AGRICULTURE SECTOR DEEP DIVE

Building a climate-adapted and resilient agri-food system in Southeast Asia

Centre for Impact Investing and Practices

IN PARTNERSHIP WITH

Alliance Bioversity & CIAT

Impact SF

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Contents

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Preamble

This deep dive on agri-food resilience, co-written by the Centre for Impact Investing and Practices (CIIP) and ImpactSF (CGIAR Hub for Sustainable Finance), examines the evolving landscape of agriculture and food systems in Southeast Asia (SEA), outlining both the opportunities and risks shaping the sector. It illustrates how climate change is compounding pressures on yields and food security, underscoring the need to strengthen adaptive capacity among producers while identifying opportunities across agricultural value chains.

The analysis herein considers a range of solution categories, including technical interventions, ecosystem enablers, improved access to financing, and mechanisms to enhance financial resilience. It also argues for a step-change in approaches to unlocking capital for the sector, alongside more rigorous frameworks for defining and measuring impact - particularly in relation to livelihoods.

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This report serves as an accompaniment to the main report **"Climate Adaptation and Resilience in Asia: Pricing Risk, Sizing Opportunities, Financing Solutions"**, by the Centre for Impact Investing and Practices (CIIP) with Temasek, Invesco, and ImpactSF(CGIAR Hub for Sustainable Finance), and support from Dalberg. Containing insights from over 250 funders, corporates, and solution providers, and powered by analysis tracking ~US$100 billion in real fund flows to CA&R in Asia over the past five years, the main report examines the comprehensive costs of climate hazards and risks, identifies opportunities in high-impact solutions and business model innovation, explores pathways to scaling adaptation financing, and maps out the intersectional impacts of CA&R.

The report highlights how funders from across the spectrum of capital can collaborate to address the region's adaptation and resilience goals.

This deep dive can also be read in tandem with the **"Climate Adaptation and Resilience in Asia Case Study Library"** by CIIP, with contributions from Invesco and ImpactSF, which includes examples on technical solutions, ecosystem and business model enablers, financial services, and capacity building initiatives in the agri-food sector.

The main report and case study library can be found on CIIP's website here:

This deep dive on agri-food resilience examines the evolving landscape of agriculture and food systems in Southeast Asia (SEA), outlining both the opportunities and risks shaping the sector.

Climate adaptation and resilience in Southeast Asia's agri-food system

The impact of climate on agriculture in SEA

Key hazards affecting agriculture in SEA

Heat

Pests

Disease

Humidity

Drought

Storms

Water stress
(includes rising salinity)

Flooding

- Agriculture is the **only sector** that is a priority sector across the National Adaptation Plans of **all 11 SEA countries**
- There are interwoven impacts to be reaped from improving climate adaptation in agriculture, such as **environmental sustainability, food security, income stability, and livelihood uplift**

9.8%
of Southeast Asia (SEA)'s GDP in 2022 was contributed by the agriculture sector. This is equivalent to US$354.3 billion[1]

30%
of SEA's food commodities is produced by smallholder farmers[2]

What this sectoral deep dive will cover:

a **Map out the opportunities and risks faced by the agri-food system in SEA**

b **Illustrate the compounding effects of climate change on regional production, food security, and economic stability**

c **Highlight the need to improve adaptive capacity across the sector and key value chains**

d **Outline a holistic suite of solutions required - technical, ecosystem enablers, access to financing, and financial resilience**

e **Recommend a step-change approach for system transformation, including Private-Public-Philanthropy (PPP) partnerships**

f **Define and measure impact in climate adaptation and resilience within the agri-food sector**

Source: 1 ISEAS Yusof Ishak Institute (2025): Outlook for Agriculture and ASEAN's Role in Southeast Asia's Food Security; **2** Australian Centre for International Agricultural Research (2024): Defining the future of smallholder farmers in Southeast Asia.

SEA's agri-food system is a key pillar of the region's economy, with opportunities from both growing regional demand...

Agriculture is a key sector in SEA

9.8%

of SEA's GDP in 2022 was contributed by agriculture. This is equivalent to US$354.3B[1]

9%

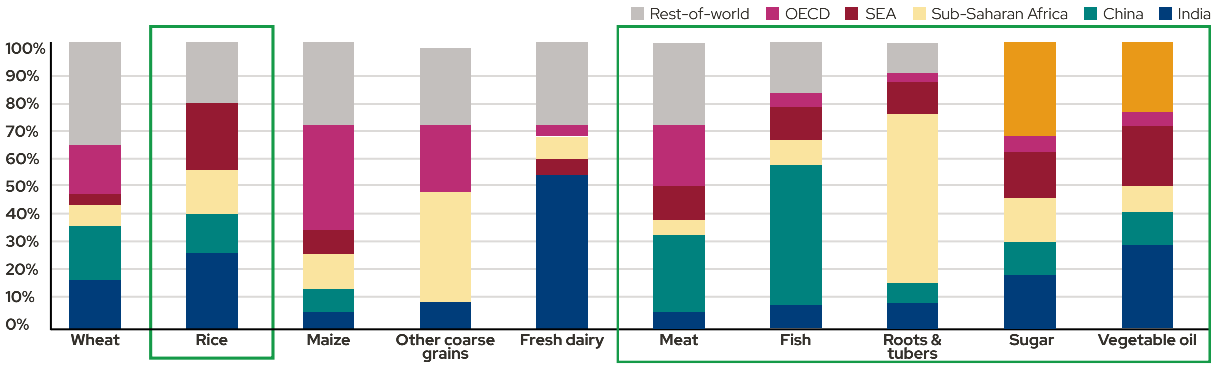
of global agricultural exports of food, feed, fibre, and industrial products comes from SEA[1]

Figure 1. Percentage contribution to regional agricultural GDP by key commodities

Top 5 crop commodities in SEA	Rice 30-50%[2]	Cassava 10-30%[3]	Sugarcane 10%[4]	Maize <10%[5]	Soybean <2%[6]
Key export commodities from SEA	Oil palm 10-30%[7]	Coffee <10%[7]	Cacao <10%[7]		
Animal husbandry value chains in SEA	Livestock >20%[8]	Aquaculture 10-20%[9]			

Regional demand for key agricultural produce is growing

Figure 2. Regional shares in commodity consumption growth, 2016-2026[10, b]



- Even as productivity is either stagnating or declining or is impacted by boom-bust cycles, there has been an increase in consumption demand for key products such as **rice, vegetable oil, sugar, roots and tubers, fish, and meat**
- **Changing diet compositions due to growing middle class** – an estimated 50 million additional consumers in this income bracket across Indonesia, Malaysia, the Philippines, Thailand, and Vietnam by 2022[11] – explain the increase in consumption of protein-heavy products such as meat and fish[12]

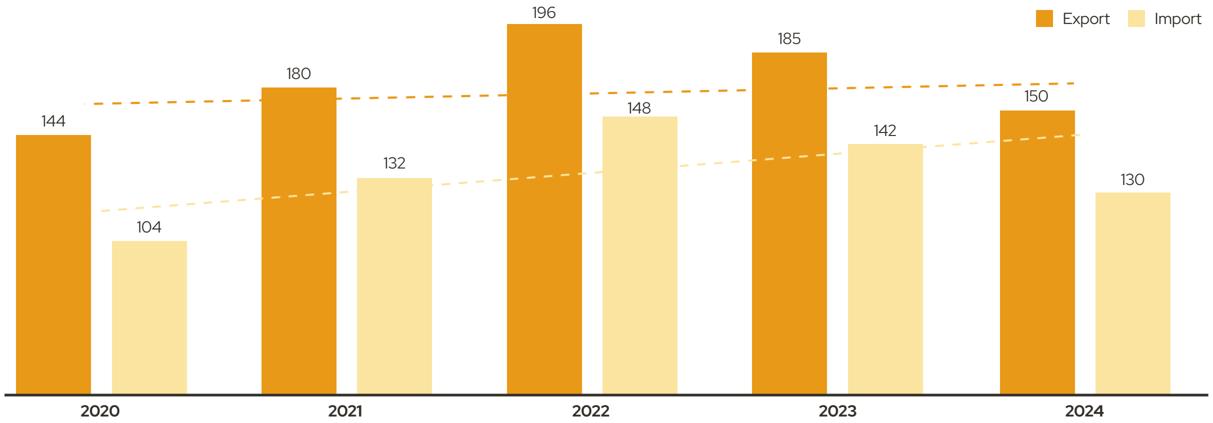
Note: a Also includes additional analysis by ImpactSF; **b** Demand growth compares 2026 to baseline (2014-2016) average. SEA includes Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, Vietnam.

