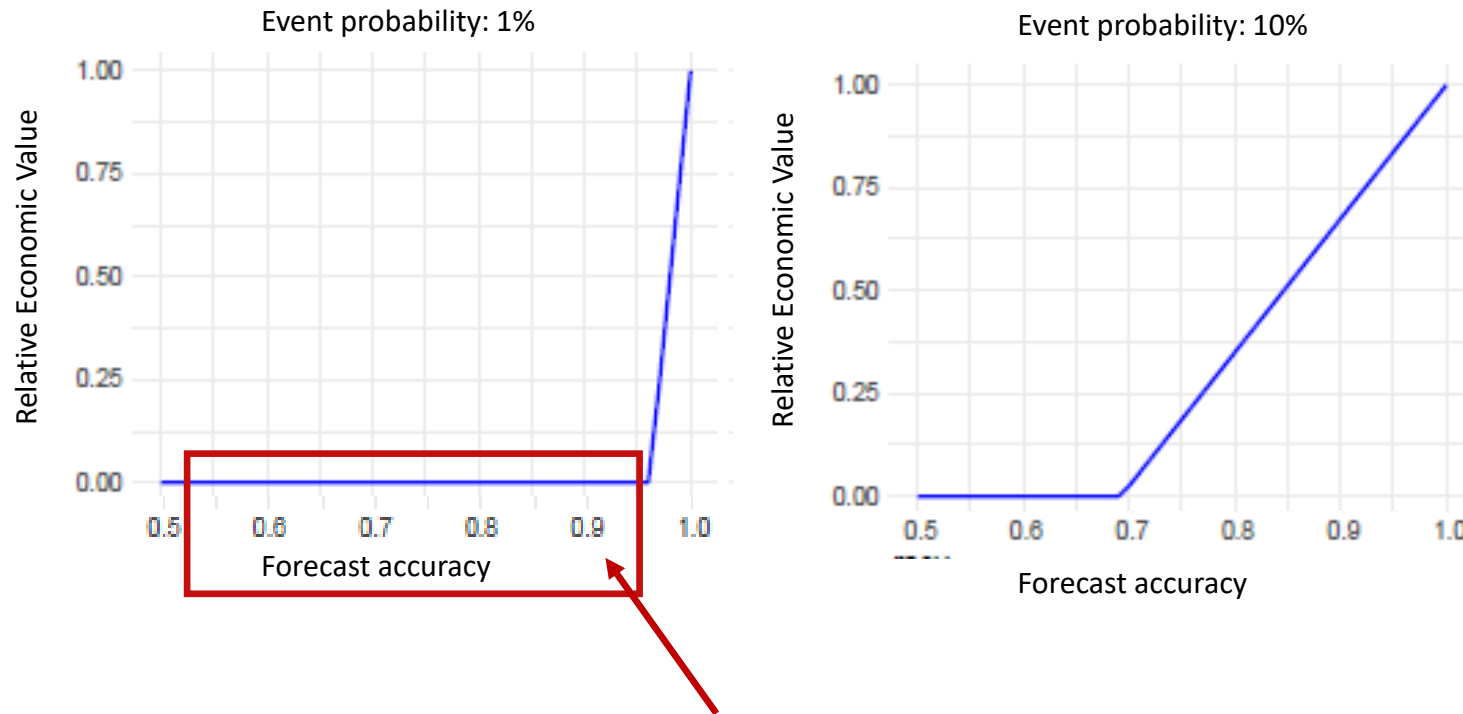
- What are the values of better information and how can they be fully realized?

Question 3

- How do the sectoral benefits translate to both short-term gains and long-term development benefits?

The theory of the link between accuracy and economic value

If the cost of protecting against an adverse event is 20% of the cost of the event without protection



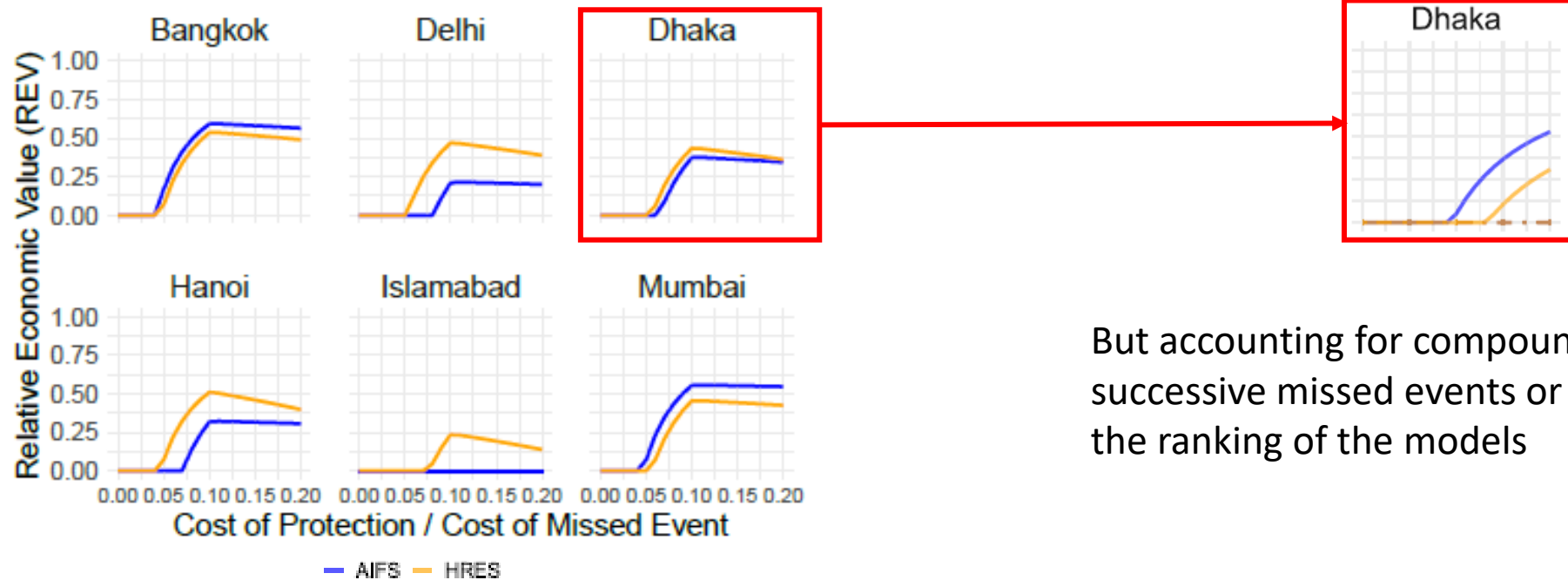
Investment to improve skills in this domain has zero value... but is still needed

