Transforming Economies for a Climate-Resilient Future: Lessons from Agriculture, Carbon Management, and Resource Conservation

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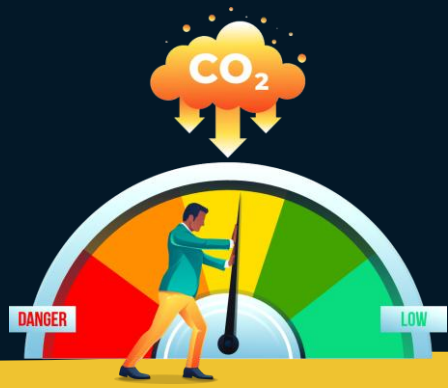


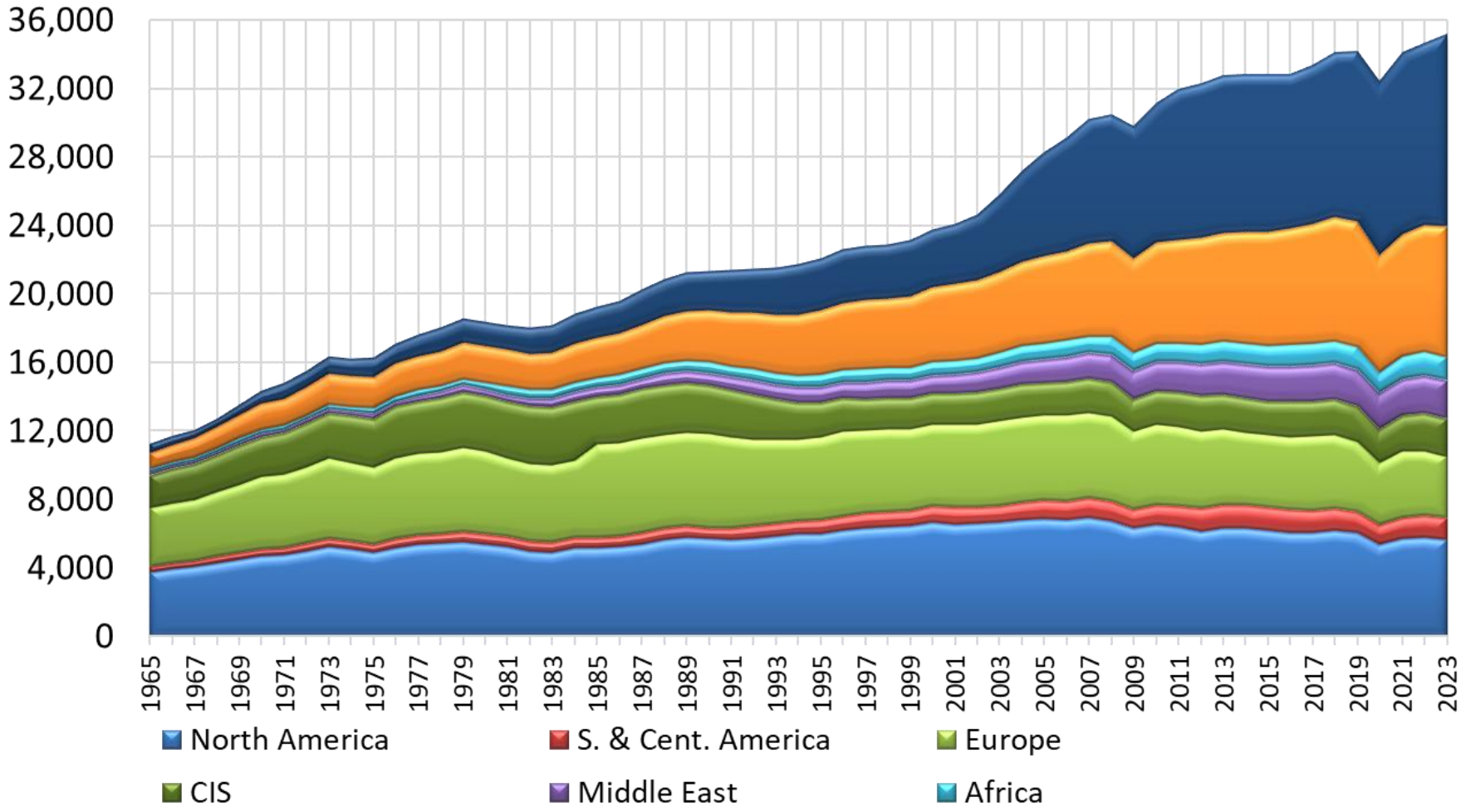
The International Conference of Economists 2025, 18th National Conference of Economists, and 18th Graduate Conference in Economics. Theme: Transforming Economies for Equity, Stability, and Sustainability: The Power of Diversity. Faculty of Economics, Kasetsart University, July 18, 2025

Outline

- Status of Greenhouse Gas Emission
- Physical Impacts of Climate Change
- Impact of Transition Risks from Climate Change
- Physical Impacts of Climate Change on Thai Agriculture
- Carbon Management
- Resource Conservation

Status of Greenhouse Gas Emission

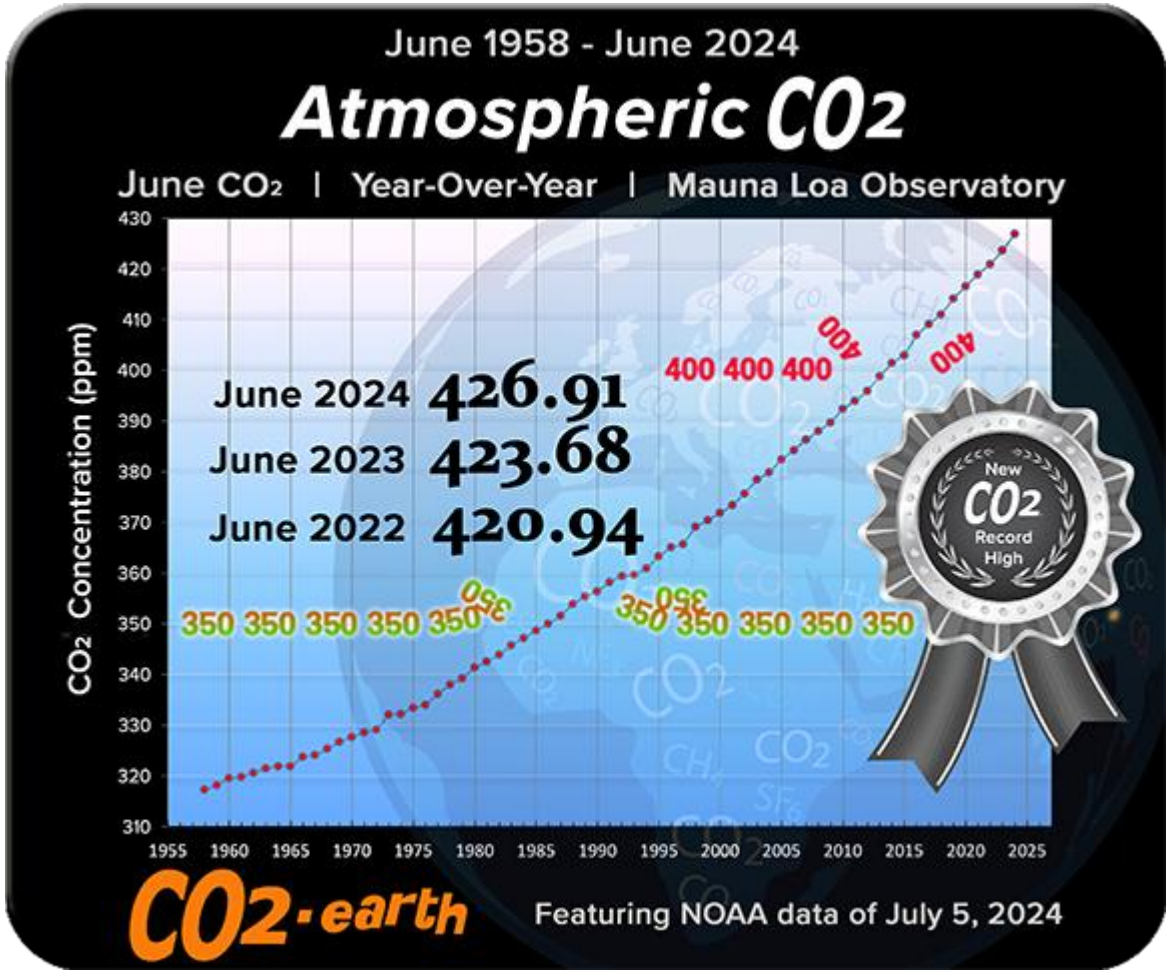
GHG emission has increased over time!



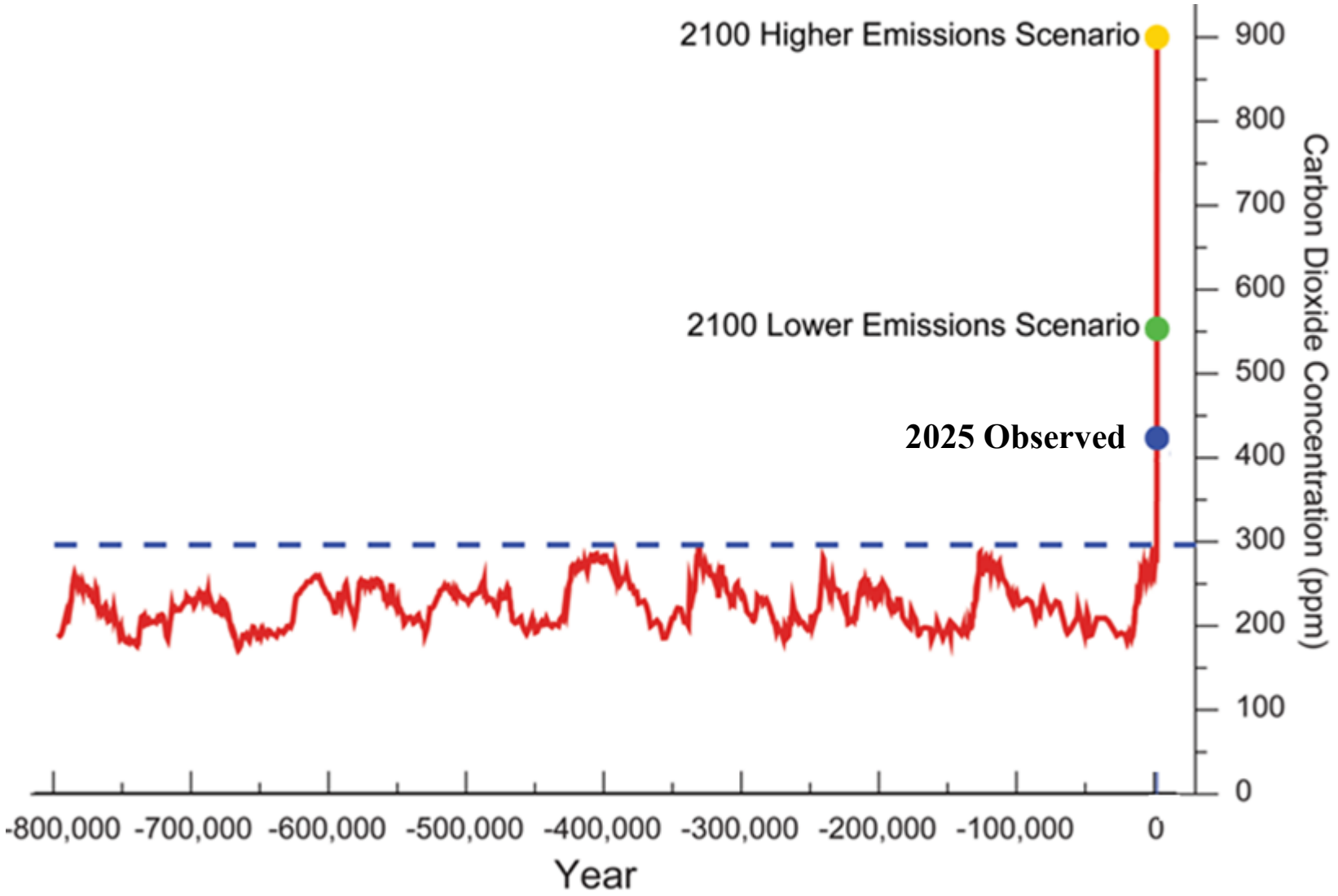
Source: Statistical Review of World Energy (2024)

Status of Greenhouse Gas Emission

As a result, the atmospheric CO_2 concentration has increasing over time!



Status of Greenhouse Gas Emission

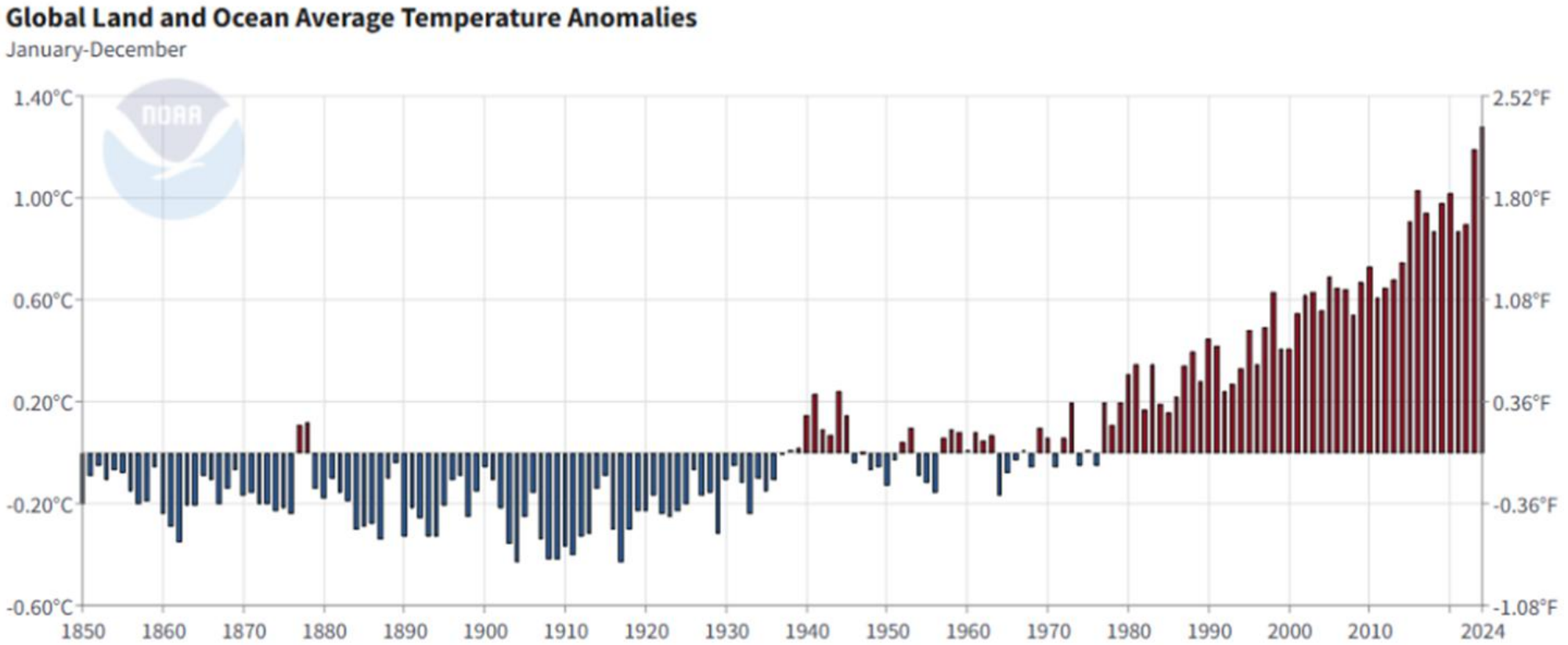


Source: Adapt from IPCC (2013)

Current and expected atmospheric CO_2 concentrations exceed the historic levels !!!