Source: 1 ISEAS Yusof Ishak Institute (2025): Outlook for Agriculture and ASEAN's Role in Southeast Asia's Food Security; **2** Shen et al. (2022): Southeast Asia must narrow down the yield gap to continue to be a major rice bowl; **3** Abebaw (2025): A Global Review of the Impact of Climate Change and Variability on Agricultural Productivity and Farmers' Adaptation Strategies; **4** Solomon et al. (2024): Sustainability Issues and Opportunities for Sugar and Integrated Industries in ASEAN Region; **5** Grote et al. (2020): Food Security and the Dynamics of Wheat and Maize Value Chains in Africa and Asia; **6** Harisman, K., Birnadi, S., & Subandi, M. (2019): Development of Soybean Cultivation as Leading Commodity in Regional Agribusiness Area; **7** Taniushkina (2024): Case study on climate change effects and food security in Southeast Asia; **8** Australian Centre for International Agricultural Research (2022): Southeast Asian livestock futures: what role for smallholders?; **9** Hisamunda et al. (2009): Commercial aquaculture in Southeast Asia: Some policy lessons; **10** OECD, FAO (2017): OECD-FAO Agricultural Outlook 2017-2026 ; **11** Bain & Company (2019): Understanding Southeast Asia's Emerging Middle Class; **12** S.Rajaratnam School of International Studies (2022): CO22061 | Animal Feed and Meat: Asia's Looming Food Crisis.

...and continued trade potential

SEA's agriculture sector continues to grow

Figure 3. Value of agricultural trade for ASEAN member states, US$B[1]



- SEA continues to be a net exporter of agricultural produce and products, with export value increasing year-on-year
- The region's trade balance is narrowing as imports continue to increase - trade balance in 2024 has decreased 25% compared to 2020. This implies a higher dependency on external sources for food and feed. This can be attributed to a stronger demand growth for food products (and especially higher value, more processed and convenient food products), as a result of rising incomes and an increasingly urbanised population[2, 3]
- About a quarter of agricultural production is traded within ASEAN, with the rest of production volume (75%) exported to rest-of-world.[4] To increase regional food resilience, it is crucial to also improve intra-regional trade

Top export products from SEA, average from 2019-2023[1, 5, a, b]

	Palm[i]	Rice[ii]	Shrimp, prawns[iii]	Cassava[iv]
Export value (US$)	48.4B	21.6B	7.4B	5.3B
CAGR	8.5%	7.3%	-1.9%	10.4%
Import Dependency Ratio (IDR)	9.8	7.2	4.8	6.0

Definitions: i Includes Palm kernels, Palm oil, Cake of palm kernel, Oil of palm kernel; **ii** Includes Rice; Rice, broken; Rice, milled; Rice, milled (husked); Rice, paddy (rice milled); Oil of rice bran, Flour of rice; Cake of rice bran, Husked rice; **iii** Includes top prawn species such as Black Tiger Prawn, and shrimp species like Whiteleg Shrimp (Vannamei); **iv** Includes Cassava, dry; Cassava, fresh; Starch of cassava, Flour of cassava, Tapioca of cassava; **v** Other tropical fruits n.e.c is among the Top 5 with US$3.9 million in export volume, but it is not included as this category contains too many other sub-types (e.g. durian, mangosteen, etc).

Top import products from SEA, average from 2019-2023[1, 5, a, b]

	Soybean[i]	Wheat	Rice[ii]	Maize[iii]
Export value (US$)	17.0B	10.0B	8.1B	6.2B
CAGR	9.2%	7.4%	20.6%	6.4%
Import Dependency Ratio (IDR)	97.3	99.8	7.2	33.7

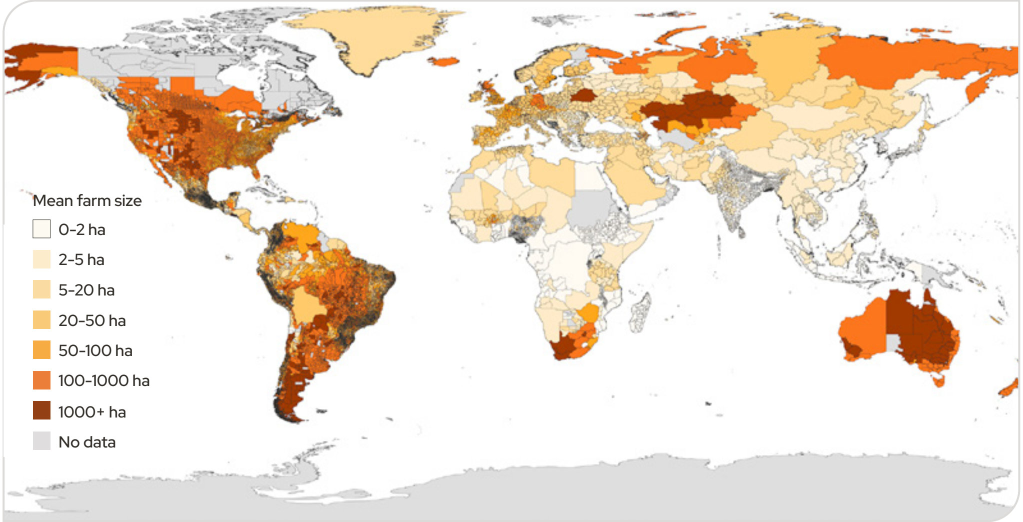
Definitions: i Includes Soya bean oil, Soya beans, Soya paste, Soya sauce, Cake of soya beans; **ii** Includes Rice; Rice, broken; Rice, milled; Rice, milled (husked); Rice, paddy (rice milled); Oil of rice bran, Flour of rice; Cake of rice bran, Husked rice; **iii** Includes Maize (corn), Oil of maize, Bran of maize, Flour of maize, Germ of maize.

Note: a Latest available information for aquaculture is 2023, hence analysis is conducted for the last 5 years, inclusive of 2023; **b** Import Dependency Ratio (IDR) is defined as imports x 100/ (production + imports – exports). The complement of this ratio to 100 would represent that part of the domestic food supply that has been produced in the country itself.[6] The higher the ratio, the more dependent on imports for this commodity. Average IDR across 2019-2023 is derived for this analysis. **Source: 1** FAO (n.d.): FAOSTAT, and CIIP analysis; **2** ISEAS Yusof Ishak Institute (2025): Outlook for Agriculture and ASEAN's Role in Southeast Asia's Food Security; **3** OECD and FAO (2023): OECD-FAO Agricultural Outlook 2023-2032; **4** Teng et al. (2021): Advances in Food Security and Sustainability, Chapter Four – ASEAN responses to COVID-19 for assuring food security; **5** FAO (n.d.): FishStatJ – Software for Fishery and Aquaculture Statistical Time Series, and CIIP analysis, **6** FAO (n.d.): Metadata.

However, agriculture in the region is highly fragmented, and is facing the compounded pressures of reducing farm sizes and climate change

>500 million smallholder farmers globally, many concentrated in Asia, with ~100 million in SEA alone[1, 2]

Figure 4. Global map of mean farm size across 20,124 administrative units for 200 countries and territories



Note: The modal year of the dataset is 2000 at the national level and 2006 at the subnational level, but includes a span of datasets as far back as 1960 and as recent as 2022.[3]

While smallholder farmers are responsible for significant regional food production...

30%
of SEA's food commodities are produced by smallholder farmers[4]

9.4M
people in SEA are engaged in fisheries, which is 1.4% of the region's population. This is more than three times the global average[5]

...most live under the poverty line

US$500-2,000
typical annual income, which is close to or below national poverty lines[6] Most live on less than US$2 a day[7]

<10%
of smallholders can access formal finance to invest in better practices. Most rely on informal finance, with interest rates reaching as high as 25%[6]

...and face heightened climate change impacts

>10%
projected cropland area loss in Indonesia, Malaysia, the Philippines and Vietnam by 2028, if no action is taken to mitigate climate effects[8]

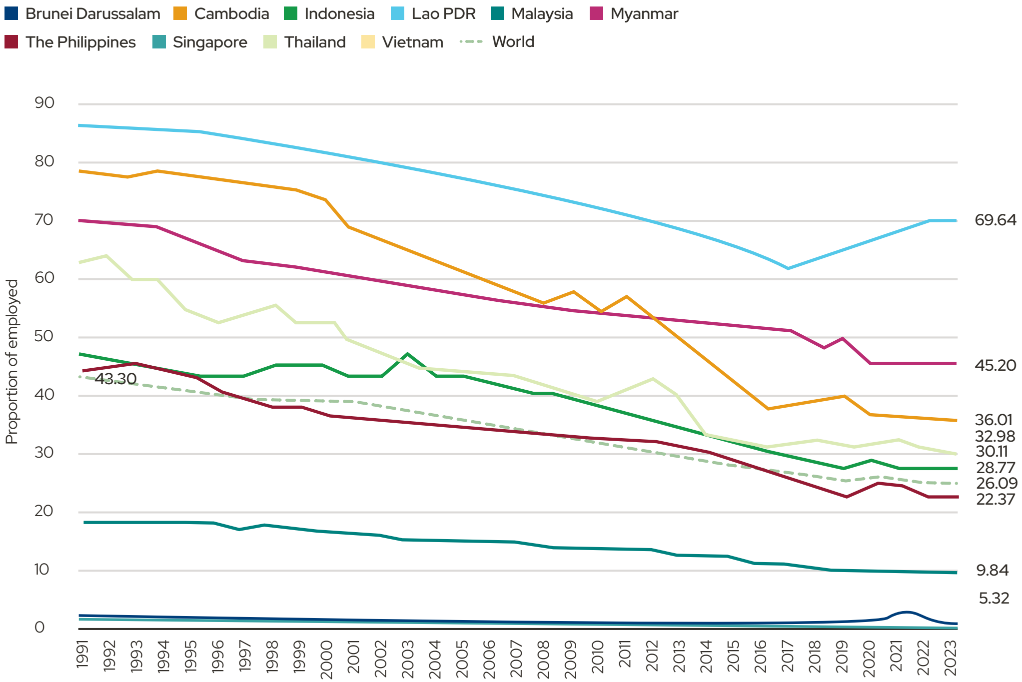
20M
livelihoods affected in the Mekong Delta due to salinity intrusion, now an annual hazard. Up to 45% of the Delta's agricultural area is projected to be affected by 2030[9]