- Forecasts have 0 or even negative value until reaching an accuracy threshold -> non-linearity!
- **Marginal assessments are poor guide for long-term gains**
- **But a given skill might be sufficient for some other decisions!**

Real-world forecasts: comparing model performance

Relative Economic Value of forecasts as a function of varying cost-loss ratios for 10m wind extremes in six South and South-Eastern Asian cities. March 2024 – Feb 2025

Despite generally higher accuracy, AIFS does not systematically perform better than HRES (2 out of the 6 cities) -> sensitivity (true positive event detection).

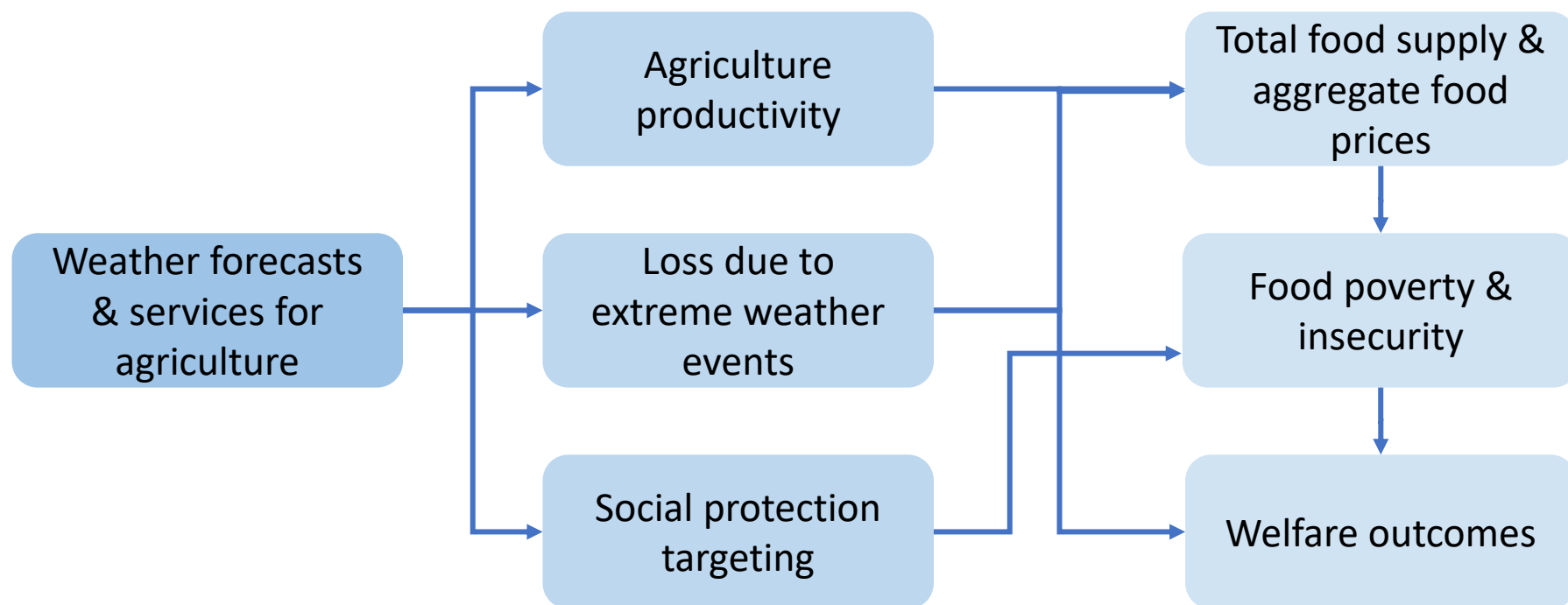


But accounting for compound costs from successive missed events or false alarms can alter the ranking of the models