Impacts may be bigger than the history of the mankind !!!

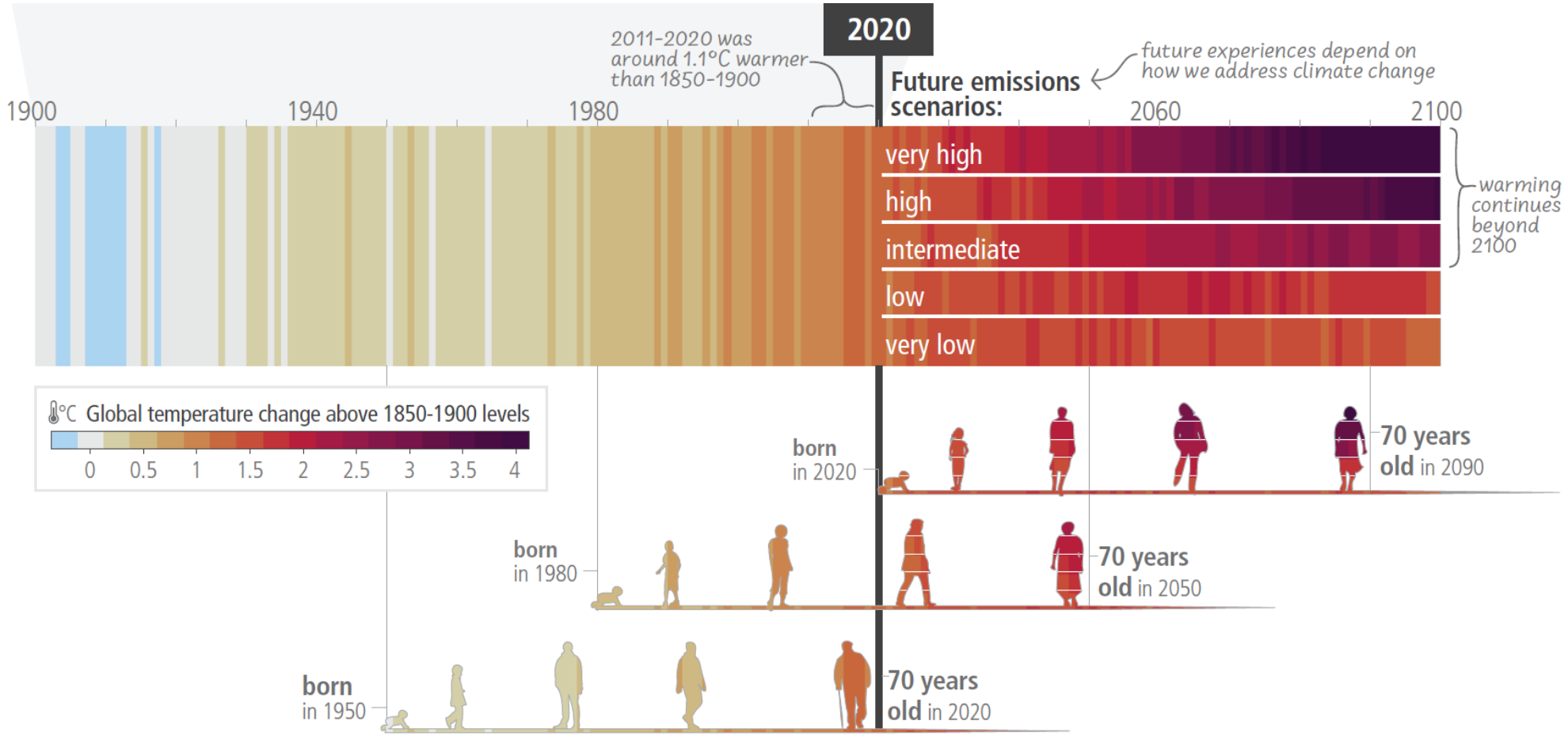
Past Physical Impacts of Climate Change on Temperature



- 47th consecutive year (since 1977) annual temperature have been above 20th century average.
- The 10 hottest years in the world happened in the past 10 years (2015-2024).
- 2024 was the warmest year in NOAA's 175-year series.
- The January 2025 global surface temperature ranked warmest in the 176-year record.

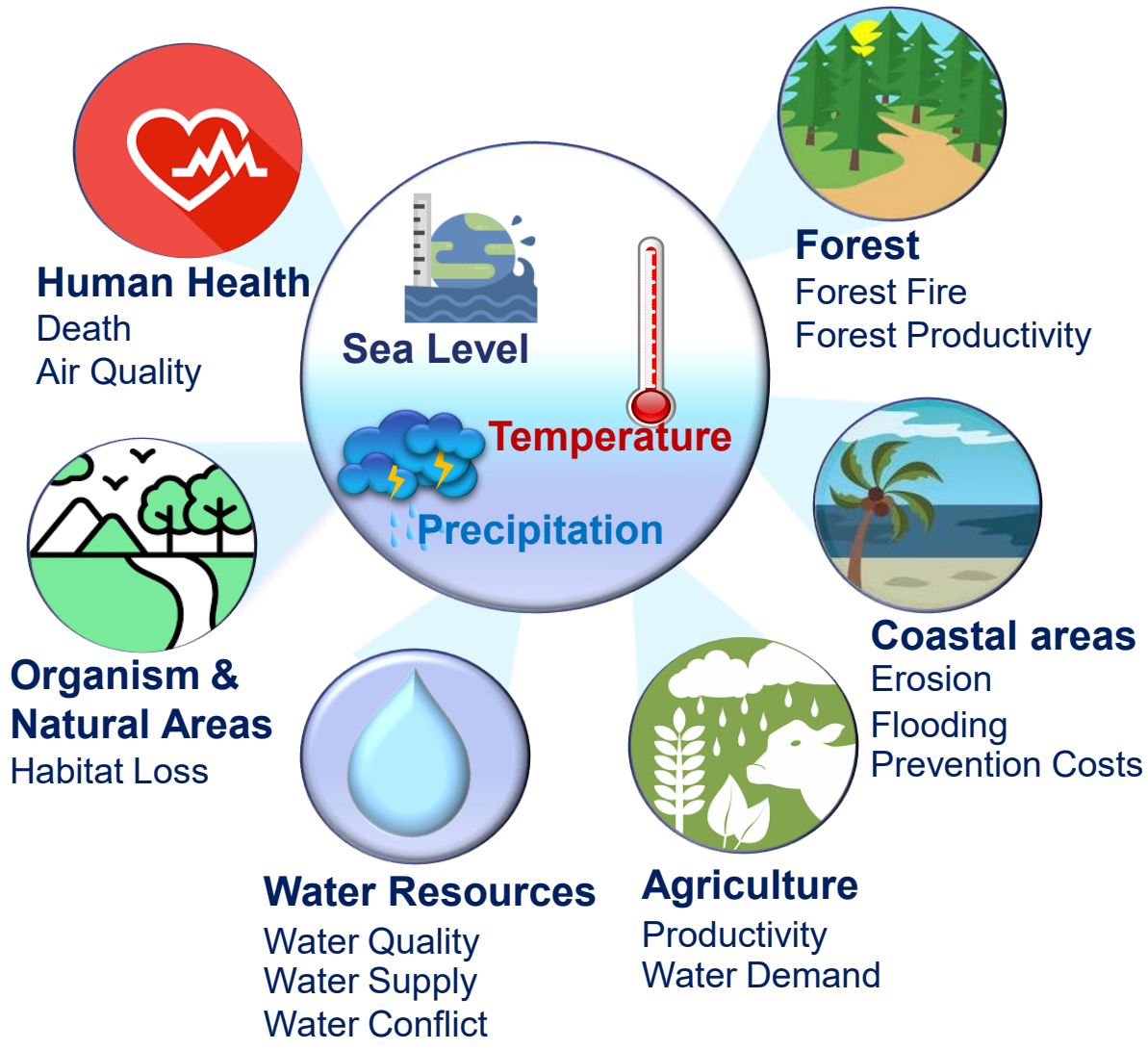
Future Physical Impacts of Climate Change on Temperature

The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near term.



Source: IPCC, 2023: *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 184 pp., doi: 10.59327/IPCC/AR6-9789291691647.

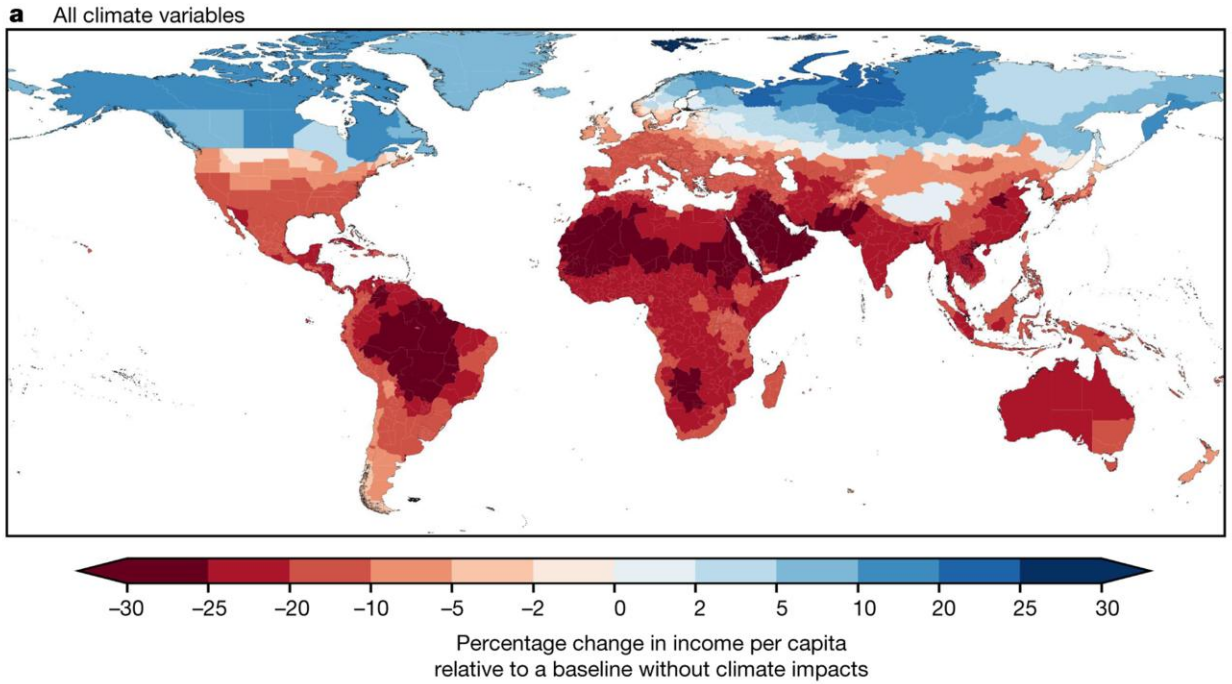
Future Physical Impacts of Climate Change



- The impacts are widespread, affecting sectors from agriculture, forestry, coastal areas, water resources, and health, to living organisms.
- This has implications for businesses and industries linked throughout the value chain, including food, fashion, cloud computing, banking, and more.