Source: 1 World Economic Forum (2024): Industry government collaboration on agritech can empower global agriculture; 2 FAO Regional Office for Asia and the Pacific (2025): Southeast Asian countries advance climate-smart agriculture through regional cooperation; 3 Fortin et al. (2026): Global dataset on mean farm size reveals important subnational variability; 4 Australian Centre for International Agricultural Research (2024): Defining the future of smallholder farmers in Southeast Asia; 5 Mongabay (2025): Southeast Asia's fisheries thrive despite decades of overfishing warnings: Study; 6 GrowAsia (2024): Unlocking Resilience: How Social Finance can Help Southeast Asia's Smallholder Farmers Adapt to Climate Change; 7 World Bank Group (2016): A Year in the Lives of Smallholder Farmers; 8 Taniushkina et al. (2024): Case study on climate change effects and food security in Southeast Asia; 9 Nanyang Technological University (2025): Salinity intrusion threatens Vietnam's rice bowl.

Moreover, farmer populations in SEA are shrinking and ageing, which threatens the production capacity and the stability of the trade

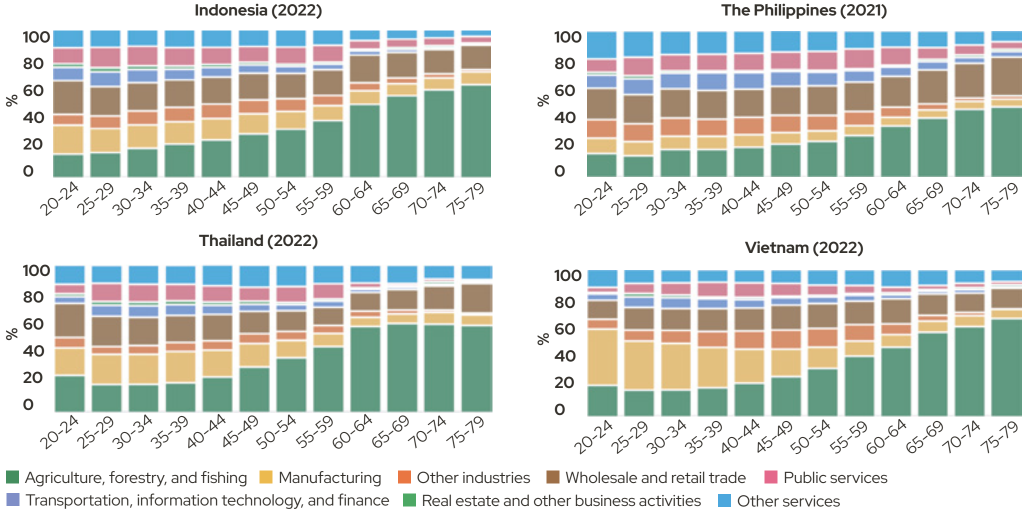
The number of people employed in agriculture is shrinking year-on-year...

Figure 5. Proportion of people employed in agriculture between 1991-2023[1]



...with most above the age of 50 across major agricultural countries in the region

Figure 6. Share of employment by sector and by age in top agricultural countries in Southeast Asia[2]



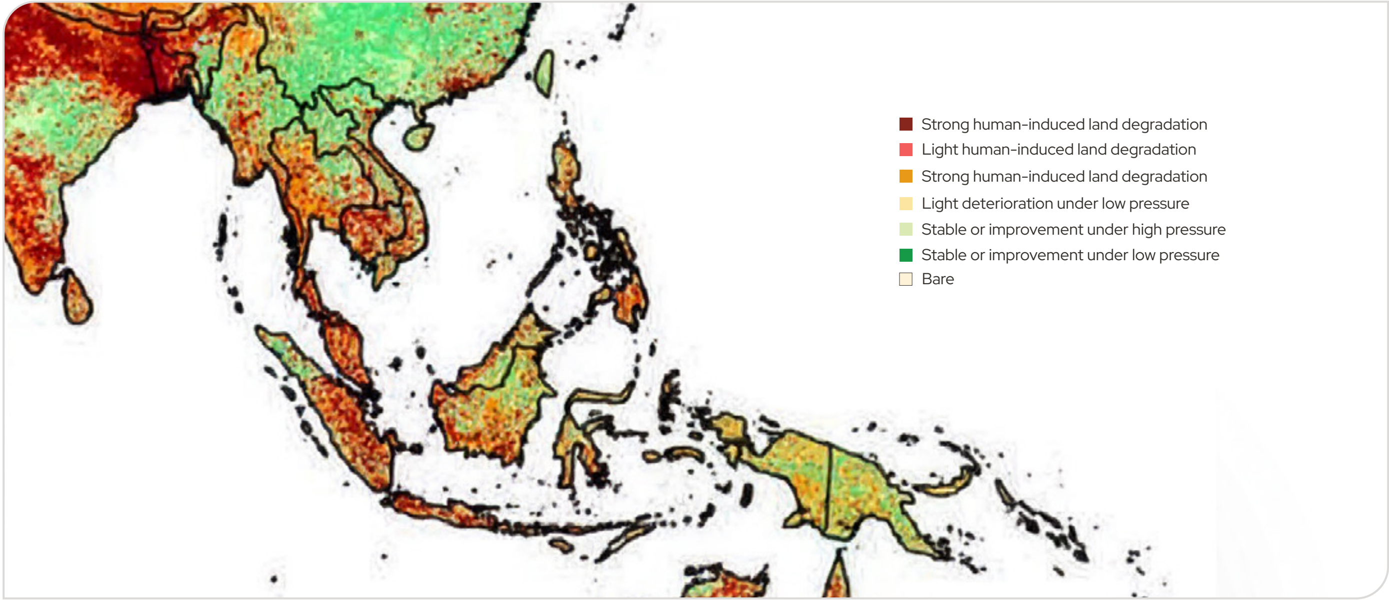
- Limited safety nets leave many older people with no choice but to work past statutory retirement age[2]
- Many of these farmers have little access to machinery, leaving them to cope with declining physical strength and limited family support as younger relatives leave for the cities[2]

Source: **1** Fulcrum (2025): Migrant Agriculture Workers: Potential Resource for Southeast Asia's Food-resilient Future; **2** Asian Development Bank (2025): Mechanisation and Financing Can Extend Older Farmers' Working Lives.

While the current intensification of agricultural activities is causing a negative flywheel of unsustainable practices and degrading land

Agricultural activities have intensified significantly in recent years as farmers struggle to meet growing demand. Many of the practices adopted are unsustainable and counterproductive. Today, human-induced land degradation affects 34% of agricultural land.[1]

Figure 7. Land degradation classes based on severity of human-induced pressures and deteriorating trends, 2015[1]



As agriculture intensifies, the extent and severity of land degradation increases due **to soil erosion, nutrient depletion, and increase in soil salinity**[1]

Smallholder farmers tend to **increase the use of variable inputs** (e.g., fertilisers and pesticides) to increase their productivity, rather than investing in fixed inputs such as machinery[2]

67% increase in agrochemical use **since 1990**, with **pesticide imports increasing nearly 7x** between 1990 and 2010[3]

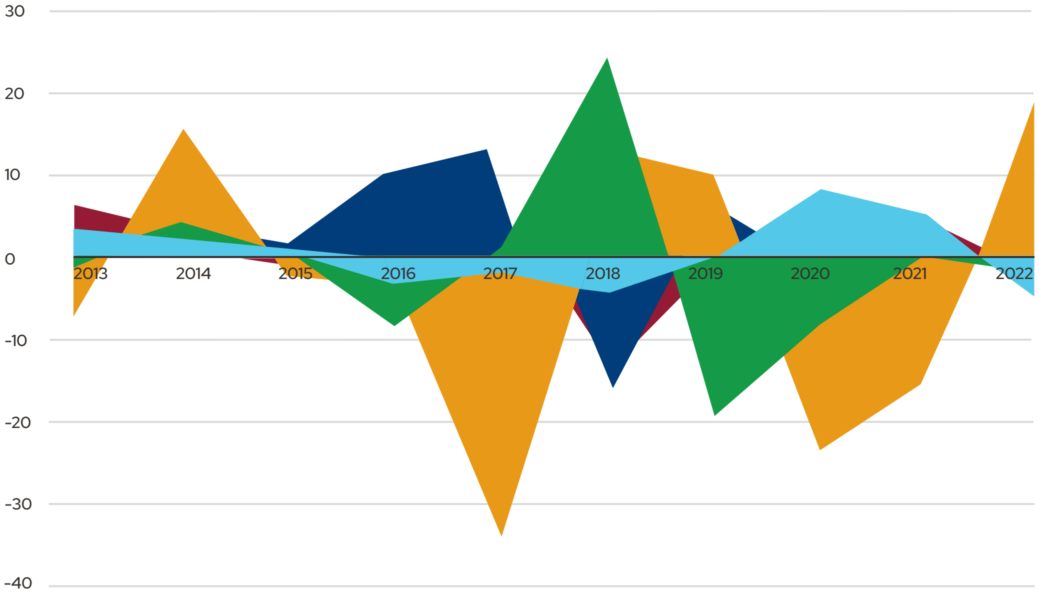
Smaller farms typically **apply less irrigation**, especially in low- and middle-income countries, which makes them **more vulnerable to water scarcity** than larger farms[2]

Note: Extracted from global distribution of land degradation. Overall trend combined with cumulative pressure by direct human drivers. Human-induced land degradation refers to a negative trend caused by human activity, while deterioration refers to a negative trend caused by natural phenomena, or by human action where status is low.