An example: Agriculture and food security

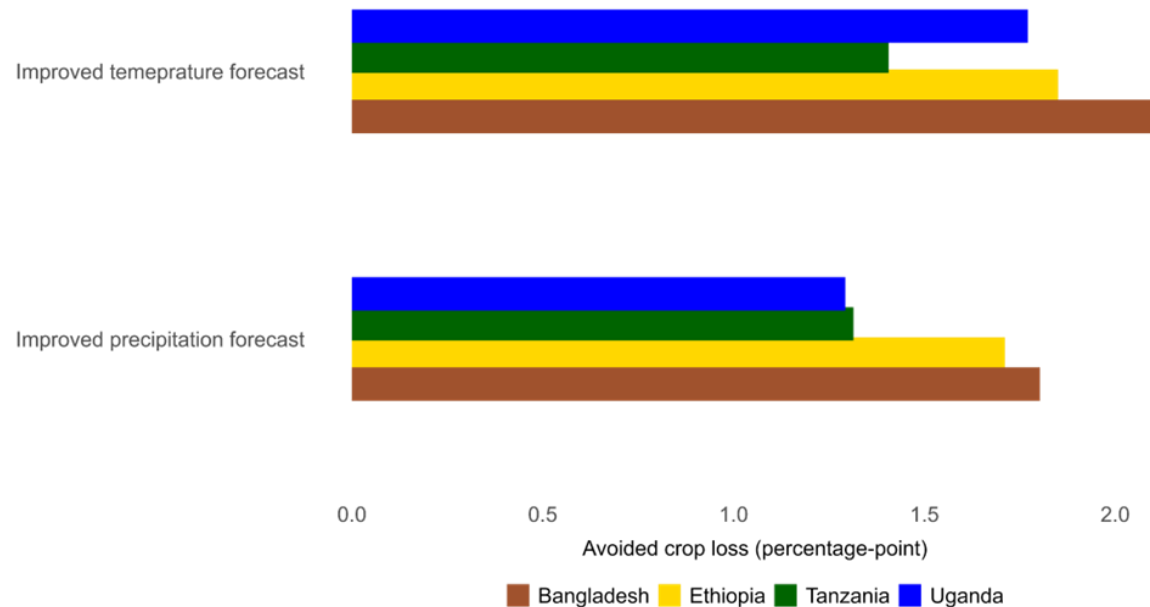


Weather forecasts, agriculture outcomes, and welfare benefits



- Countries covered: Tanzania, Ethiopia, Uganda, Bangladesh
- Econometric analysis
- Work done by Elizabeth J Z Robinson, Shouro Dasgupta, Kestrel Lambert, at the London School of Economics

Weather forecasts, agriculture outcomes, and welfare benefits



A 1% improvement in forecast accuracy would on average:

- reduce share of farmers reporting losses by 1.3 to 2.1%.
- increase labor hiring by 3.4 to 8.6%
- increase income of the poorest 40% households by 0.6 to 1.5%
- reduce food insecurity of households by 0.5 to 1%

Data Sources:

- Realized weather (P, T) and Soil Moisture: ERA5
- Forecasts: daily forecasts bulletins of 3 – 6 months lead time - accuracy metrics (**RMSE**: Root-Mean-Squared-Error, **MAD**: Mean-Absolute-Deviation, **MAPE**: Mean-Absolute-Percentage-Error)
- Agricultural, welfare outcomes (inequality, food insecurity, and poverty), and controls: Household surveys

Estimates are not final

Sources:

- Robinson et al. (forthcoming); Food security benefits of more accurate weather forecasts in the context of a changing climate
- Robinson et al. (forthcoming); Attributing better development outcomes to improvements in weather forecasting skill

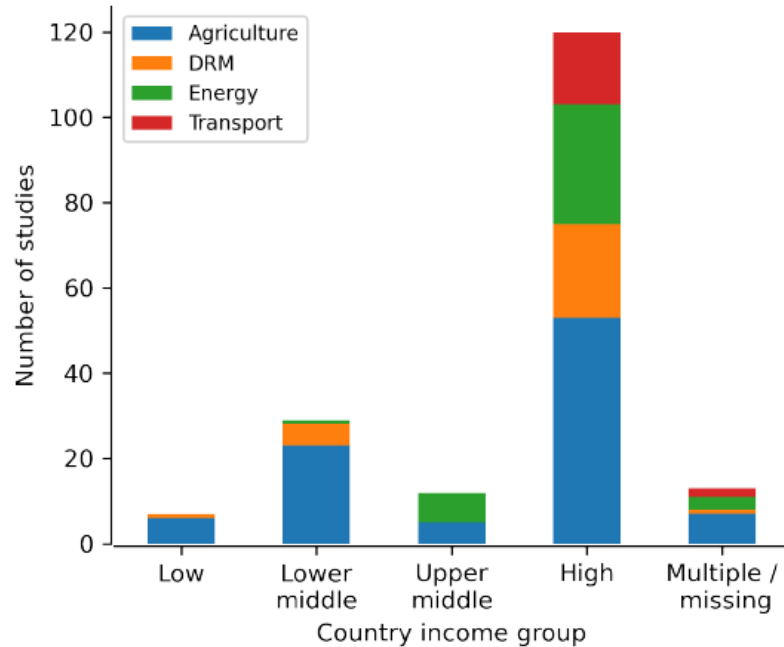
Other sectors: transport, energy, risk management