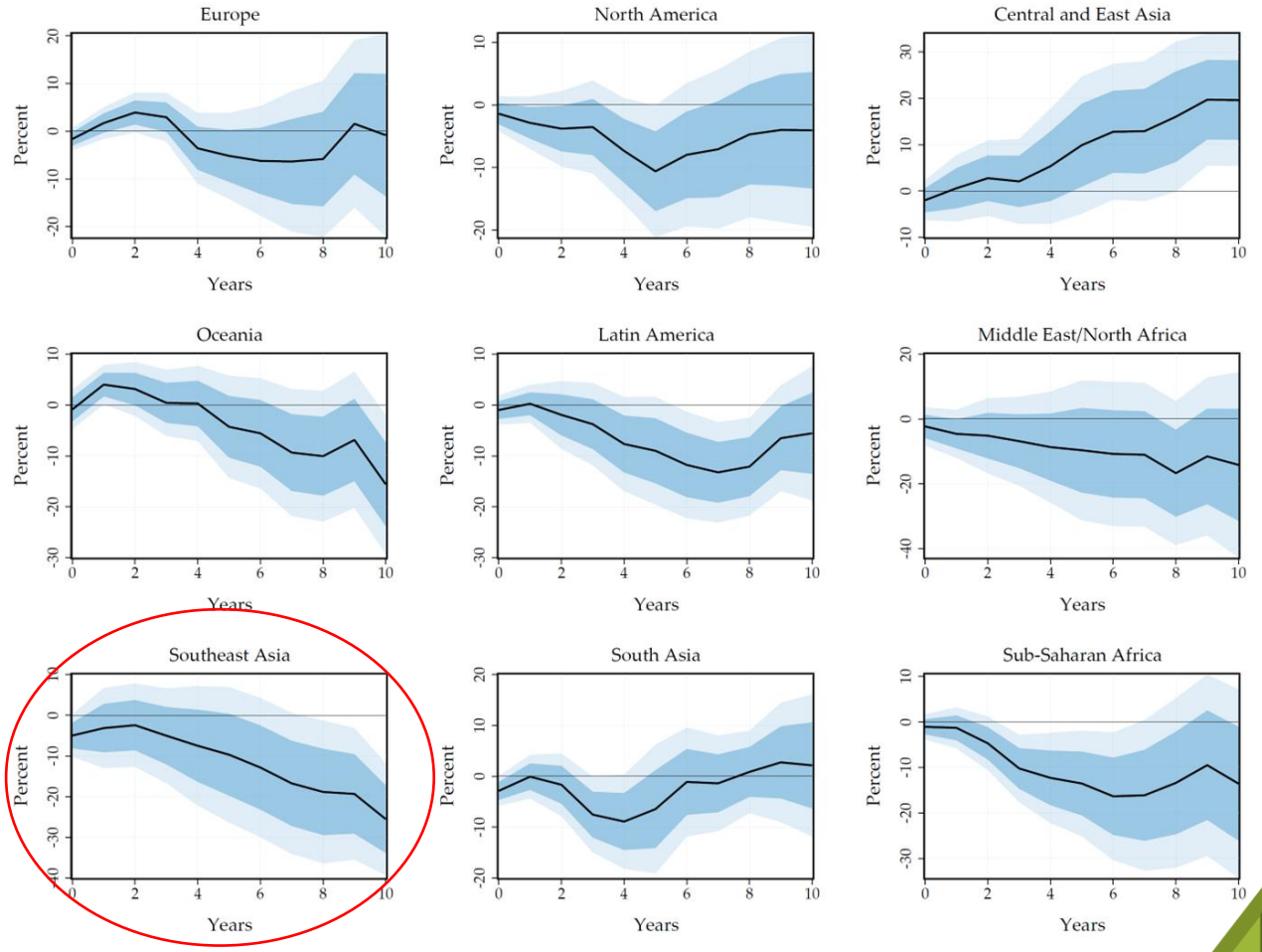
Future Physical Impacts of Climate Change on GDP per Capita

Global GDP per capita will decline 19% over the next 26 years, independent of GHG emissions choices



Source: Kotz, M., Levermann, A., & Wenz, L. (2024). The economic commitment of climate change. *Nature*, *628*(8008), 551-557.

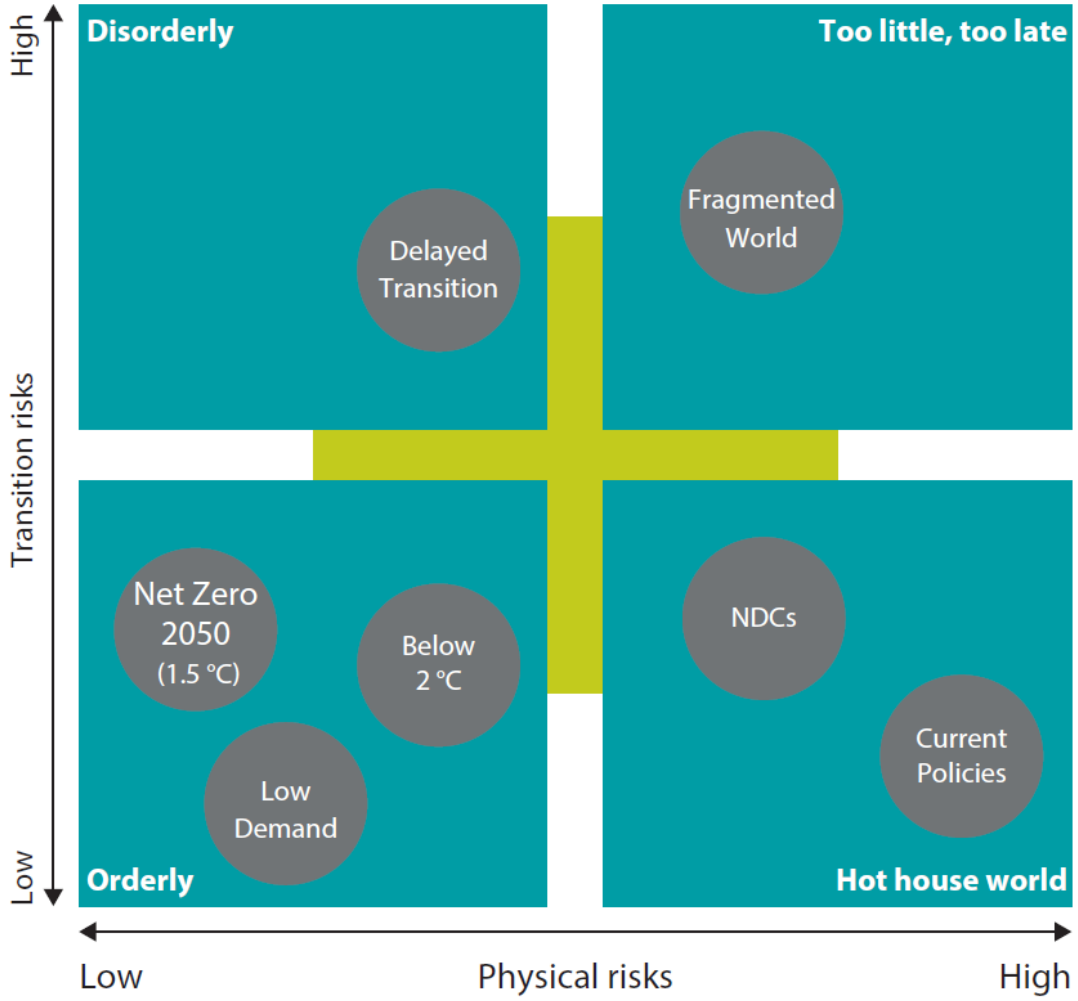
Southeast Asia is expected to suffer the greatest negative impacts from climate change

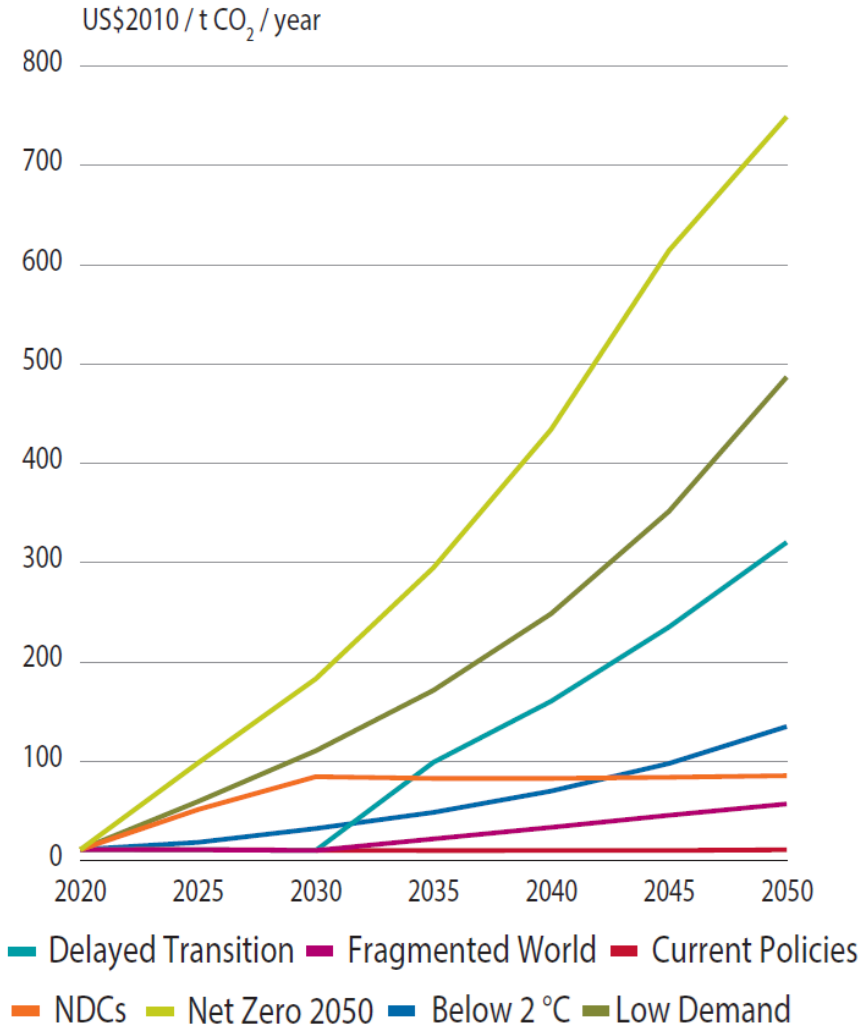


Source: Bilal, A., & Känzig, D. R. (2024). *The Macroeconomic Impact of Climate Change: Global vs. Local Temperature* (No. w32450). National Bureau of Economic Research.

Impact of Transition Risks from Climate Change on Carbon Price

Cost of GHG emissions tends to increase according to recent future projections.

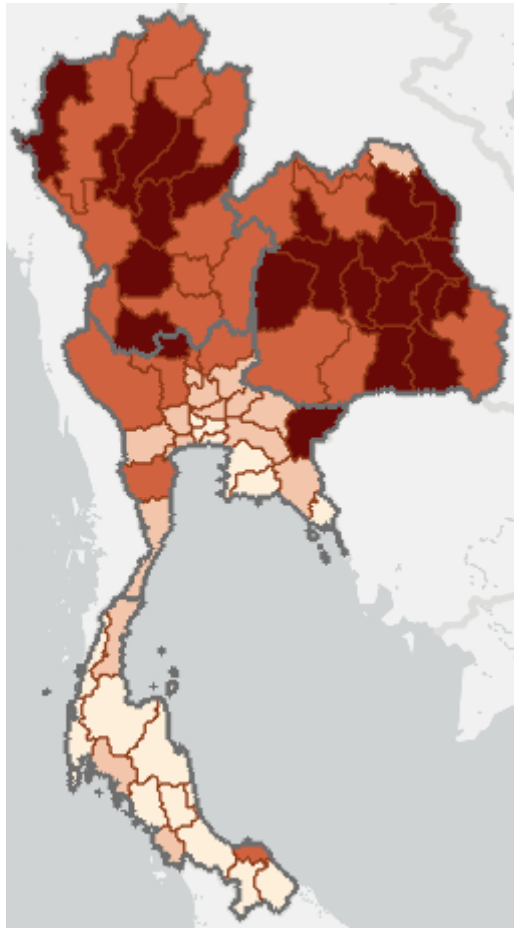




Source: NGFS (2024)

Past Physical Impacts of Climate Change on Farm Households

Farm households are affected by issues linked to climate change.



2023 Agricultural Census

National Level

Farm households facing problems/disasters

54.3 Percent

Top-five problem/disaster

- Fertilizer, pesticide, and fuel prices have increased significantly 65.2%
- Drought and lack of water sources 42.1%
- Falling crop prices due to market oversupply 34.6%
- Obtained low production 25.3%
- Flooding, Mudslides, Storms 25.3%

ทั่วประเทศ | จังหวัด 5 อันดับแรก

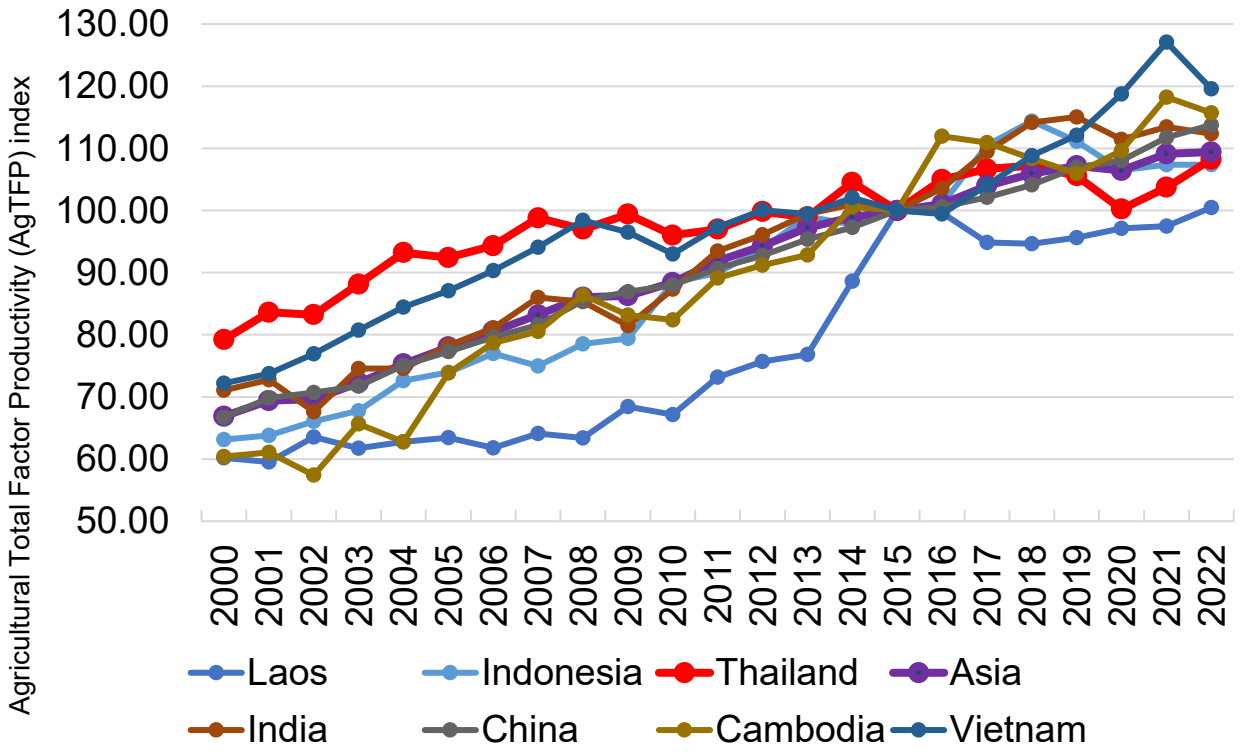
Source: 2023 Agricultural Census, National Statistical Office (2024)

Impact of Physical Risks from Climate Change on Agricultural Total Factor Productivity (AgTFP)

Thailand is facing the low and unsustainable growth in global competitiveness of farm products.