Source: 1 FAO (2021): The State of the World's Land and Water Resources for Food and Agriculture – Systems at breaking point; **2** Su et al. (2022): Gridded 5 arcmin datasets for simultaneously farm-size-specific and crop-specific harvested areas in 56 countries; **3** FAO (2023): Pesticides use and trade.

As a result, agri-production in the region is stagnating, especially for key staple crops

Figure 8. Growth rates of SEA's five major food commodities, 2013-2022 (%)[1]



	Rice	Maize	Soybean	Sugarcane	Cassava
Average annual growth, 2013-2022	-0.4%	1.3%	-7.2%	1.2%	1.2%

- Regional total agriculture factor productivity for crops such as rice, sugarcane, and oil palm across SEA showed increases until 2010, after which productivity has either stagnated or declined[2]
- An important reason for stagnation yields is the decrease in input use efficiency, as a result of ineffective management or lack of response from the soil. For example, fertiliser recovery efficiency (i.e., nutrient uptake by the crop from the fertiliser compared to total applied) for rice averages around 40%, which not only leads to stagnating yield growth, but also to declining profitability[3]
- Additionally, the average annual production growth of staples (i.e., top five food crops) has stagnated at under 1.3% or declined in the past decade. This would threaten the region's food security if the production of staples cannot keep up with growing demand
- For commodities such as coffee, cacao, livestock (milk) and aquaculture, although there has been an upward trend in productivity, this has been significantly impacted by boom-bust cycles recently[4]
- Additionally, wild catch is declining fast due to overfishing, and the "catch per unit effort" has declined significantly. This means fishers need to spend more time to catch fewer fish today[5]

Source: 1 ISEAS Yusof Ishak Institute (2025): Outlook for Agriculture and ASEAN's Role in Southeast Asia's Food Security; **2** Liu et al. (2020): Agricultural Productivity Growth and Its Determinants in South and Southeast Asian Countries; **3** ASEAN (2017): ASEAN Guidelines on Soil and Nutrient Management; **4** Blundo-Cato et al. (2025): Assessing the multidimensional impacts of agroecological practices in Southeast Asia. A review; **5** FAO Regional Office for Asia and the Pacific (2010): Status and potential of fisheries and aquaculture in Asia and the Pacific 2010.

This underscores the need for new farming approaches, to reduce reliance of manual labour in agriculture while ensuring production levels can be maintained or even increased

Mechanisation to improve efficiency

Example: Agricultural mechanisation in Thailand

- Thailand embarked on its agricultural mechanisation journey since the 1890s and ramped up in the next century as more machineries were imported[1]
- Today, powered machinery such as tractors, has replaced many jobs formerly carried out by menial labour
- In 2000, only 40% of farmers in the Central Plains were using large four-wheeled tractors for land preparation for rice planting. By 2019, 92% of farmers were using large tractors equipped with rotary tillers or rotavators for ploughing, which increased efficiency and reduced time. Hand transplanting has virtually disappeared in the Central Plains today[2]

5-25%

Estimated increase in per capita farm income of smallholders in Southeast Asia given an increase in crop commercialisation[3]

US$224/ha

Current cost of mechanisation per hectare of farmland in 2016, a 58% increase compared to the cost in 2010[3]. While there is an urgency to shift towards mechanisation, affordability is of key concern too

Innovations for higher yields and lower costs

Example: Temasek Life Sciences Laboratory's (TLL) aquaculture facility

- Launched Singapore's first urban fish farm using shipping containers, integrating advanced aquaculture biology and engineering to enable fish production in fully controlled environments
- Compared with traditional farming methods, the facility is approximately 25% more productive within a compact footprint, while reducing resource use, eliminating antibiotics, and delivering consistent, high-quality output
- Its compact footprint allows underutilised urban spaces to be repurposed as productive and sustainable aquaculture hubs, shortening supply chains and bringing fresh fish closer to consumers
- By combining modular infrastructure, precision aquaculture and flexible urban deployment, TLL aims to transform aquaculture into a distributed, climate-resilient, and resource-efficient food production system

270+

Agrifood tech startups in SEA, with 43% of them based in Singapore[4]

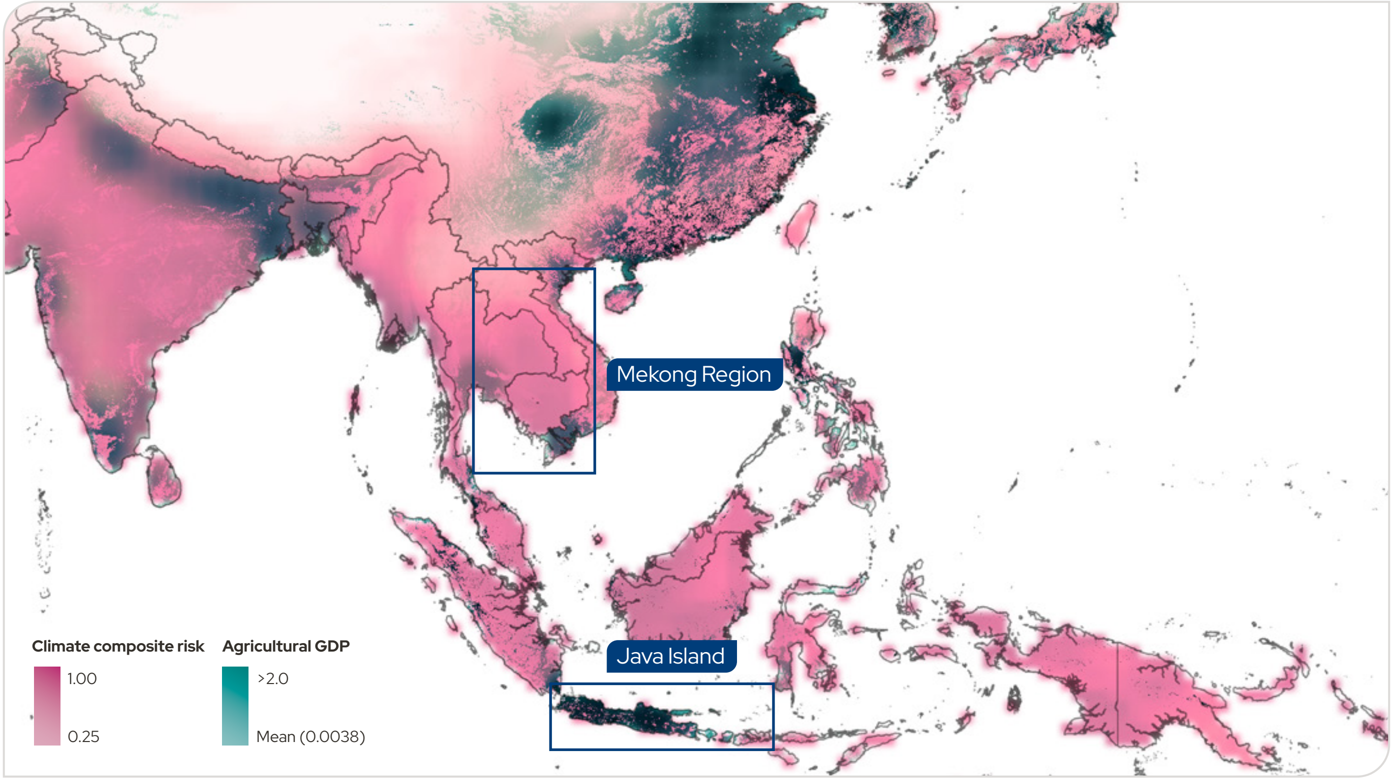
US$1.27B

Investment into agrifood tech in 2022, a 6x increase compared to 2018[4]

Source: 1 Food and Fertilizer Technology Center for the Asian and Pacific Region (2023): Prospects of Smart Agricultural Mechnisation in Thailand in Post COVID-19 Pandemic; **2** Promkhambut et al. (2023): Rethinking agrarian transition in Southeast Asia through rice farming in Thailand; **3** Do et al. (2026): Crop commercialisation, structural change and income inequality: Insights from smallholder farmers in rural Southeast Asia; **4** Forward Fooding and Singapore Economic Development Board (2023): AgriFoodTech in Southeast Asia – 2023 Ecosystem Report.