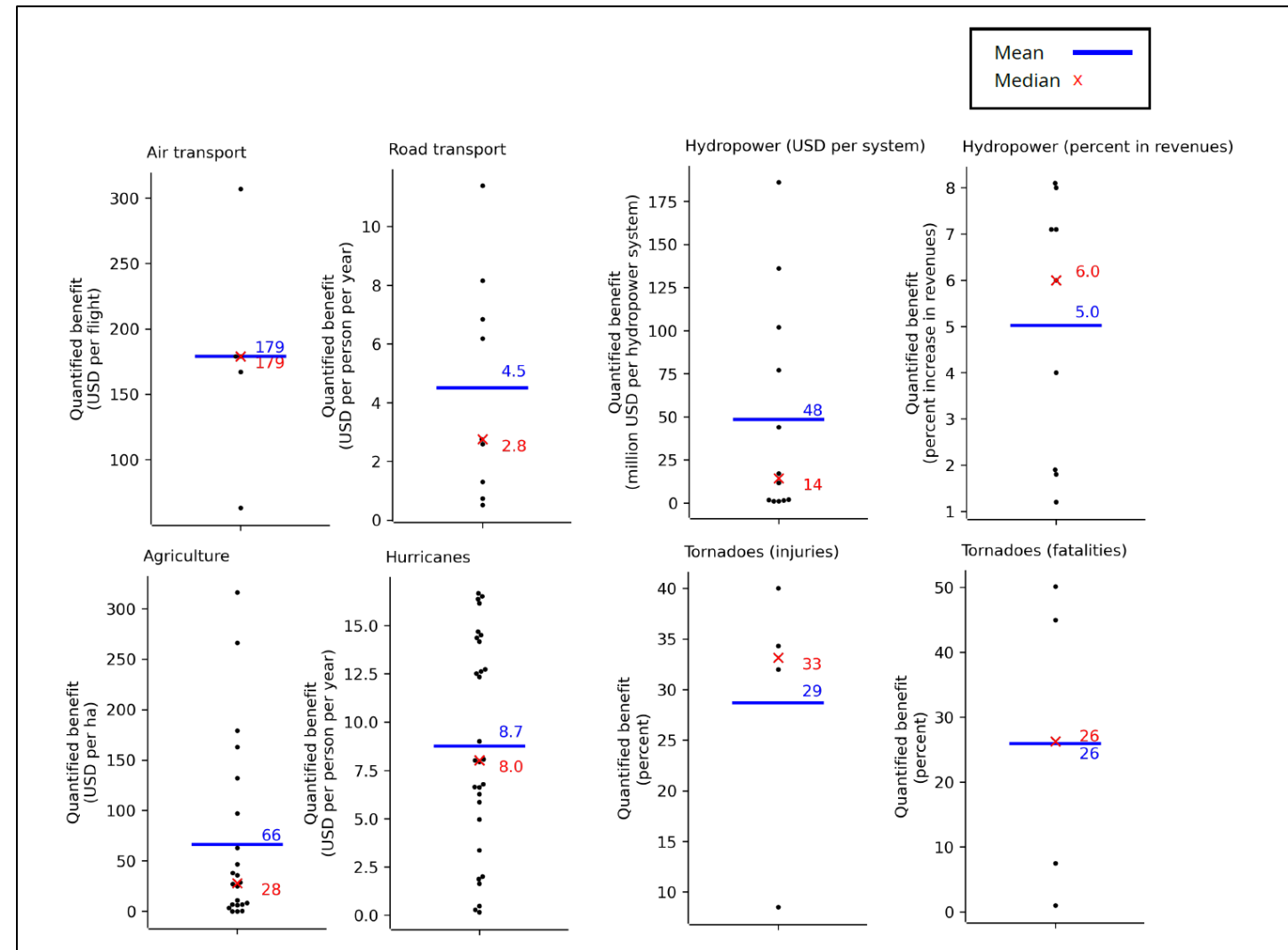
The economic value of weather forecasts

A systematic literature review

Source: [Farkas et al. \(2025\)](#)



- Lack of evidence in low- and middle-income countries, and outside of agriculture.
- Large variance in results, but agreement on the existence of gains
- Uncomfortable fact is that results from theoretical studies have much larger benefits.



Extrapolation of quantified benefits by (sub)sectors

Sub-sector “cluster”	Starting values from the literature	Multiplied by	Extrapolation, global (millions USD per year) [rounded to closest million]
Air Transport	63 – 307 USD per flight	Number of flights	2,249 – 10,960
Road transport	0.5 – 11.4 USD per person	Population	4,030 – 91,884
Hurricanes	0.16 – 16.66 USD per person	Population exposed to hurricanes (USA) & tropical cyclones (global)	90 – 9,323
Cereal agriculture	0 – 316 USD per ha per year	Land under cereal production	0 – 231,171
Hydroelectric power	1.2 – 8.1% increase in revenues	Median price times hydropower generation (USA) & hydropower market size (global)	2,961 – 19,984
TOTAL			9,330 – 363,322