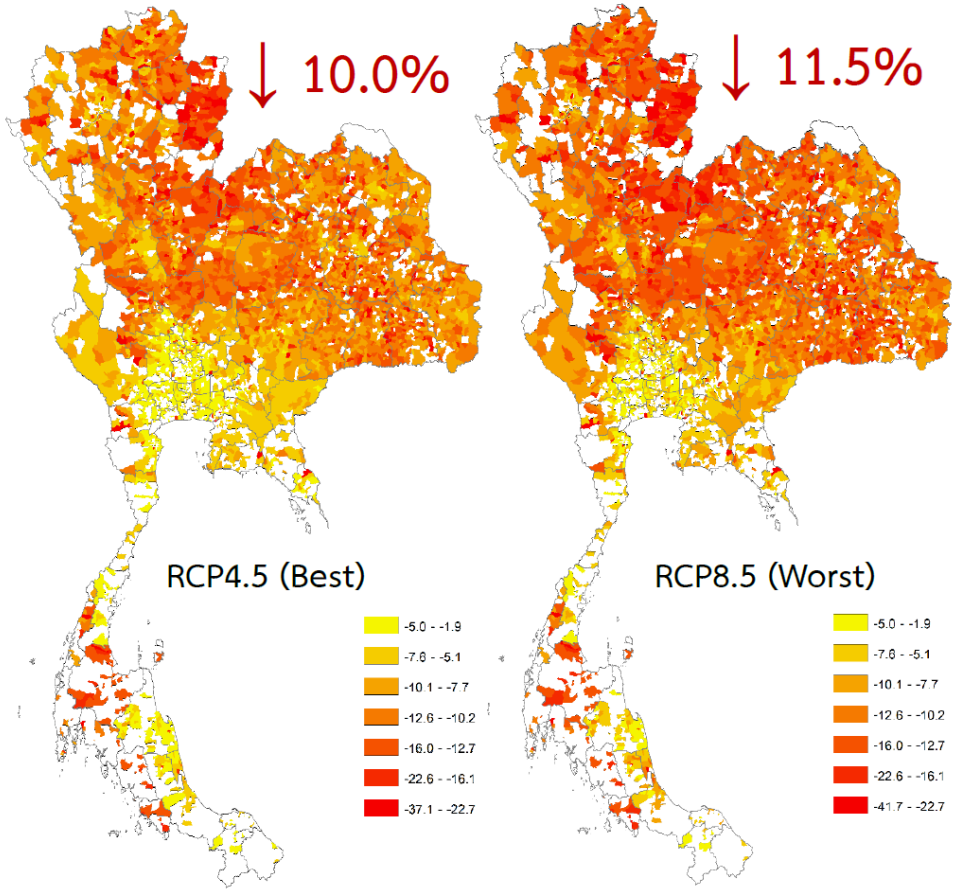
Average annual growth of AgTFP (%)

Country	2003-2022	2003-2012	2013-2022
Thailand	1.09	1.39	1.00
Asia	2.21	3.00	1.32



Source: Attavanich et al. (2025) extracted from USDA (2024)

Climate change is projected to reduce the farm productivity ranging from 10.0% in RCP4.5 and 11.5% in RCP8.5.

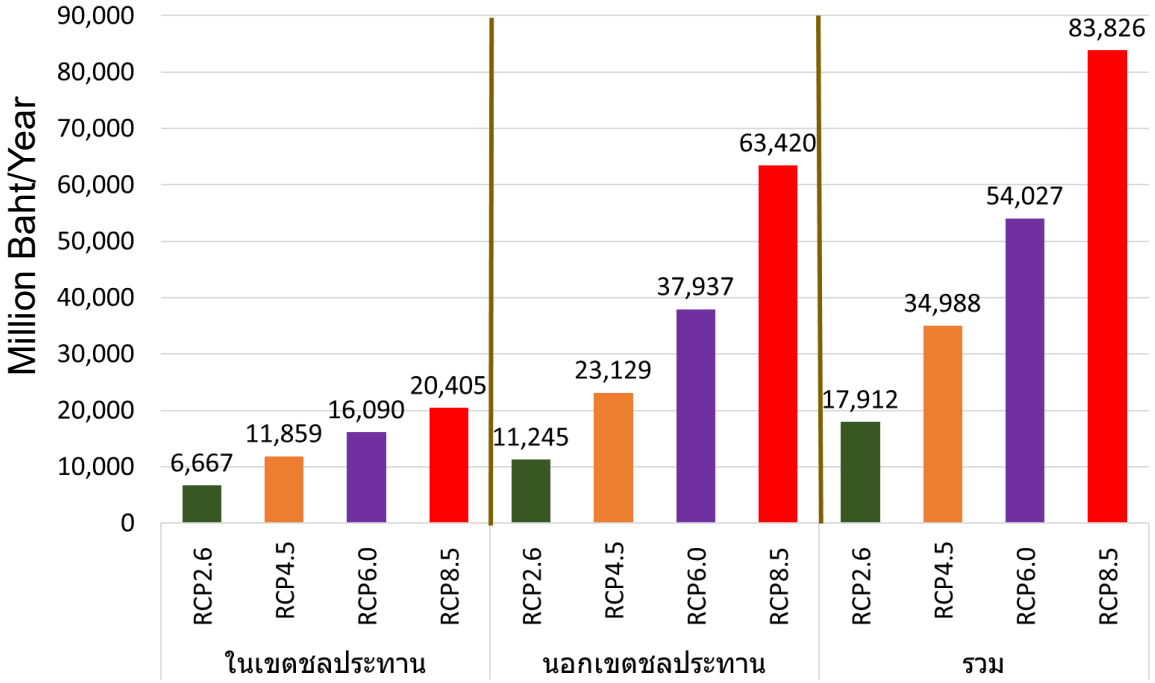


Projected impacts from climate change (2046-2055)

Source : Attavanich et al. (2019)

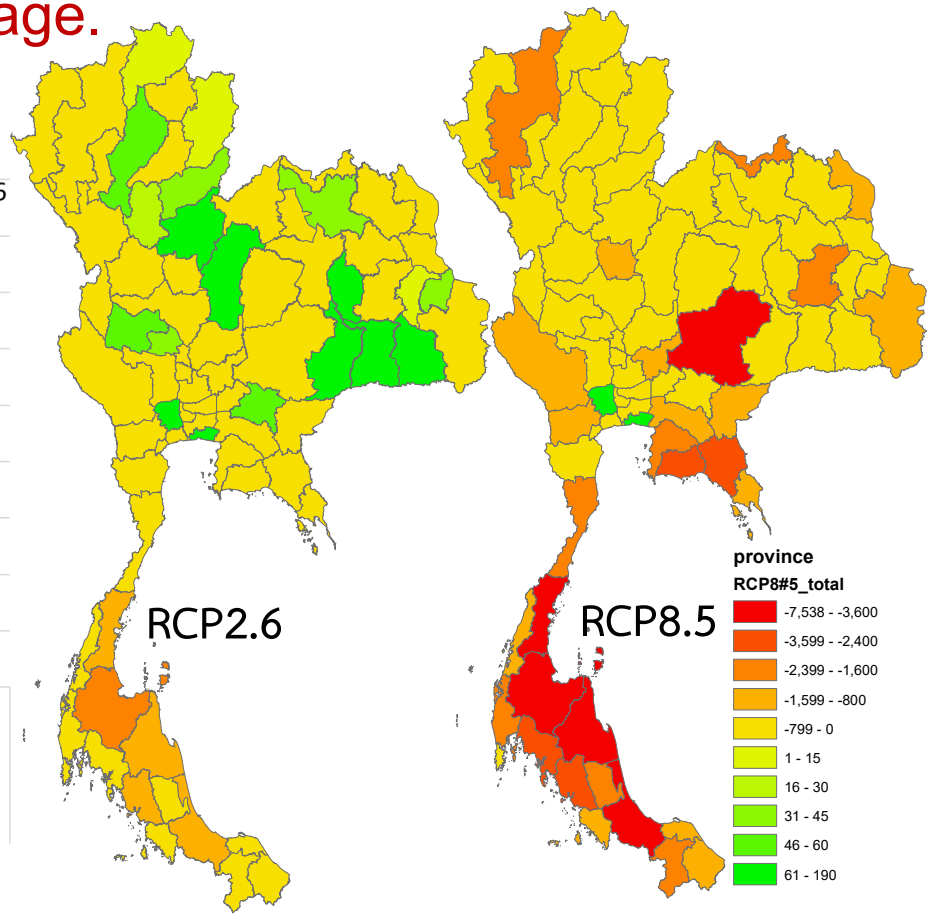
Physical Impacts of Climate Change on Thai Agricultural Sector

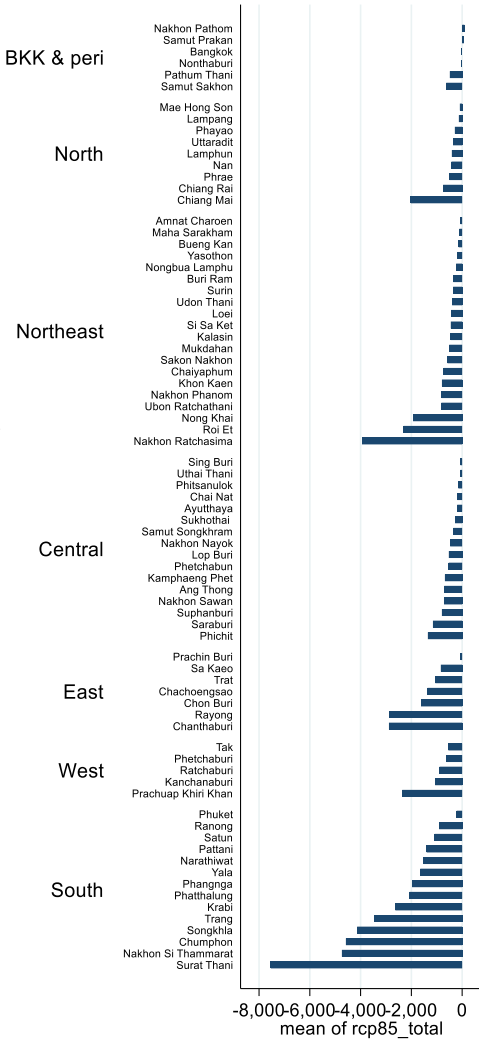
- Accumulated damage value ranges from 0.609 – 2.850 trillion baht.
- Non-irrigated area will suffer highest damage.



Source: Attavanich (2017)

- The southern and eastern regions will suffer more damage than other regions.





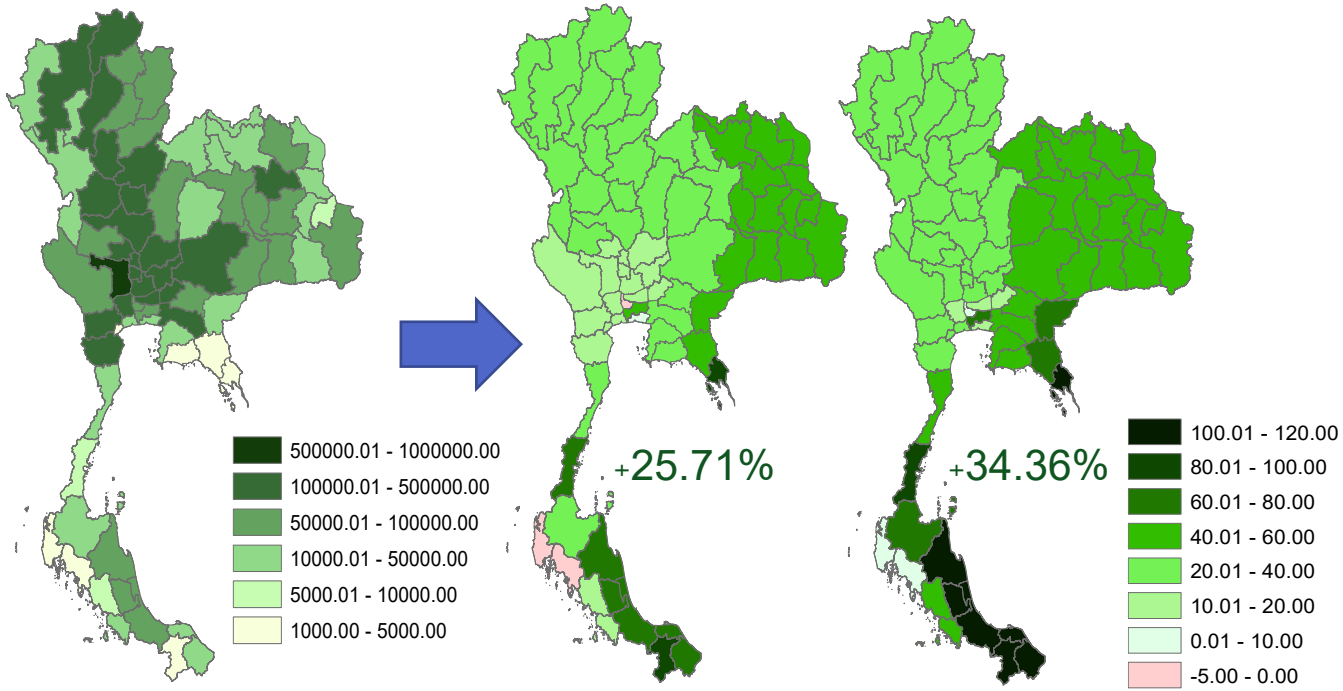
Impact of Physical Risks from Climate Change on Thai Agri-Food Sector

Rice Production

- In-season rice production in the irrigated area is expected to increase,
- while its production tends to decline in the rainfed area

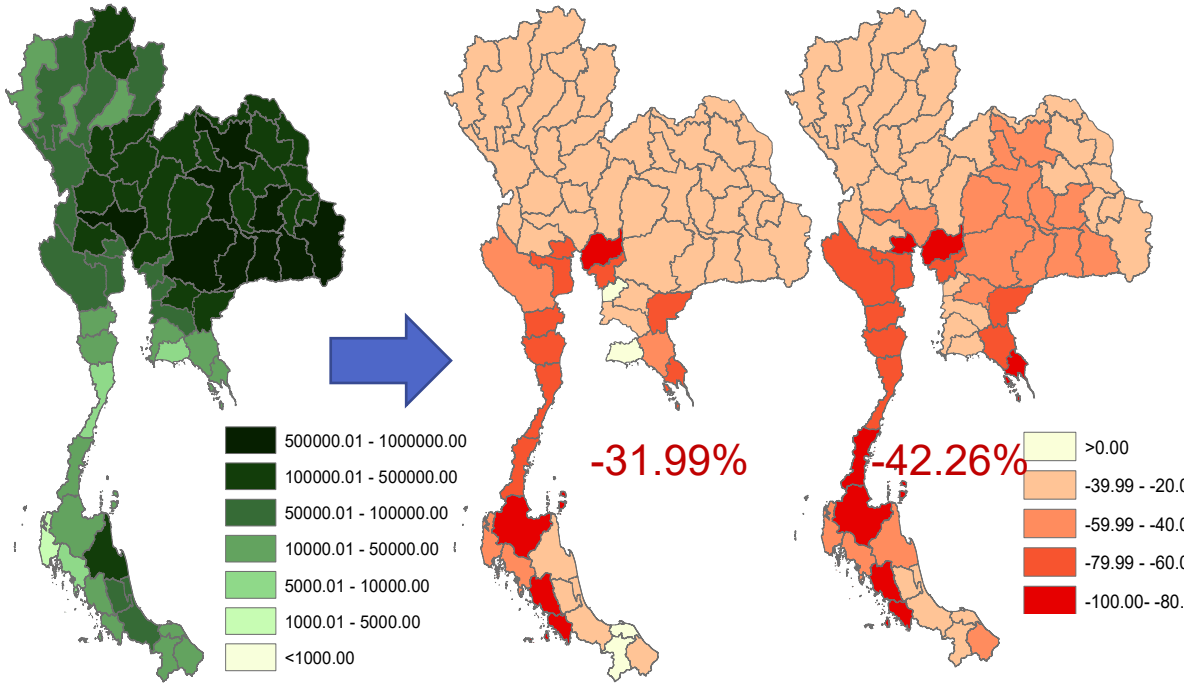
% changes of total production in 2046-2055 under scenarios from the baseline 1992-2016

In-season rice in the irrigated area



Baseline production (MT) | % change of production with RCP 4.5 | % change of production with RCP 8.5

In-season rice in the non-irrigated area



Baseline production (MT) | % change of production with RCP 4.5 | % change of production with RCP 8.5

Source: Pipitpukdee (2020)

Impact of Physical Risks from Climate Change on Thai Agri-Food Sector

- Projected impact on durian yield in 24 provinces in 2050

- Every province will be negatively affected.