Looking ahead, climate change will significantly impact agriculture in the region

Figure 9. Overlay of climate composite risk on top of agricultural GDP concentration in SEA



6 to 7%

Decrease in rice grain yields for every 1°C increase in temperatures[3]

- Areas that contribute significantly to regional agriculture GDP, such as the **Mekong Region across Cambodia, Myanmar, Thailand, and Vietnam, and Java Island in Indonesia**, are facing high climate risk, and require urgent action to safeguard food security and smallholder livelihoods
- **Extreme heat** has been identified as the dominating concern in tropical and sub-tropical SEA. This has far-reaching impacts on agricultural value chains[3]
- High temperatures will also affect the nutritional quality of rice grains, which in turn will **affect the market price and incomes of farmers**[3]

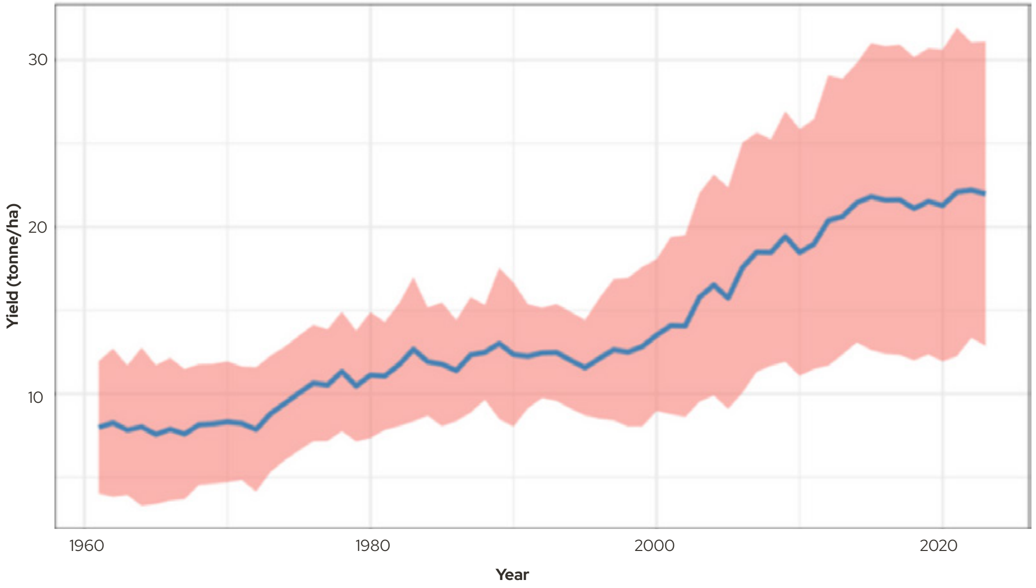
Note: Analysis by CIIP. Recorded GDP numbers are from 2000-2020, while GDP projections are for the period of 2025-2100 at five-year intervals under five Shared Socioeconomic Pathways (SSPs)1. Climate data is based on near-term future period of twenty years, from 2020-2040.[2]

Source: 1 Wang and Sun (2023): Global gridded GDP under the historical and future scenarios; **2** CGIAR (2024): Global climate hazard indices: heat, drought, flood and compound; **3** ISEAS Yusof Ishak Institute (2025): The critical impact of extreme heat on rice production in Southeast Asia.

In the nearer term, some crops may be more resilient and have enhanced productivity potential despite changing climate conditions

Example of a more resilient crop: Cassava

Figure 10. Cassava historical yield growth in SEA and yield variability[1, a]



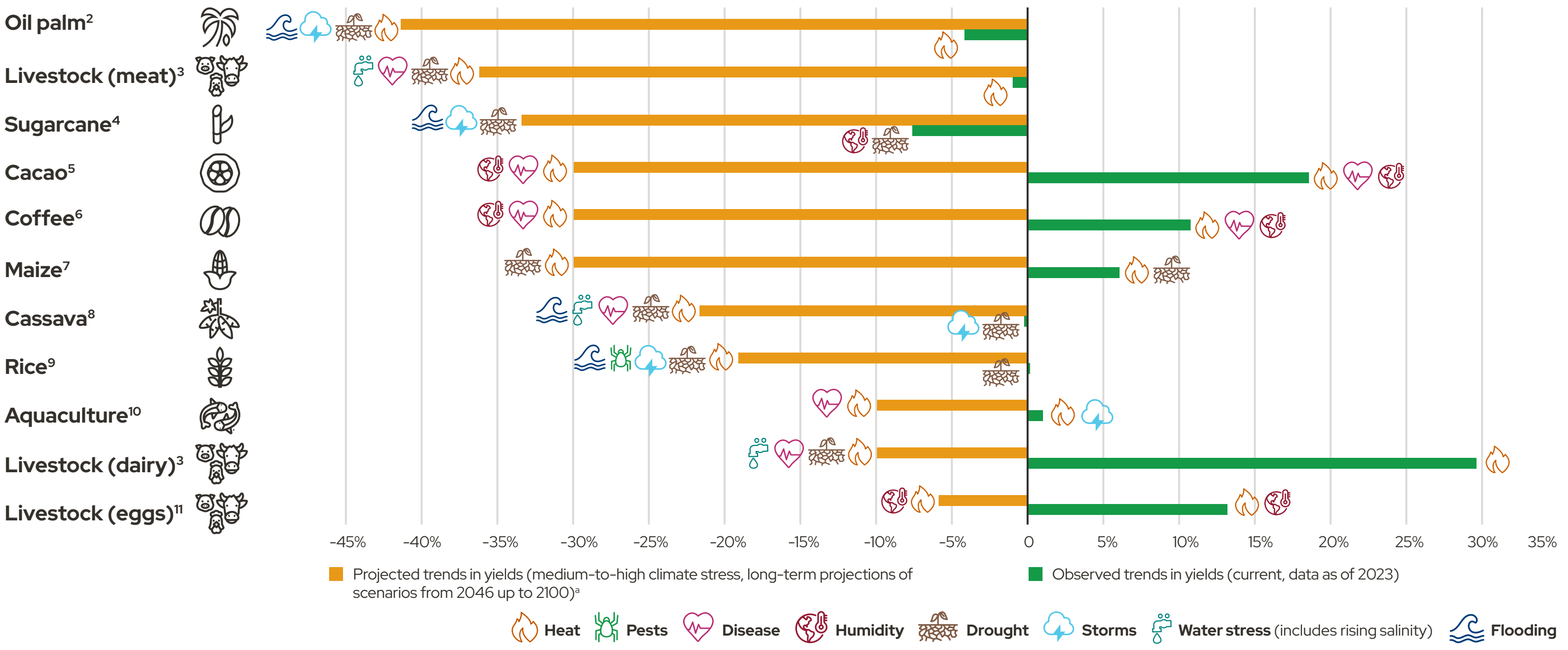
- To better understand the exact impact of climate change on crop yields, the Singapore Food Agency (SFA) commissioned a study to identify key climate risks to agriculture with the aim of reinforcing regional commitment to evidence-based climate adaptation measures for managing such risks.
- Undertaken by the Tropical Marine Science Institute (TMSI) of the National University of Singapore (NUS), initial findings indicate that, between 2025 and 2045:
  - **Future climate conditions are expected to strongly impact SEA's food security, with moderate to severe impacts on rice, maize, and sugarcane.** This will be starkest within irrigated systems and during dry-season cycles given the expected increase in temperature and other climatic extremes.
  - **There is enhanced productivity potential for resilient crops such as cassava, as well as resilient crop varieties such as submergent-tolerant rice in some countries and provinces.**
- However, looking ahead into the further future, all crops and value chains **will be negatively impacted by the effects of climate**. There is **immediate urgency to** address the effects of climate on agriculture while the situation can still be remediated to prevent more extensive damage in due course.
- Singapore will host the 48th ASEAN Ministers on Agriculture and Forestry (AMAF) Meeting in October 2026 where this study's findings will be shared with the region's Ministers.

Note: a The middle line represents the weighted average yield across producing countries, while the surrounding band represents the weighted standard deviation for yields in each year; **b** The study provides essential insights into future climate change impacts on the ASEAN agricultural sector from 2025 to 2045, using a physical crop model, DSSAT (Decision Support System for Agrotechnology Transfer), which leverages the results of the Third National Climate Change Study undertaken by the Centre of Climate Research Singapore (CCRS). This study examines future crop yields for five key crops - rice, maize, cassava, sugarcane and soybean – under various climate change scenarios. **Source: 1** CGIAR and Alliance Bioversity & CIAT (2025): Shaping the Future of Cassava Production in Southeast Asia: Challenges, Trends, and Strategic Priorities to 2050.