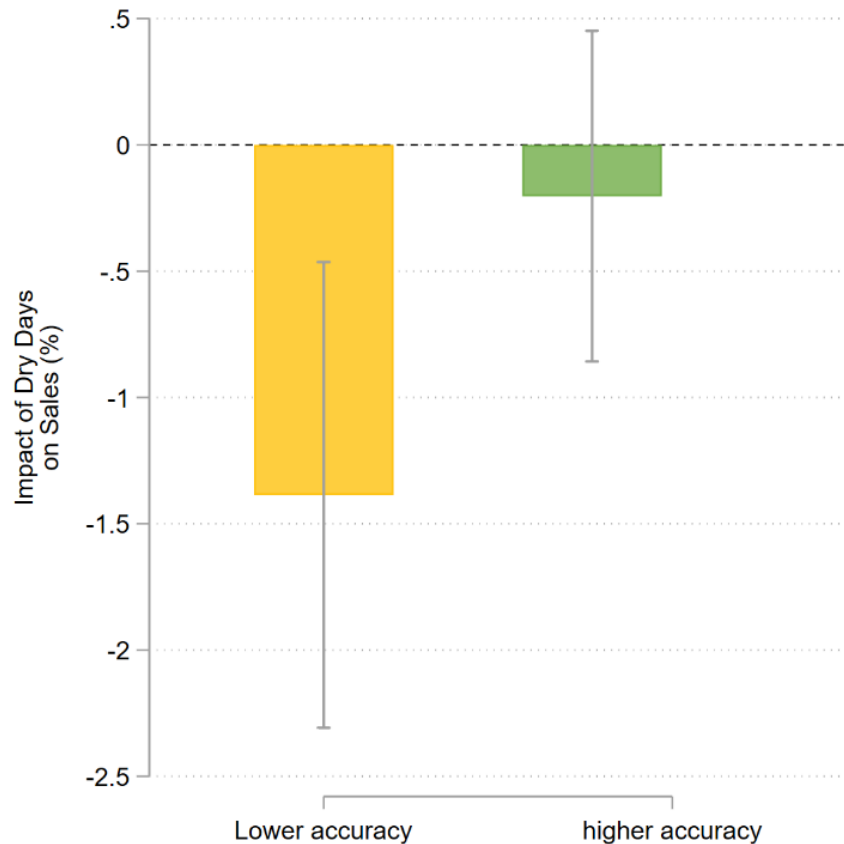
Approach

- Lowest and highest central-estimate “per unit” (per flight, per person, per ha of land, ...) from the lit review, in real terms and PPP (2024-international \$)
- Scaled to USA or World based on total flights / population / land surface area

Caveat

- No other adjustment re. context of original studies
- Starting values are based on a variety of methods (each with different assumptions)
- Central/point estimates used (not considering uncertainty ranges in the original studies)
- Values from improvement in the service or from the overall service
- Some studies assume no barriers (esp. theoretical studies)

What about firms?



Zaveri et al. (forthcoming); Forecast Accuracy and Firm Sales Losses from Extreme Weather: Global Evidence. **Estimates are not final.**

APPROACH:

1. Combine 3 global datasets
 - World Bank Enterprise Surveys (WBES) Sample of >28,000 geolocated firms in 79 economies from 2009 to 2019
 - Realized precipitation (ERA5-Land dataset ([Muñoz-Sabater et al., 2021](#)))
 - High resolution gridded dataset of forecast accuracy ([Linsenmeier and Shrader, 2026](#))
2. Econometric set-up

QUESTION(S)

- What is the impact of an extreme dry day on firm sales?
- And can forecast accuracy buffer against these negative shocks?

RESULTS

- An additional “extreme dry day” reduces firm sales by 1.4% to 2.4%.
- Access to better forecasts reduces this impact to ~0 (statistically).
- **Benefits extrapolated to the universe of firms of going from below to above median forecast accuracy is in the range of \$ 164 – 276 billion annually.**

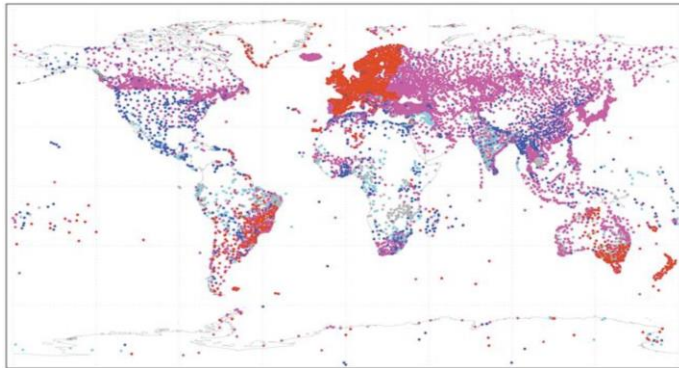


Assessing the value of
improved observation
systems

Value of additional observations for disaster resilience

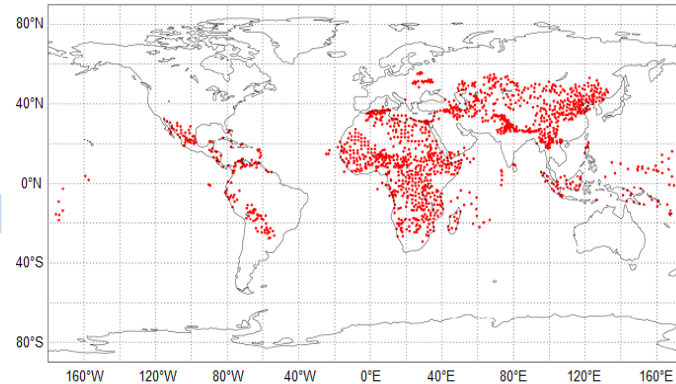


Current active land surface stations,
December 2020.