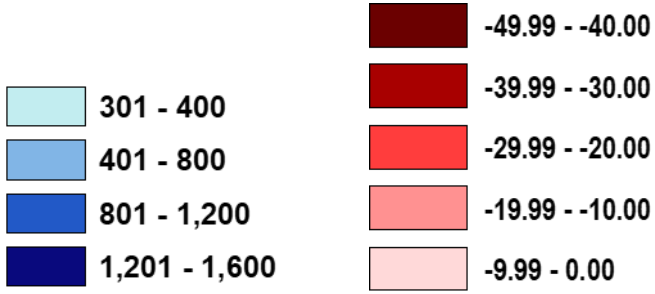
Chanthaburi decreased 11.04-11.90%

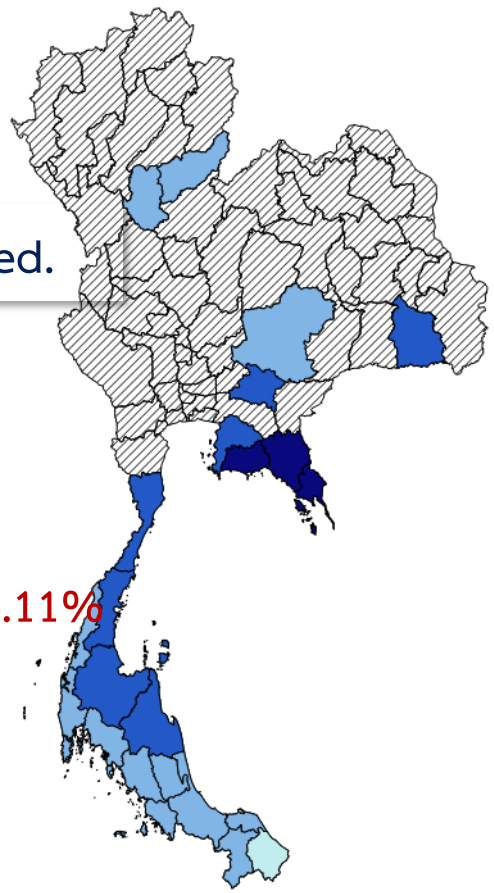
Chumphon decreased 11.52-13.06%

Rayong decreased 11.66-12.65%

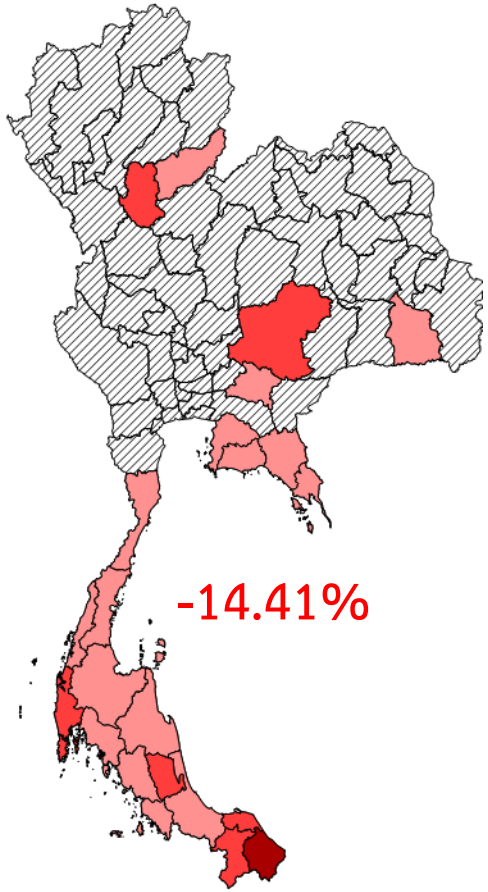
Nakhon Si Thammarat decreased 12.59-15.11%

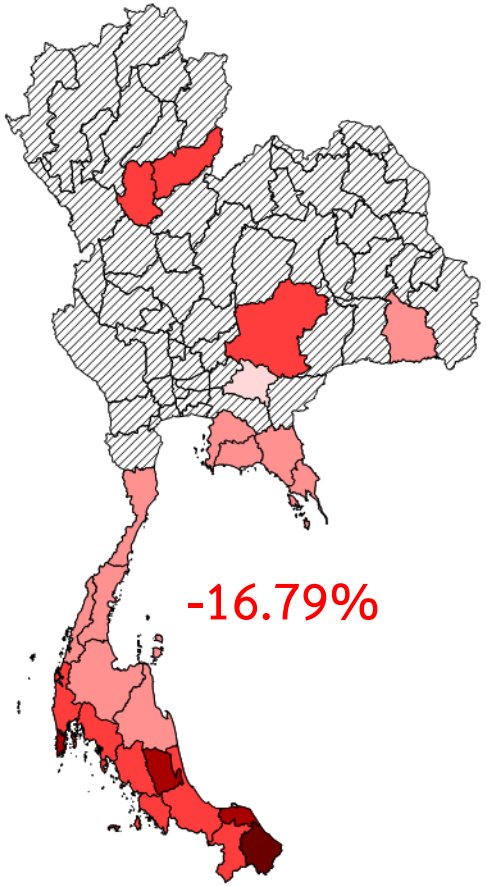
Surat Thani decreased 10.82-12.55%





Baseline (kg./rai)
(2003-2021)





SSP 2-4.5 SSP 3-7.0

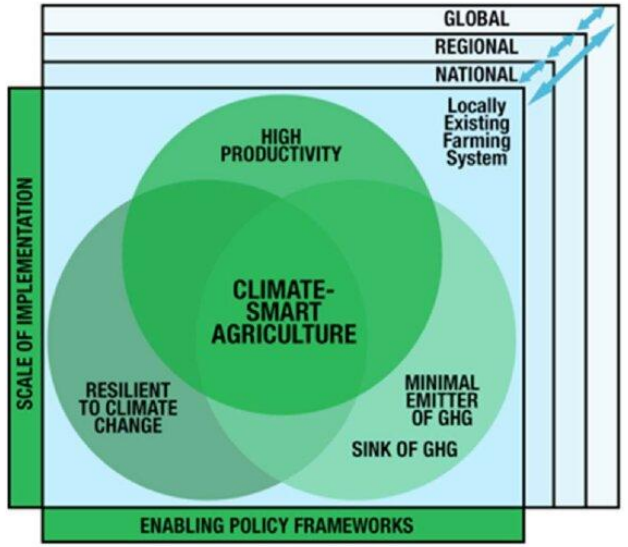
%National yield change is a weighted average of average harvested area values from 2003-2021.

Source: Attavanich & Pipitpukdee (2024)

Recommendations to Promote Climate Resilience Agriculture

Promote the Adoption of Climate Smart Agricultural Innovations

- Growing crops that are suitable for soil and water
- Adopt the alternate wetting & drying for rice cultivation
- Reducing the burning of crop residues
- Applying fertilizer according to the soil and plant needs.
- Using farm digital technologies and modern machinery
- Adopting sustainable production standards (e.g. GAP, organic



Cooperation with local educational and private institutions along with adequate budget support.

Improve production efficiency and climate resilience

Source: Attavanich et al. (2019; 2022)

Recommendations to Promote Climate Resilience Agriculture

Support research to validate and scale optimal climate-smart innovations suitable for the context of the area and type of agricultural products.

With 606 participating experts (Smart farmers, representatives from private organizations, government officials, academic & researchers), we can validate several climate-smart innovations.

Scoring Criteria
(Wassmann et al., 2019; FAO, 2022)
-Reduce Damage
-Cost Effective
-Ease of Use
-Community Benefits
-Productivity Improvement
-Opportunities for Scaling
-Policy Alignment
-Mitigation Potential
-Maturity of Technology
-Paradigm Shift Potential

Name of CSAI	Crop scope	Ranking index (%)
Kasetsart University test kit	Multi-crop	83.49
Agrocares soil scanner	Multi-crop	83.45
Trichoderma	Multi-crop	79.55
Stingless bee	Multi-crop	79.13
Metarhizium	Multi-crop	79.07
Dragonfly application for rice production	Rice	80.29
Rice straw removal (Kubota's HB135 baler)	Rice	80.07
Microorganism for decompose rice straw	Rice	78.54
Cassava mosaic virus (CMD) resistant varieties developed by KU & TTDI (Itthi 1, Itthi 2 and Itthi 3)	Cassava	80.06
Controlled released fertilizer & controlled released nitrogen for cassava	Cassava	79.54
Hydro cooling technology in longan	Longan	82.96
Smart fertilizer of longan	Longan	82.53
Hot wind forecast & warning system in longan	Longan	80.62
Intercrop in aromatic coconut	Coconut	79.62

Source: Attavanich et al. (2023; 2024; 2025)

Recommendations to Promote Climate Resilience Agriculture

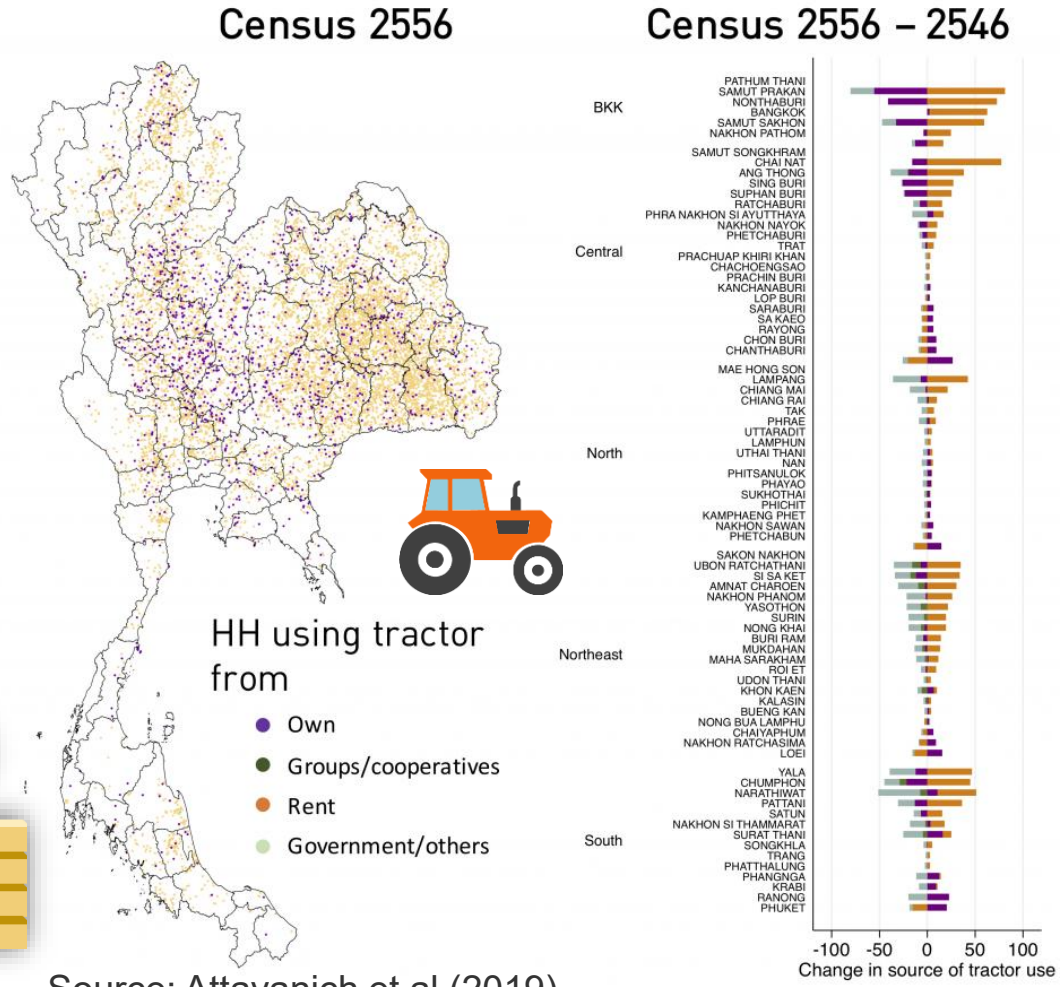
Promote sharing economy and the adoption of modern machines and farm digital technologies for small farms with competitive market environment

Create various co-benefits

- Reduce greenhouse gas emissions
- Reduce damage from climate change
- Lower production costs and increase income
- Increases yield per rai
- Alleviates the challenges of an aging society
- Ease labor shortages
- Reduce inequality
- Decrease air pollution