In the long term, significant disruption from climate hazards are expected across all key agricultural value chains in the region

- Observed yields across SEA indicate that **sugarcane, cassava, livestock (meat), and open aquaculture have declined compared to other commodities**. This is partly due to exposure to humidity, excess rainfall, and heat
- In contrast, **export commodities such as coffee and cacao have recorded yield growth despite experiencing hazards. This suggests stronger adaptive capacity (e.g., coffee and cacao producers in Indonesia)**, particularly through access to international markets, in comparison to other commodities[1]
- Projected impacts (assuming ceteris paribus, excluding the potential adaptive capacity of producers) on yields show a general decline across all commodities with the greatest decline for oil palm and the least for aquaculture and livestock

Figure 11. Projected yield declines and top climate hazards for top agricultural value chains in SEA



Note: a Yield trends are based on climate projections. These projections are simulated using different models and time horizons. It is important to note that yield projections do not consider the adaptive capacity of producers as this cannot be forecasted, while the observed yield trends are a result of the adaptive capacity of producers. **Source: 1** Andani et al. (2022): Multifaceted Social and Environmental Disruptions Impact on Smallholder Plantations' Resilience in Indonesia; **2** Sarkar et al. (2020): Impacts of climate change on oil palm production in Malaysia; **3** Ou and Mendelsohn (2017): An Analysis of Climate Adaptation by Livestock Farmers in the Asian Tropics; Thornton et al. (2022): Impacts of heat stress on global cattle production during the 21st century: a modelling study; Palandri et al. (2025): High-frequency data reveals limits of adaptation to heat in animal agriculture; **4** Pipitpukdee et al. (2020): Climate Change Impacts on Sugarcane Production in Thailand; **5** Lahive et al. (2018): The physiological responses of cacao to the environment and the implications for climate change resilience. A review; **6** Pham et al. (2019): The impact of climate change and variability on coffee production: a systematic review; **7** Tran et al. (2025): Changing Agrometeorological Conditions for Maize (Zea mays L.) Under the Subtropical Climate of Northern Vietnam; **8** Pipitpukdee et al. (2020): Impact of Climate Change on Land Use, Yield and Production of Cassava in Thailand; **9** Chun et al. (2016): Assessing rice productivity and adaptation strategies for Southeast Asia under climate change through multi-scale crop modeling; **10** Nguyen et al. (2022): Aquaculture Farmer's Economic Risks Due to Climate Change: Evidence from Vietnam; **11** Tesakul et al. (2025): Effects of heat stress on egg performance in laying hens under hot and humid conditions.

In fact, climate hazards are already impacting several key food produce in the region

A Prolonged **drought brought on by El Niño** in 2015-2016 has caused palm oil yields to decrease by 13% in Malaysia and 5-10% in Indonesia[1,2]

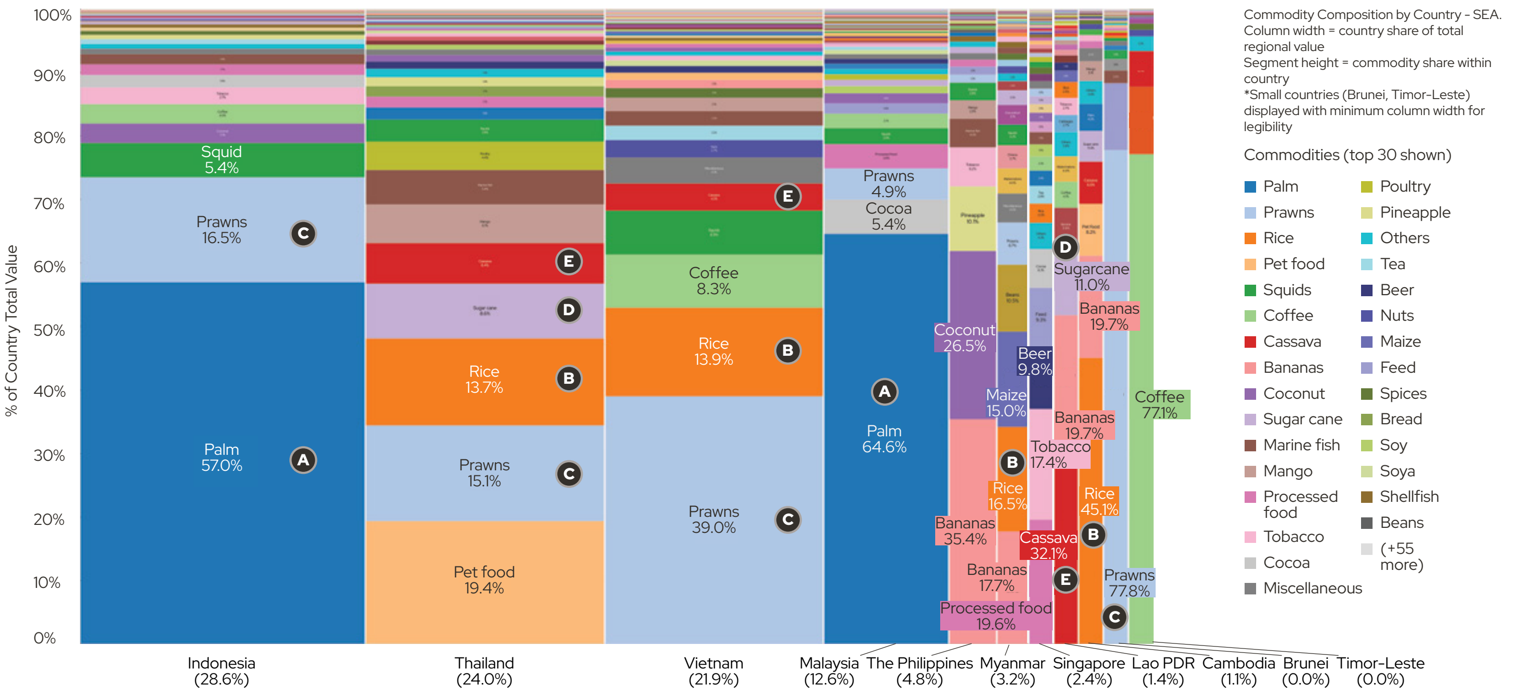
B In 2020, Thailand faced its **second-worst drought in a decade**, causing **rice production to decline 40%** compared to the previous season.[3] Salinity intrusion has further caused total **rice paddy field area to decline in the Vietnam Mekong Delta by 10% since 2015**[4]

C **Increased temperature and unusual rainfall patterns** have led to more shrimp diseases and damage to the aquatic environment.[5] **Rising salinity** has also caused shrimp populations to grow more slowly[6]

D There is a **0.17% decrease in global sugar production** for every 1 degree increase in temperature[7]

E Fluctuations between El Niño and La Niña creates **drought conditions**, which threaten cassava production.[8] Temperature and rainfall can also create **favourable conditions for the whitefly, a vector for the cassava mosaic disease (CMD)**[9]

Figure 12. Distribution of agricultural output (export value) in SEA countries, five-year average from 2019-2023



Note: Analysis by CIIP. Data source: FAOSTAT and FishStat, see more in methodology.

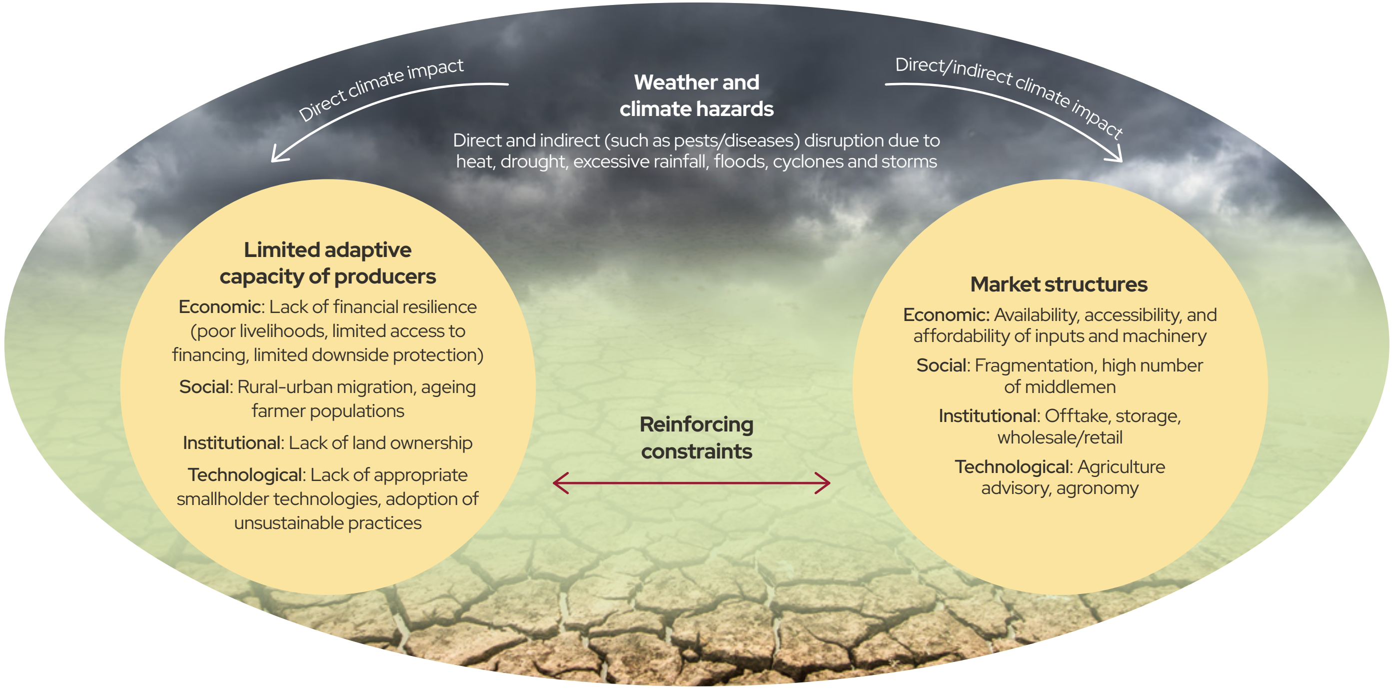
Source: 1 Malaysian Palm Oil Board (2017): Overview of the Malaysian Palm Oil Industry 2016; **2** A Foreign Agricultural Service (2016): Indonesia Oilseeds and Products Update November 2016; **3** Prasertsri (2020): The Impact of Drought on Agriculture in 2020; **4** Wang et al. (2025): Quantifying salinity and drought drive forces on paddy field loss in the Mekong Delta, Vietnam; **5** Do and Ho (2022): Climate change adaptation strategies and shrimp aquaculture: Empirical evidence from the Mekong Delta of Vietnam; **6** World Bank Group (2016): A Tale of Two Shrimpers: How will the Mekong Delta adapt to climate change?; **7** Headley et al. (2024): Modeling climate variability and global sugarcane production: Empirical consideration for collective policy action; **8** Sowcharoensuk (2025): Industry Outlook 2025-2027: Cassava Industry; **9** Hareesh et al. (2023): Cassava mosaic disease in South and Southeast Asia: current status and prospects.