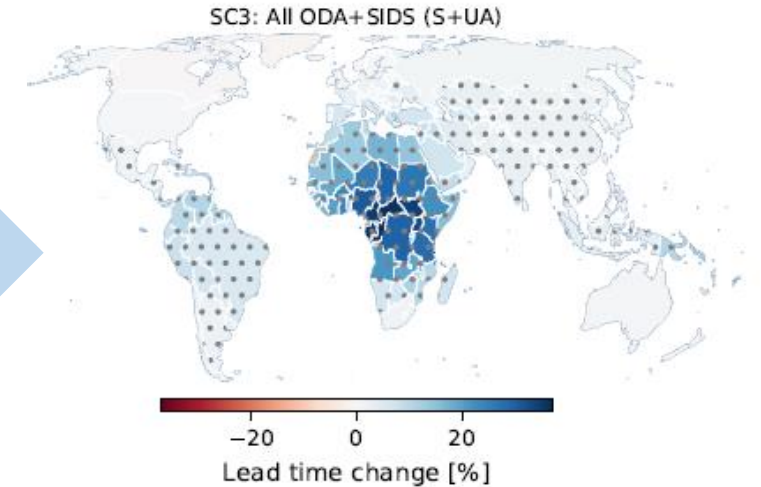


Source: ECMWF and WMO

Additional surface observations
as per scenario 3.



Source: ECMWF



Source: WB and ECMWF

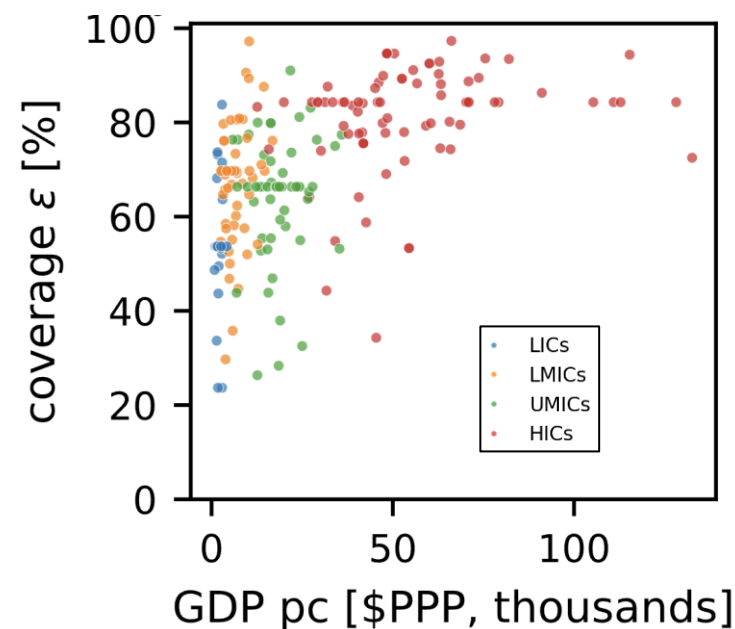
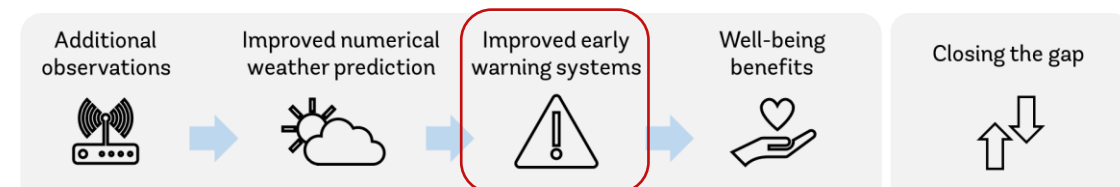
- Minimum requirements on surface-based weather observation defined by the Global Basic Observing Network (GBON)
- Existing infrastructure is sparse in some regions of the world

- SOFF to support countries in achieving GBON standards
- several investment scenarios

Additional data leads to improvement in skills, in form of earlier lead times

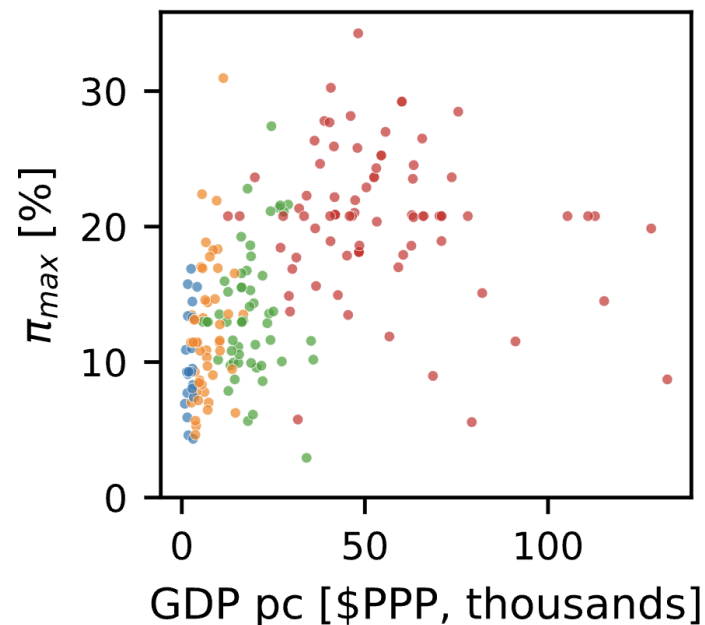
This is work in progress with ECMWF, for the assessment of benefits from SOFF investment scenarios