- **Adoption of digital farm technology will increase household income of 107,839-128,011 Baht/household/year.**

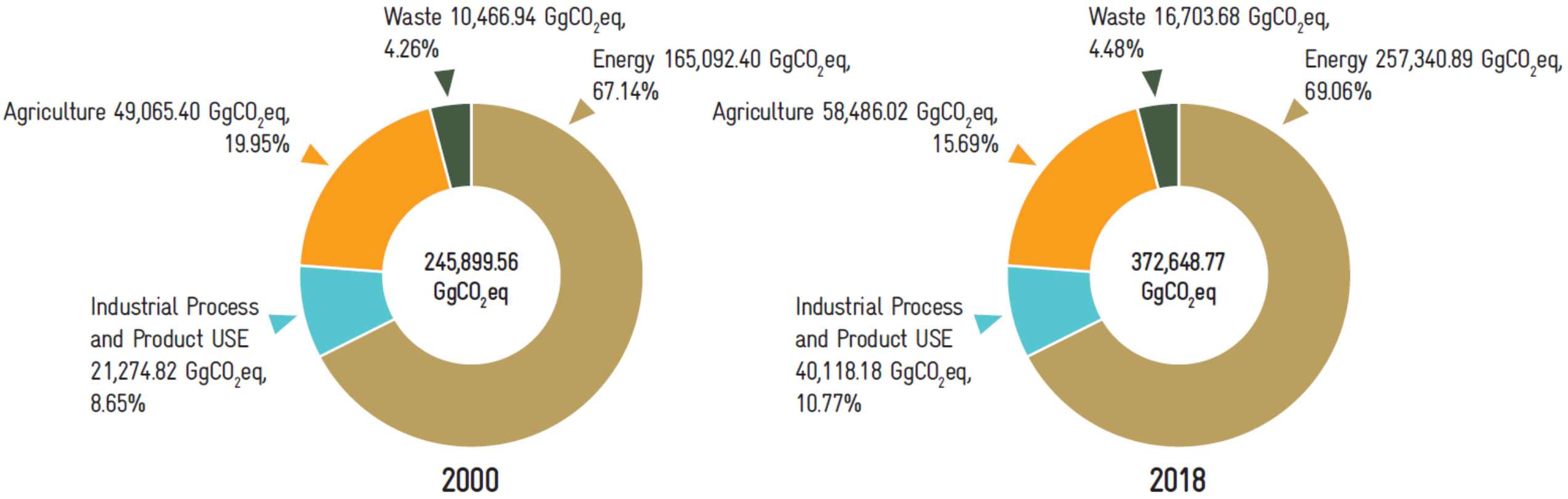
Source: Attavanich et al. (2022)



Source: Attavanich et al.(2019)

Carbon Management

In Thailand, Energy & Agricultural sectors are major sources of GHG emissions.

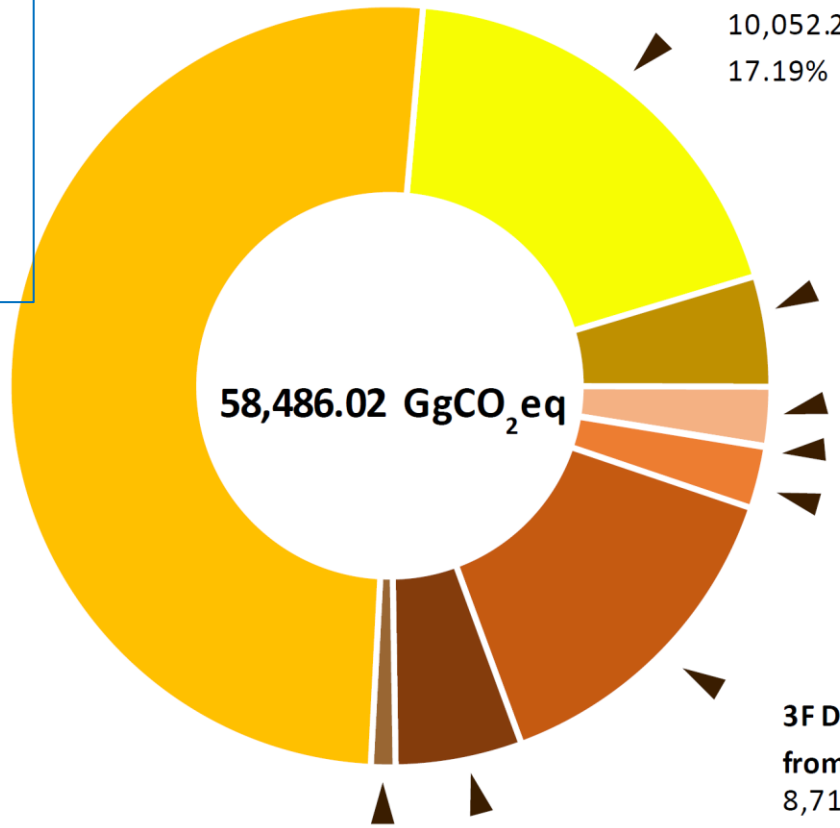


Number and proportion of greenhouse gas emissions by economic sector (excluding land use change and forestry)

Source : Thailand's Fourth National Communication, UNFCCC 2022.

Carbon Management

Rice cultivation produces the most GHG, accounting for 51.28% of total GHG emissions in the agricultural sector



3A Enteric Fermentation
10,052.24 $GgCO_2eq$
17.19%

Enteric fermentation ranked 2nd , which emitted 17.19%

3B Manure Management
2,494.12 $GgCO_2eq$
4.26 %

3C Field Burning of Agricultural Residues
1,706.82 $GgCO_2eq$, 2.92%

3D Liming, 27.59 $GgCO_2eq$, 0.05%

3E Urea Application
1,671.38 $GgCO_2eq$, 2.86%

3F Direct N_2O Emission from Managed Soils
8,715.01 $GgCO_2eq$, 14.90%

3I Rice Cultivation
29,990.25$GgCO_2eq$
51.28%

3H Indirect N_2O Emission from Manure Management
569.27 $GgCO_2eq$, 0.97%

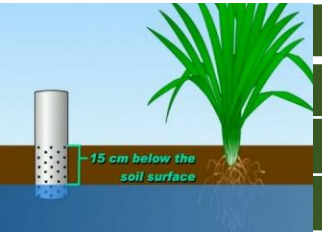
3G Indirect N_2O Emission from Managed Soils
3,259.34 $GgCO_2eq$, 5.57%

Direct N_2O emission from managed soils ranked 3rd (14.90%)

Source : Thailand's Fourth National Communication, UNFCCC 2022

Predicted GHG Emission Reduction under Mitigation Options

1. Alternate Wetting and Drying (AWD)



Change of CO_2eq from BAU ($MtCO_2$)		
	SSP1-2.6	SSP2-4.5
2030	-0.25	-0.21
2035	-0.39	-0.38

2. Reduce Burning in Agriculture

Change of CO_2eq from BAU ($MtCO_2$)		
	SSP1-2.6	SSP2-4.5
2030	-0.568	-0.597
2035	-0.872	-0.876

3. Site-Specific Nutrient Management

Change of CO_2eq from BAU ($MtCO_2$)		
	SSP1-2.6	SSP2-4.5
2030	-0.0234	-0.0259
2035	-0.0386	-0.0331

Source: Attavanich and Pengthamkeerati (2023)

4. Improve feeding with fresh grass

Change of CO_2eq from BAU ($MtCO_2$)		
	SSP1-2.6	SSP2-4.5
2030	-0.1252	-0.1313
2035	-0.2937	-0.2877

5. Promoting biogas production from swine manure using a closed-system biogas digester

Change of CO_2eq from BAU ($MtCO_2$)		
	SSP1-2.6	SSP2-4.5
2030	-0.0420	-0.0578
2035	-0.2283	-0.2394

All 5 Options

Change of CO_2eq from BAU ($MtCO_2$)		
	SSP1-2.6	SSP2-4.5
2030	**-1.0086**	**-1.0220**
2035	**-1.8226**	**-1.8162**

Co-Benefits of Greenhouse Gas Emission Reduction

Practicing Alternate Wetting and Drying (AWD) rice cultivation yields high direct net benefits and co-benefits, totaling 11,128 baht per rai.

Items	Value
Increase in net return per rai from adopting AWD practice (Baht/Rai)[1]	365.43
Value of benefits from water saving through AWD cultivation (Baht)	10,693.25
Value of benefits from greenhouse gas (GHG) emission reduction (Baht)	69.37
Total net benefits per rai from AWD rice cultivation (Baht)	**11,128.06**

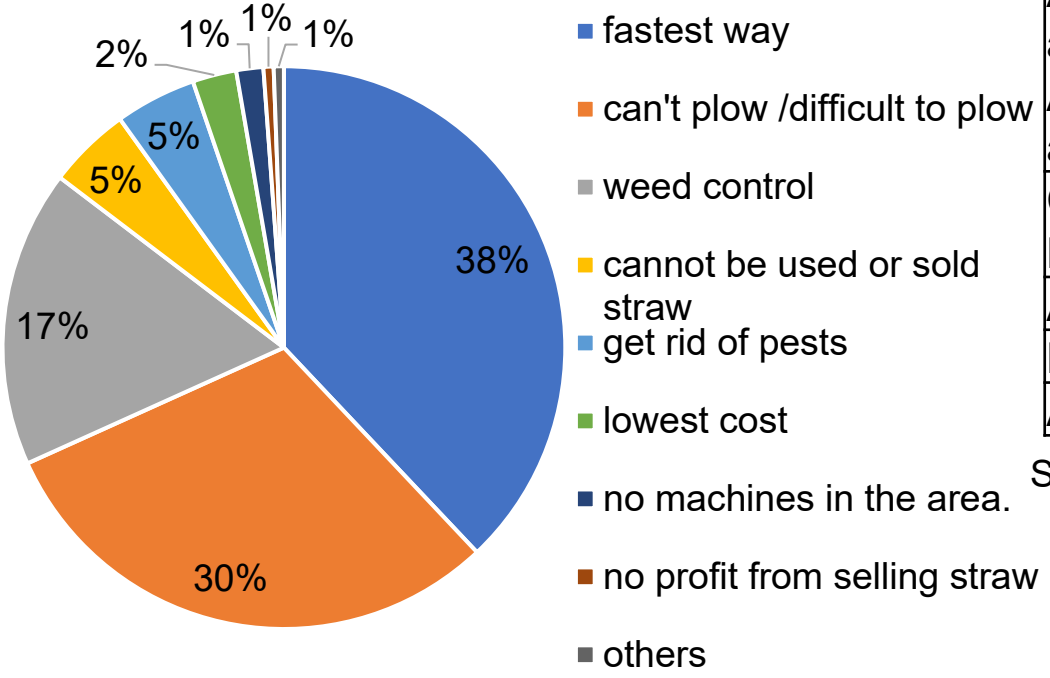
If AWD rice cultivation is adopted on 40% of the dry-season rice harvested area within irrigated zones by 2032, the Net Present Value (NPV) from adopting AWD would be **103,762 million Baht.**

Source: Pengthamkeerati and Attavanich (2022)

Addressing Crop Residue Burning (CRB) in Thailand

Interview 1,030 sampled rice farm households in Chachoengsao, Nakhon Nayok, and Ayutthaya in 2024.

Top three reasons of burning are fastest way to mange the farmland; can't plow/difficult to plow; and weed control, respectively.



Topics	Burn	Not burn
Respondents (Households)	663	367
Respondents (%)	64.37	35.63
All people burn (%)	45.55	7.63
A majority of people burn (%),	40.87	29.97
Air pollution is very bad to health of you and family (%)	14.18	25.89
Air pollution does not affect health of you and family (%)	25.79	19.07
Causing the soil quality to decrease (%)	38.31	59.13
No impact/Unknown (%)	41.48	31.06
Area have baler machine (%)	59.13	70.03
No access to water source (%)	19.76	5.99
Average farm size (rai)	33.15	27.62

Source: Attavanich, Lopes, Tiwari, & Viriyavipart (2025)

Recommendations to Promote Carbon Management

1. Alternate Wetting and Drying (AWD)

- Promote the AWD over traditional methods, as it offers strong co-benefits.
- Promote the consolidation of smallholder farmers' plots to increase the efficiency of water management and allow farmers to benefit from economies of scale through Laser Land Leveling.

2. Reduce Burning in Agriculture

- Expedite the enactment of the **Clean Air Act** that integrates economic incentives alongside legal and regulatory measures to reduce burning.
- Raise awareness among farmers about the dangers of air pollution, including PM2.5, to human health, and the environmental downsides of burning, particularly its contribution to land degradation.
- Expand the market for rice straw collection, which is currently very limited.
- Establish centralized collection points in nearby areas would help farmers reduce their transportation costs for baled straw.