Against this backdrop, there is a need to strengthen the adaptive capacity of food producers in the region

According to the IPCC, adaptive capacity is the **'potential or ability of a system, region, or community, to adapt to the effects or impacts of climate change'**. Determinants of adaptive capacity relate to the **economic, social, institutional, and technological change**.[1]

- SEA's agri-food system is shaped by structural market constraints that influence how producers, especially smallholder farmers, **respond to market changes and build adaptive capacity**. These factors can be shaped through **policy and decision-making**
- Producers' adaptive capacity and their interaction with market structures are further constrained by **weather and climate hazards**, which **cannot be controlled but can be managed**
- **Adaptive capacity is also being eroded** as climate hazards become more frequent, and as compound risk grows
- **Poor alignment between producers and market structures** increases the risk of adopting solutions that raise greenhouse gas emissions or cause further land degradation, **intensifying the frequency and severity of climate hazards**

Constraints on adaptive capacity and the influence of climate

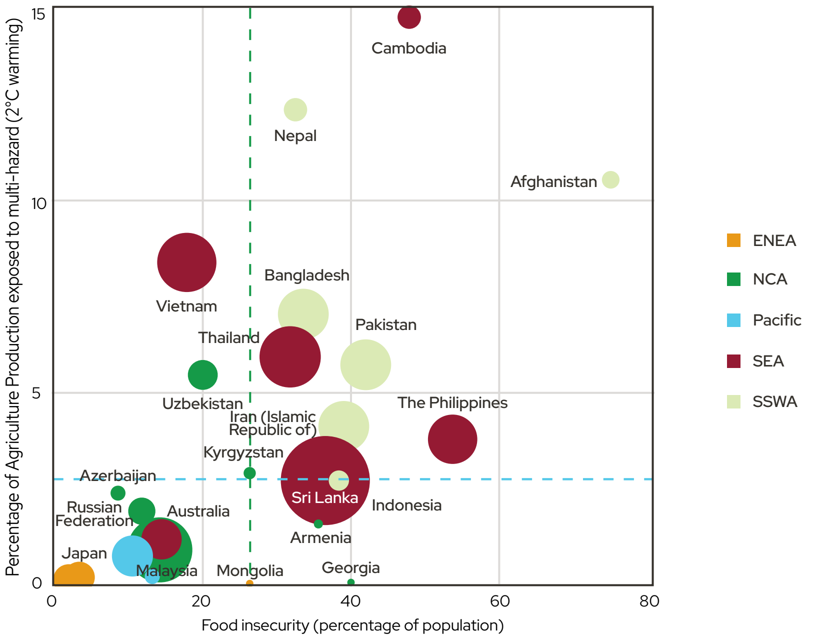


Note: a Diagram developed by ImpactSF. **Source: 1** Intergovernmental Panel on Climate Change (2001), Climate Change 2001: Impacts, Adaptation, and Vulnerability.

Failure to improve the adaptive capacity of producers in a timely manner will have implications on food security and the livelihoods of smallholder farmers

Amidst increasing consumer demand for food and agricultural products and recurring weather and climate hazards, a failure to improve the adaptive capacity of producers will lead to reliance on imports. This will **threaten the availability and accessibility of key crops and staples, resulting in increased risk of food and nutrition insecurity**. Most importantly, the livelihoods of all ~100 million smallholder farmers in SEA will also be affected.

Figure 13. Food insecurity and risk exposure of agriculture sector under 2°C warming



Note: Size of bubbles indicate total agriculture value of country (US$); dotted lines denote the 50th percentile of food insecurity and agriculture production exposure. ENEA = East and Northeast Asia, NCA = North and Central Asia, SEA = Southeast Asia, SSWA = South and Southwest Asia.

Source: 1 OECD/FAO, (2017): OECD-FAO Agricultural Outlook 2017-2026; 2 UNESCAP (2023): Seizing the Moment: Targeting Transformative Disaster Risk Resilience.

At present, the top agricultural value chains in SEA present a myriad of challenges and opportunities

	Value Chains	Agriculture GDP contribution (estimated)	Net trade balance	Domestic demand & production (in comparison to 2016)[1]	5 Market structure - Production	Market structure - Processing & trade
Top food crops for SEA	1 Rice	30 - 50%	Significantly positive	10% decrease in food expenditure	Moderate fragmentation[2]	High consolidation
Top food crops for SEA	Cassava	10 - 30%	Marginally positive	5 % increase in production	High fragmentation[3]	Moderate consolidation
Top food crops for SEA	Sugarcane	10%	Marginally negative	5% increase in production	Moderate fragmentation[4]	High consolidation
Top food crops for SEA	Soybean	Less than 1%	Significantly negative	6 - 8% increase in production	High fragmentation[5]	Moderate consolidation
Top food crops for SEA	2 Maize	Less than 10%	Significantly negative	20% increase in production	High fragmentation[6]	Moderate consolidation
Top food crops for SEA	Wheat	Minimal (mostly imported)	Significantly negative	10 - 20% increase in production	High fragmentation[7]	Moderate consolidation
Animal Production	3 Livestock (meat & dairy)	10 - 20%	Marginally positive	10% increase in demand	High fragmentation[7]	Moderate consolidation
Animal Production	Aquaculture	10 - 20%	Marginally positive	15% increase in demand	Moderate fragmentation[7]	Moderate consolidation
Export crops	4 Coffee	Less than 10%	Significantly positive	10% increase in production	Moderate fragmentation[8]	High consolidation
Export crops	Cacao	Less than 5%	Significantly positive	5% increase in production	High fragmentation[8]	Moderate consolidation
Export crops	Oil palm	10 - 30%	Significantly positive	10% increase in production	Moderate fragmentation[9]	High consolidation

Key opportunities

1. **Rice** contributes to almost half of the region's GDP and is a key staple in diets
2. Opportunity for growth for **wheat and maize** driven by **regional consumption and demand**. However, it is worth noting that wheat remains an import-dependent crop as there is currently no wheat variety that can be grown at scale in SEA[10]
3. Rapidly growing consumption of **livestock and aquaculture products** applies pressure. While stages of value chains post-production are consolidated, there is a **need to increase production volumes through strategic aggregation of producers**
4. For export-oriented crops like **coffee, cacao, and palm oil**, growing production volumes and positive trade flows may be challenged by growing climate risks
5. **Fragmentation largely exist in the production** stage for all crops in the region – opportunity for consolidation and re-industrialisation

Source: 1 OECD, FAO (2017): OECD-FAO Agricultural Outlook 2017-2026; **2** Promkhambut et al. (2023): Rethinking agrarian transition in Southeast Asia through rice farming in Thailand; **3** Delaquis et al. (2024): Public and private institutional arrangements for early generation seed production: Cassava seed value chains in Southeast Asia; **4** Prasara-A, Gheewala (2021): An assessment of social sustainability of sugarcane and cassava cultivation in Thailand; **5** Wannapee, P et al. (2022): Soybean Seed Production in Asia; **6** Belton, Fang (2022): Hybrid livelihoods: Maize and agrarian transformation in Southeast Asia's uplands; **7** International Food Policy Research Institute (IFPRI) (2023): Agricultural transformation and market integration in the ASEAN region: Responding to food security and inclusiveness concerns; **8** Perkumpulan PRAKARSA (2022): Tracking Global Value Chains (GVCs) on Palm Oil, Fisheries, Rice and Coffee Commodities in Indonesia, Thailand, The Philippines, and Vietnam; **9** Purnomo et al. (2020): Reconciling oil palm economic development and environmental conservation in Indonesia: A value chain dynamic approach; **10** Key informant interview.