Hazard warnings are enabled through an **early warning value chain**



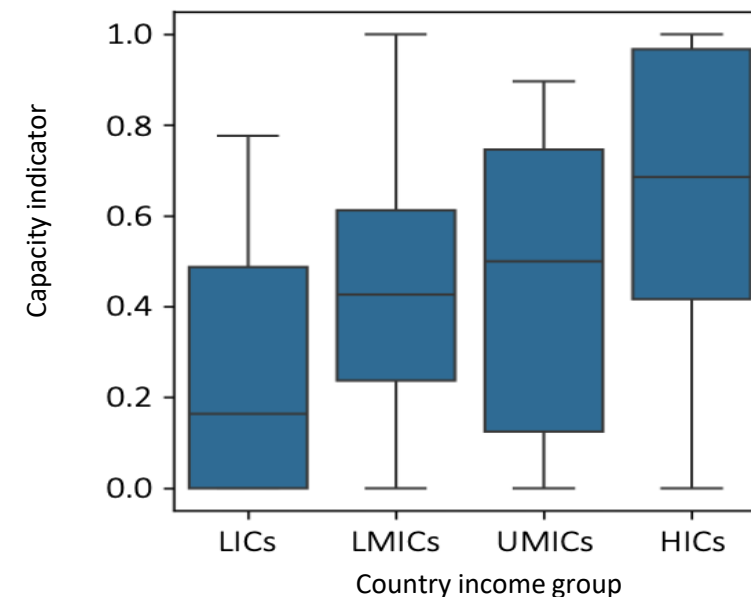
Share of the population covered by early warning systems

UNDRR (2025), Lloyd's Register Foundation (2022)



Potentially avoidable asset losses as share of moveable assets (building contents, livestock, and vehicles)

Yepes-Estrada et al. (2023), FOSTAT (FAO 2025), IRF (2025), UNECE (2025), Eurostat (2025)



Capacity of the early warning value chain (Observation to actions taken)

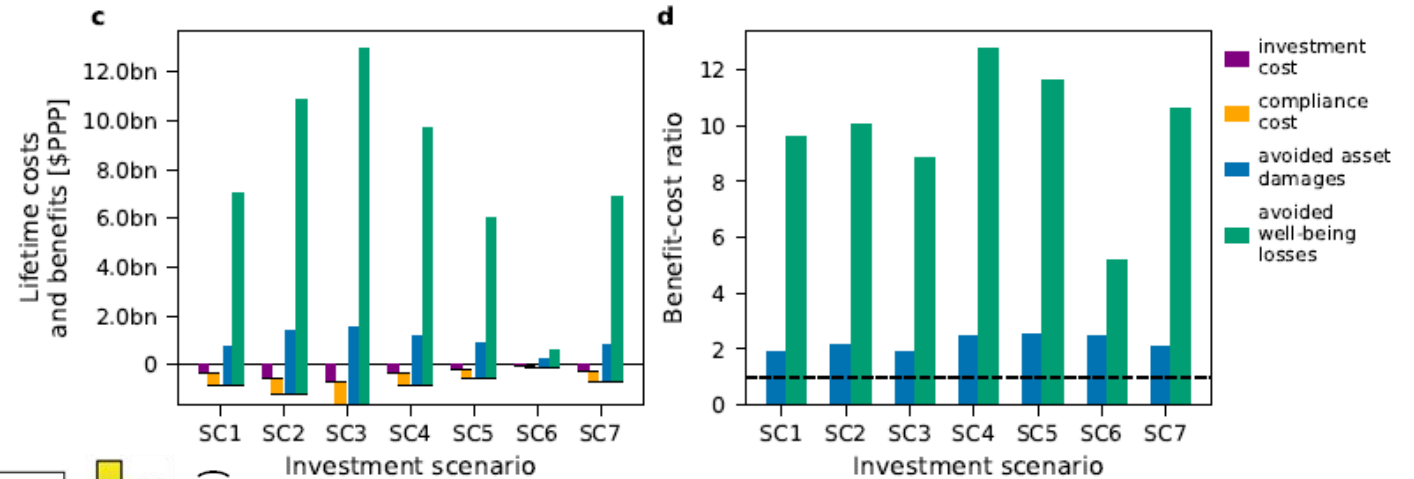
UNDRR (2025)

Value of weather information depends on the metric we use, and traditional metrics ignore poor people