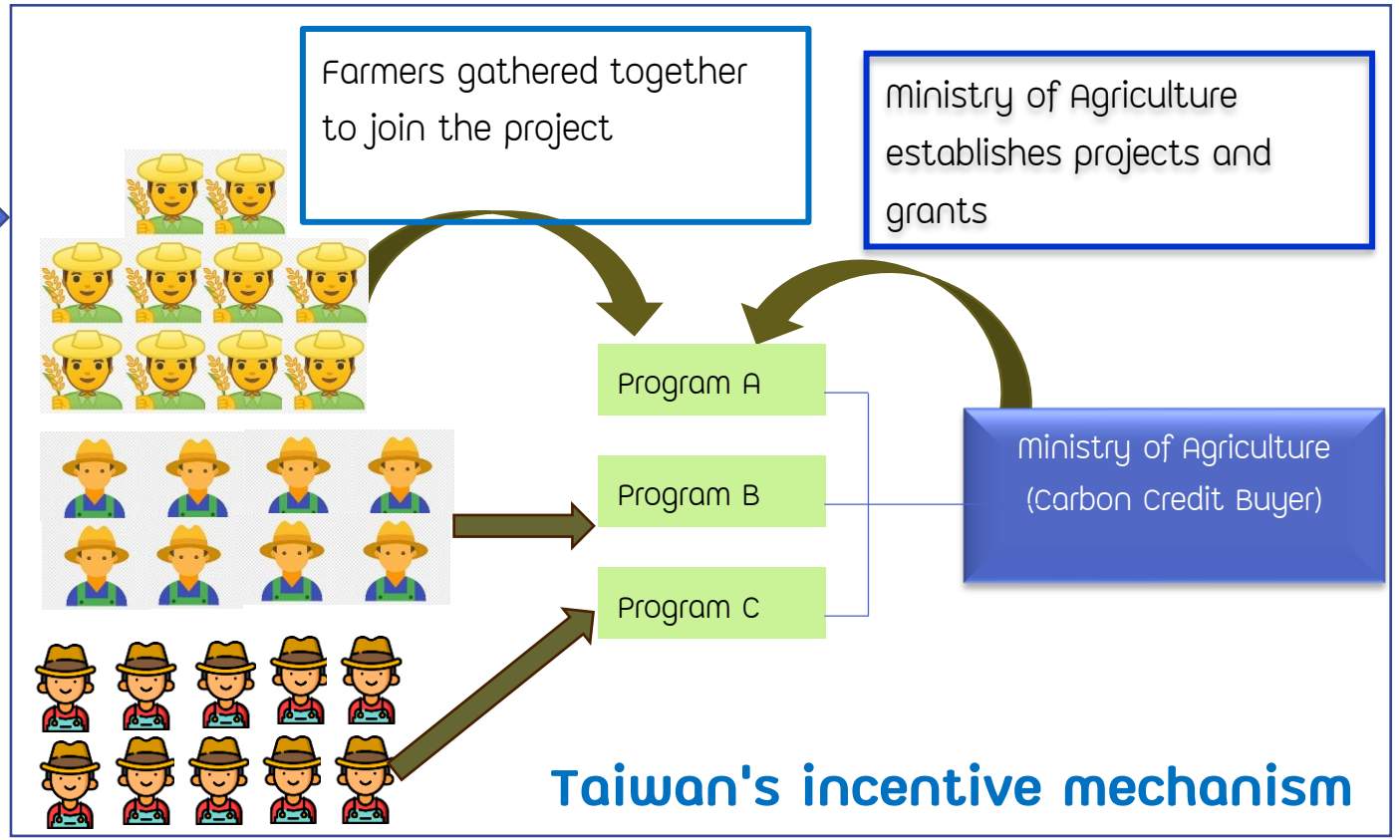
Recommendations to Promote Carbon Management

Farmers with large farm size

Ministry of Agriculture will set up a team of assistants on a case-by-case basis to help farmers apply for carbon credits

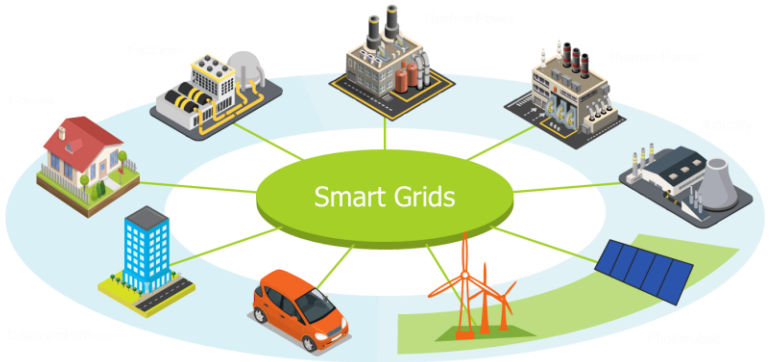
Promote and support the farmers to create carbon credit

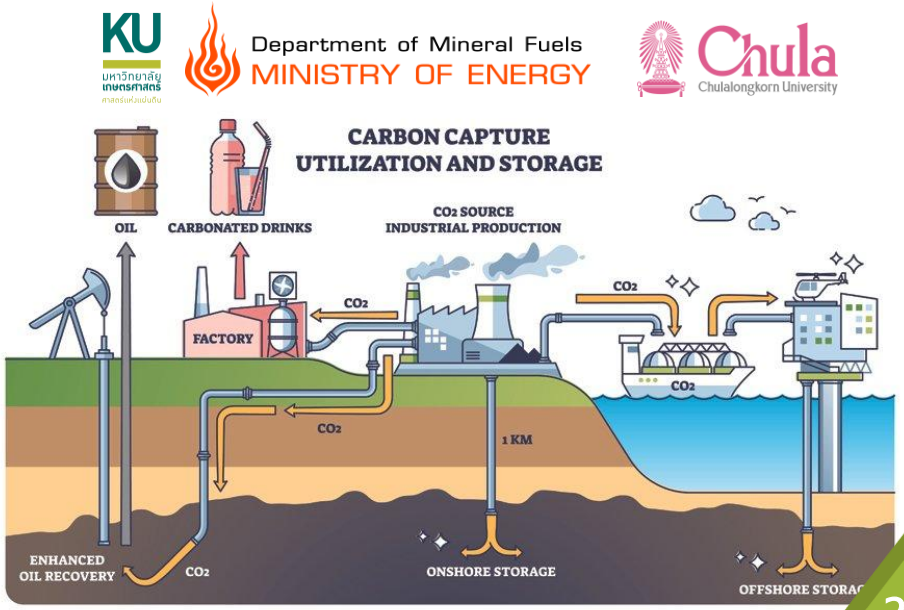
Farmers with small farm size



Recommendations to Promote Carbon Management

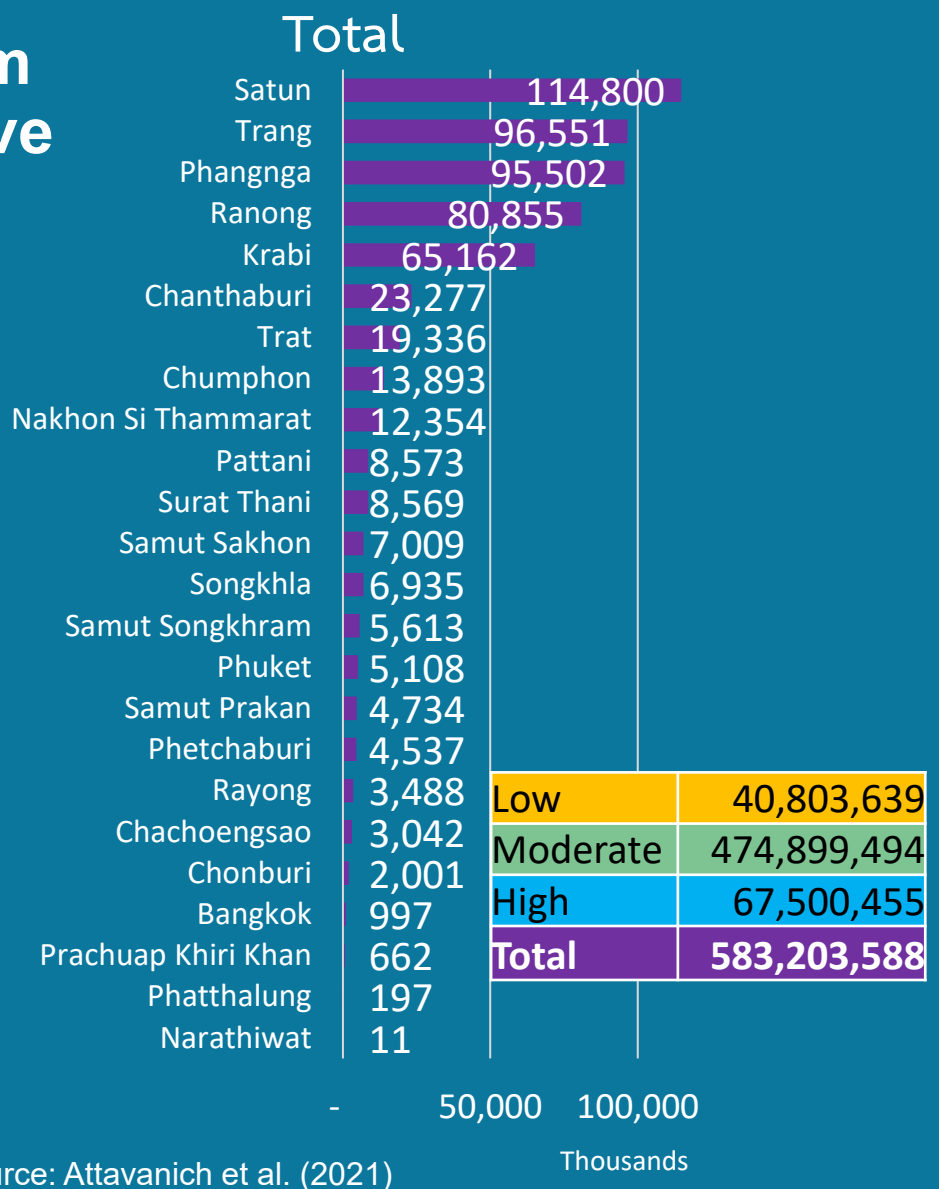
- Increase the proportion of renewable energy to replace fossil fuels and thus reduce greenhouse gas emissions.
- Support investment in renewable energy infrastructure, including energy storage and grid expansion, to mitigate issues related to power supply intermittency.
- Promote investment in Carbon Capture, Utilization, and Storage (CCUS) technologies within businesses where CCUS can be applied.





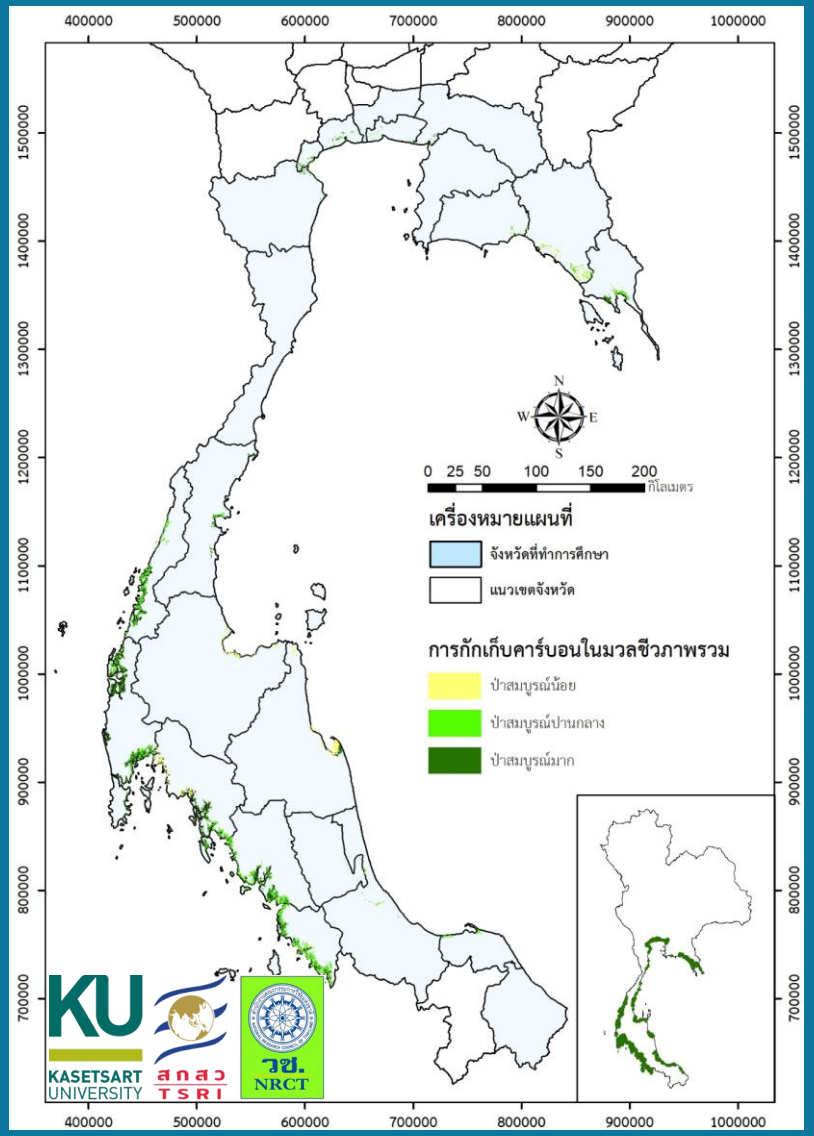
Valuation of Carbon Sequestration Services (USD/Year)

Valuing Ecosystem Service of Mangrove Blue Carbon in Thailand: A Meta Analysis



Low	40,803,639
Moderate	474,899,494
High	67,500,455
Total	**583,203,588**

Source: Attavanich et al. (2021)



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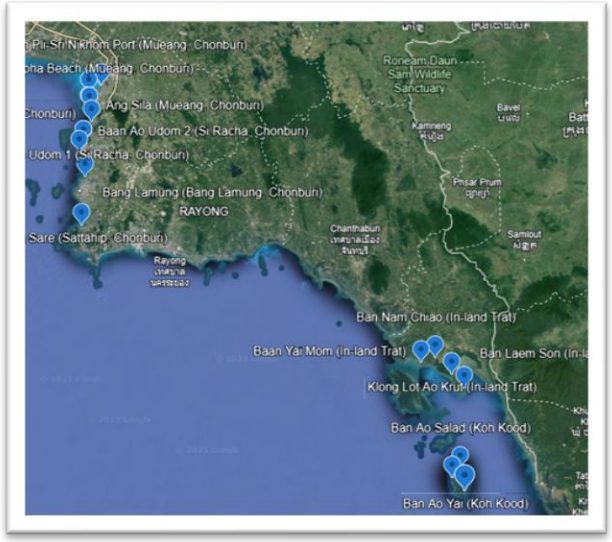
Role of Social Capital for Sustainable Fishery Management:

Economic game experiment with small-scale crab fishers in Thailand



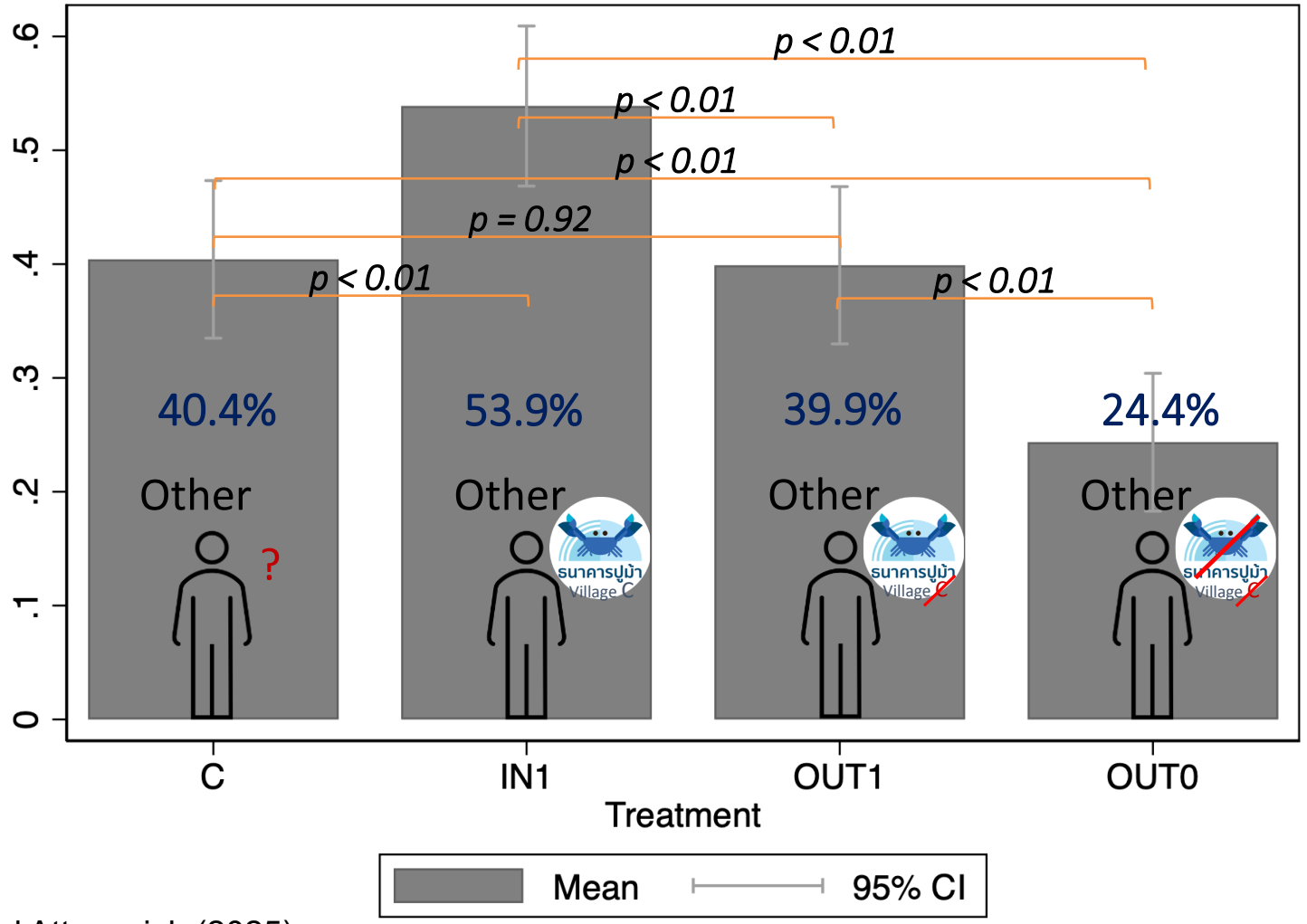
Source: Mitani, Miura, and Attavanich (2025)

Research Questions

- Does CB membership contribute to social capital accumulation within their groups?
- Does CB membership facilitate the spread of cooperation beyond the group?
  - Does a CB fisher cooperate more with a strange fisher by knowing that he is also involved in CB activity?
  - Do CB memberships alleviate aggression toward competing groups (out-group hostility) and contribute to maintaining cooperation in the broader region?

Resource Conservation - Empirical Results

CB Members (N=192)



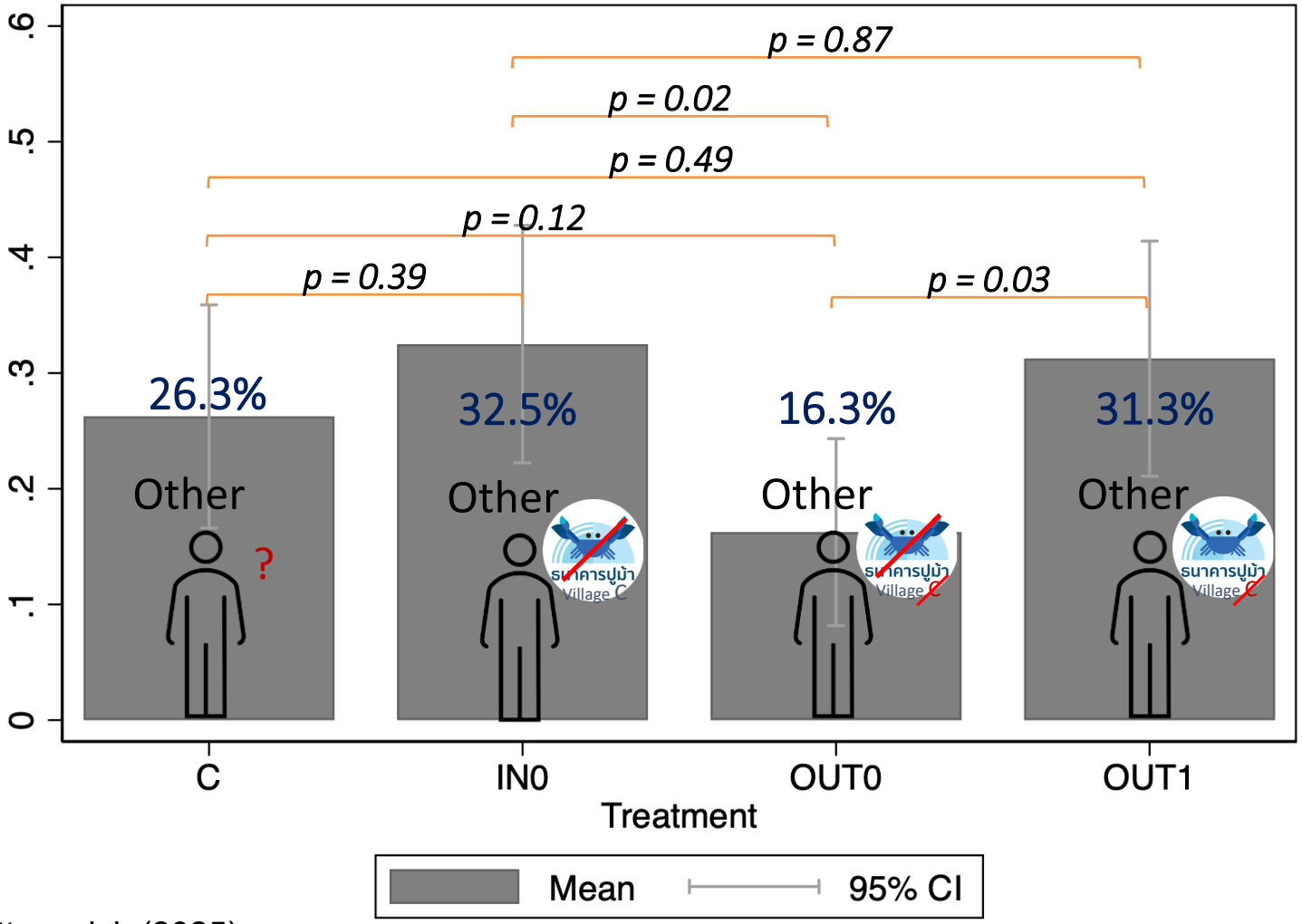
Player

You

Source: Mitani, Miura, and Attavanich (2025)

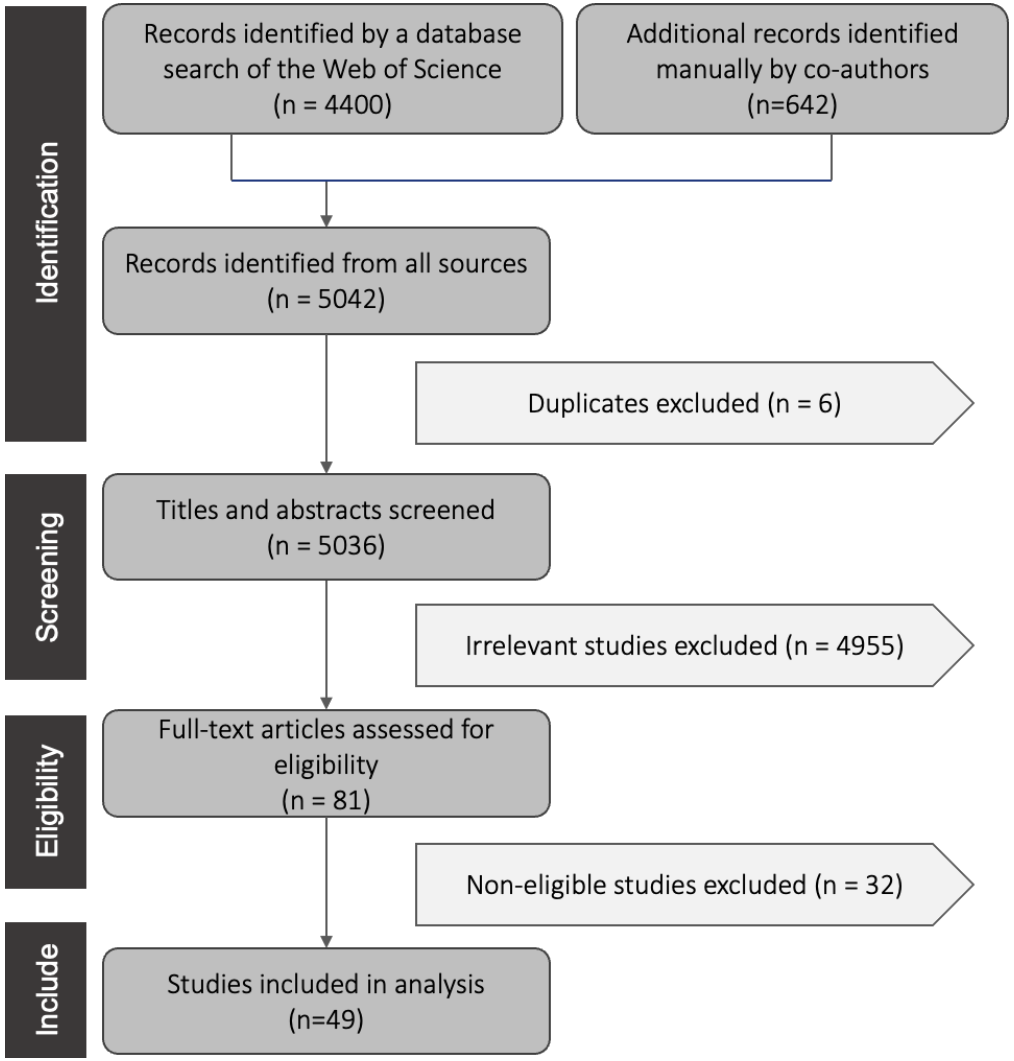
Resource Conservation - Empirical Results

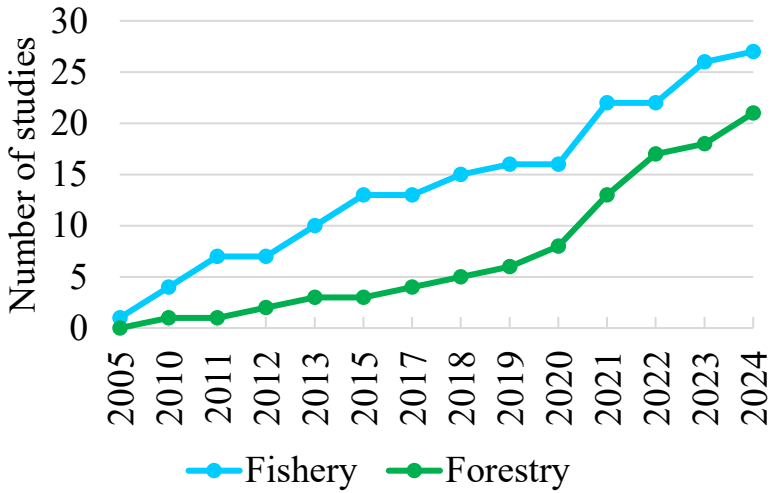
Non-CB Members (N=80)



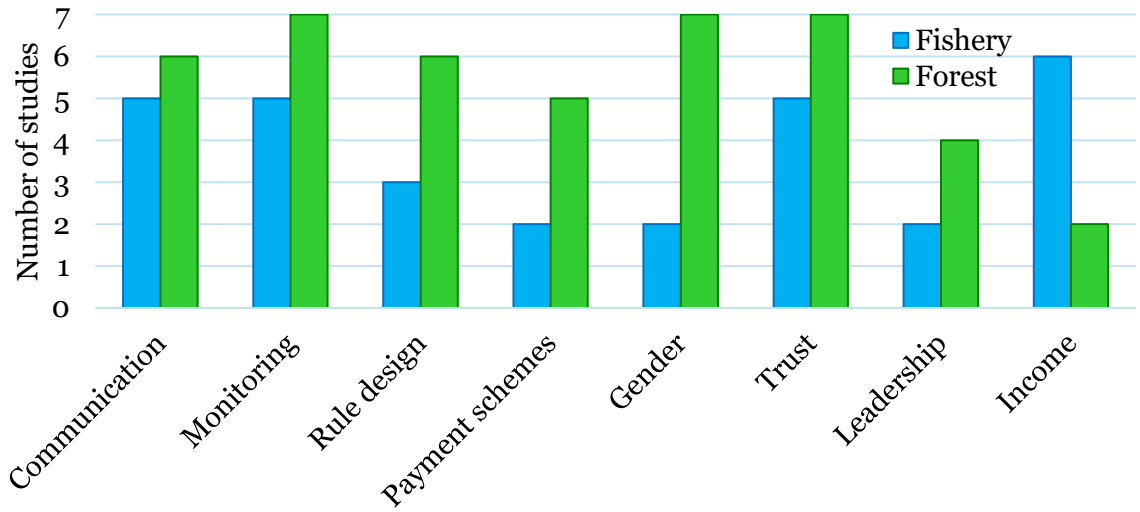
Source: Mitani, Miura, and Attavanich (2025)

Trends, Insights, and Policy Recommendations from Field Experiments on Social Capital in Forest and Fishery Resource Management.





Cumulative number of field experimental studies by CRP type



Source: Attavanich, Mitani, and Miura (2025)

Recommendations to Promote Resource Conservation

- Facilitate transparent communication.
- Invest in local monitoring and enforcement with community involvement.
- Enable collective choice and adaptive rule-making.
- Align economic incentives without undermining intrinsic motives.
- Empower marginalized groups (especially women) and local leaders.

Climate change is disrupting sustainable development in every dimension.

Now is the time for us to act—together—for a resilient and sustainable economy of the future.

Source: https://www.nature.com/articles/s41598-023-47746-w

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