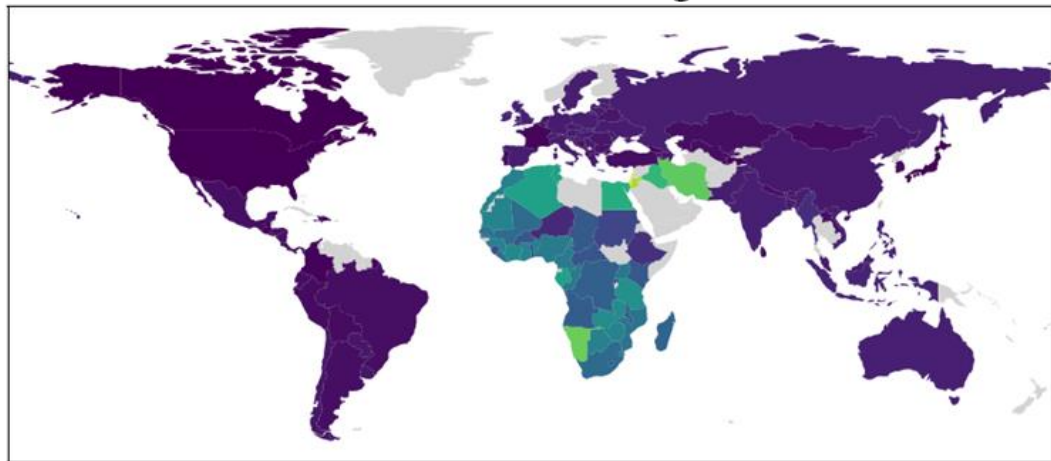
SOFF investments yield between \$30 to \$240 million of annual asset losses, globally

Translated into avoided well-being losses benefits reach between \$62 million and \$1.1 billion

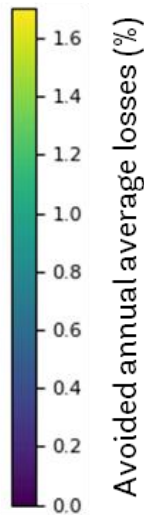
Positive Benefit Cost Ratios across all scenarios: between 5 and 12 for well-being



Avoided annual well-being losses



data source: own calculations



Absolute benefits are highest in large and / or highly exposed economies

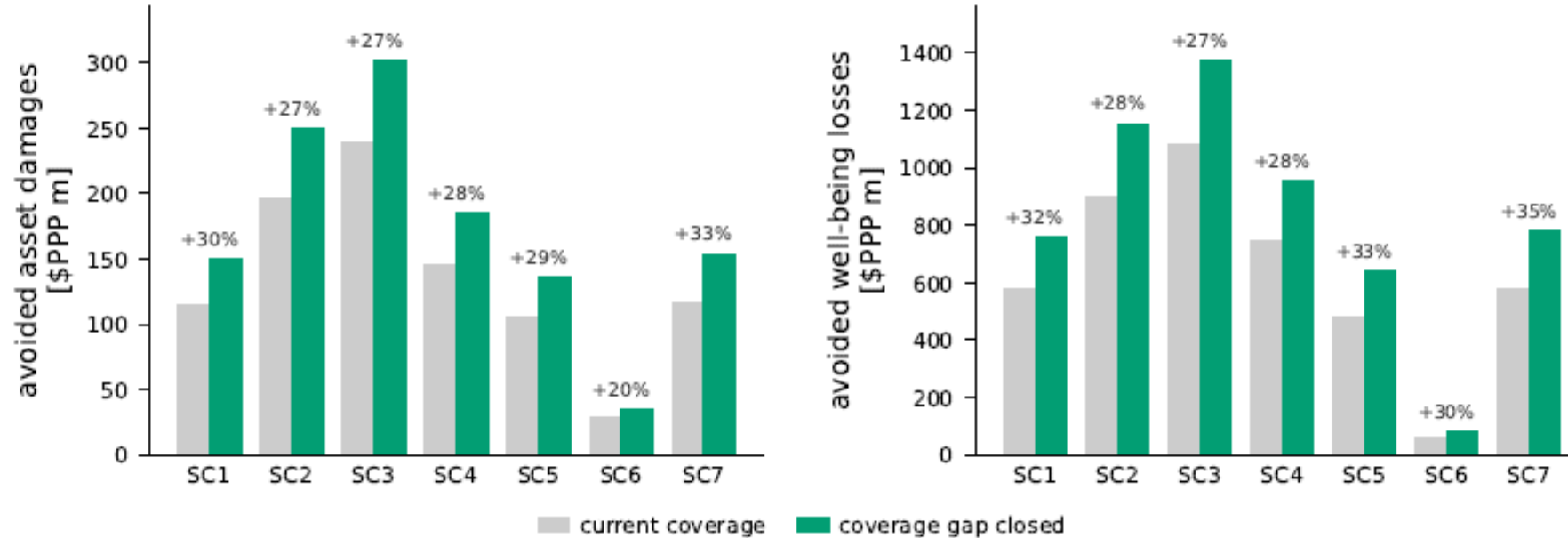
Relative benefits are highest in lower income regions with new observations (MNA / SSA)

Note that these are conservative estimates: they only account for the benefits of EWS for floods and tropical cyclones and focus on a subset of assets. They also do not consider additional benefits from better weather information

Estimates are not final



Value of weather information depends on the full chain and the ability of users to access and use information



- If all countries achieved EWS coverage corresponding to HIC's median.
- Benefits from SOFF investments in observation infrastructure would increase by ~20 – 35%

Estimates are not final

Take away points

- Marginal changes in forecast skills are not enough to estimate economic value, which is highly non-linear
 - *Work with users* : Value depends on the full causal chain, from observations to decisions
 - *Set long-term targets*: Value depend on ability to cross performance thresholds that may require many interventions
- Large range of economic values from weather information but agreement that these exist and are substantial
- In poor places, immediate economic gains are small, because there is little economic activity
 - *Expand the metrics* : small economic gains can save or transform lives
 - *Expand the time horizon* : key benefit is not to avoid economic losses, but to enable data-informed development