A "reset" is required to move the region's value chains towards resilience

- A fundamental mindset shift is needed to enable value chains to move from **traditional systems** to **transitional models** and eventually to **resilient production systems**
- This entails further tightening and reducing transaction costs in developing linkages between farmers and consumers. This can be achieved through improved access, affordability of inputs, and mechanisation (such as stress-tolerant seed varieties, climate-resilient warehousing solutions) to support sustainable intensification and address market demand. Partnerships across all levels are essential to ensure that the system change can be effective and sustainable
- This transformation of the agri-food system requires the following interventions:

Improving adaptation and resilience of agriculture

Increasing productivity

Tightening costs and reducing inefficiencies

Traditional value chains

e.g., maize, rice, sugarcane in the Philippines; livestock in Indonesia and Vietnam

- Small, fragmented smallholder farmer production
- Manual practices affected by weather hazards and climate shocks

Transitional value chains

e.g., oil palm in Indonesia and Malaysia; coffee in Vietnam

- Formal organisational (and governance) structures such as co-operatives and farmer producer organisations start to emerge, but are subjected to price risks and market fluctuations
- Limited end-to-end traceability
- Gradual shift towards (re)industrialisation

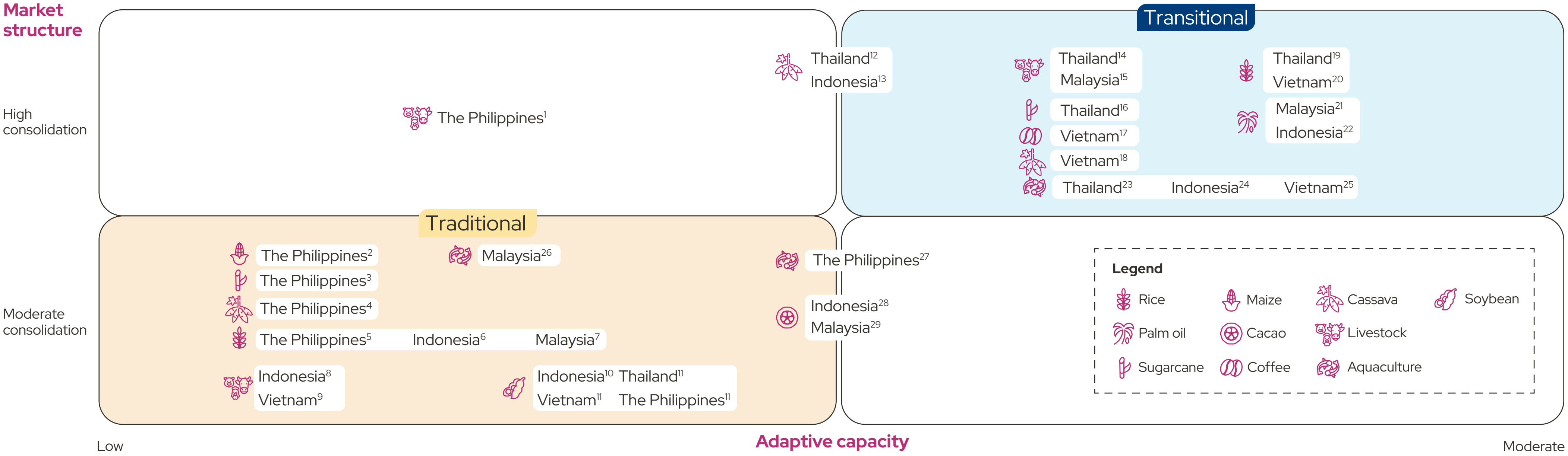
Resilient (mature) value chains

- Mechanised production
- Automated processing/logistics
- Market access is established through corporate and co-operative partnership structures
- Integrated climate-risk financing

Source: Diagram developed by ImpactSF.

Different crop value chains are at different stages of progress across SEA

- Crops currently in "transition" must become "resilient". Maintaining higher productivity should remain the priority, supported by reductions in emissions through use of biofertilisers, biopesticides, and renewable energy, and enhanced carbon capture approaches such as agroforestry
- For **aquaculture, livestock, cassava**, and similar commodities, productivity must increase to meet consumer demand. This requires **sustainable intensification of existing systems**, including improved varieties and structured aggregation of produce



Source: **1** Escandor et al. (2020): Developing and implementing a protocol for bilateral trade agreements: the Philippines' shift to a risk assessment policy and meeting its challenges; **2** Parreño, S. J. E. (2023): Analysing crop production statistics of the Philippines using the newcomb-benford law; **3** Elauria and Elauria (2012): Value Addition and Prospects of Bioethanol Production from Sugarcane in the Philippines; **4** Onsay (2021): Productivity value chain analysis of cassava in the Philippines; **5** Mataia et al. (2020): Rice value chain analysis in the Philippines: value addition, constraints, and upgrading strategies; **6** Qadir et al. (2024): Commercial rice seed production and distribution in Indonesia; **7** Dorairaj and Govender (2023): Rice and paddy industry in Malaysia: governance and policies, research trends, technology adoption and resilience; **8** Prasetyani et al. (2021): Integration of livestock supply chain strategy as part of the creative economy and creative industry in Indonesia: literature review; **9** Nguyen et al. (2023): Goat production, supply chains, challenges, and opportunities for development in Vietnam: A review; **10** Peng et al. (2026): Global soybean trade dynamics: Drivers, impacts, and Sustainability; **11** Lim et al. (2023): Mitigating the repercussions of climate change on diseases affecting important crop commodities in Southeast Asia, for food security and environmental sustainability—A review; **12** Lilavanichakul and Yoksan (2023): Development of Bioplastics from Cassava toward the Sustainability of Cassava Value Chain in Thailand; **13** Rozi et al. (2022): Prospects of Cassava Development in Indonesia in Supporting Global Food Availability in Future; **14** Trakem and Fan (2024): Agricultural trade liberalization, governance quality, and technical efficiency in the agricultural sector of Southeast Asia; **15** Zayadi (2021): Current Outlook of Livestock Industry in Malaysia and Ways Towards Sustainability; **16** Chunhawong et al. (2018): Sugar Industry and Utilisation of Its By-products in Thailand: An Overview; **17** Hoang et al. (2025): Vietnam's Coffee Exports in the Global Coffee Market: An Analysis of Competitiveness, Constraints, and Strategic Reforms; **18** Ho (n.d.) Cassava Value Chain Analysis; **19** Suebpongsang et al. (2020): Transition of Agricultural Mechanisation, Agricultural Economy, Government Policy and Environmental Movement Related to Rice Production in the Mekong Delta, Vietnam after 2010; **20** Matsubara et al. (2020): Commercialisation of Rice Farming in Northeast Thailand; **21** Kushiari et al. (2018): Oil palm economic performance in Malaysia and R&D progress in 2017 - Review article; **22** Purnomo et al (2020): Reconciling oil palm economic development and environmental conservation in Indonesia: A value chain dynamic approach; **23** Sampantamit (2020): Aquaculture Production and Its Environmental Sustainability in Thailand: Challenges and Potential Solutions; **24** Sunarno et al. (2024): A value chain and SWOT analysis for optimizing the self-sufficiency of fish feed to strengthen freshwater aquaculture production in Indonesia; **25** Tri et al. (2021): An overview of aquaculture development in Vietnam; **26** Obi et al. (2025): Overview of the fishery and aquaculture sectors in Malaysia; **27** Asurquin and Moralista (2025): Aquaculture Industry in an Island: Its Status, Challenges and Sustainability; **28** Effendy (2019): Factors influencing the efficiency of cocoa farms: A study to increase income in rural Indonesia; **29** Tee et al. (2021): Revolution of Cocoa Beans in Malaysia: Bulk to Specialty Beans.

To succeed, we must address the unique profiles and problems faced by key actors across the value chain in the region

	Inputs & enabling services	Production & on-farm management	Harvesting & collection	Storage & processing	Transport & aggregation	Markets & consumption
Key characteristics	• Consolidated at source with few big input players • Might be fragmented at point of distribution	• Highly fragmented, made up by smallholder farmers with <2 ha land • Some farmers may belong to a scheme	• Highly fragmented, farmers typically sell to a middleman • Scheme farmers may sell to a fixed offtaker, or to others	• Moderate to high consolidation, especially at the milling and processing stages	• Moderate to high consolidation • Can involve players outside of agriculture sector altogether	• High consolidation • Various levels of access to consumers, such as online and offline
Key actors	**Input providers** (Bayer, Syngenta, BASF, Yara, etc.) **Distribution:** Agri-SMEs, co-operatives, corporates with farmer schemes	Co-operatives, corporates with farmer schemes, equipment lenders (e.g., tractors and other machinery)	Offtakers (co-operatives, corporates, middlemen in between), D2C platforms (e.g., e-commerce)	Corporates, co-operatives, mills, processors, warehousing service providers	Corporates, logistics providers, processors	Corporates, agri-SMEs retailers, online marketplaces (e.g., D2C or B2B ecommerce), wholesalers
Key statistics	Top agrochemical companies control **56% of global seeds market and 61% of pesticides market**[1]	There is an estimated **100 million** smallholder farmers in Southeast Asia[2]	There can be as many as **seven layers of middlemen** in the Philippines[3]	Post-harvest losses cause **17%** of total food produced in Southeast Asia to be wasted[4]	Cold chain coverage is uneven - while **~50%** of agricultural exports is moved through cold chains in Thailand, Vietnam's coverage remains at only **~25%** for key perishables like seafood and fruit[5]	Asian consumers will spend **US$4.4 trillion more** on food over the next decade[6]

Key issues to consider:

Solutions should be right-sized and right-priced, so that the relevant actors can afford them individually or deploy them at scale cost-effectively

Role of agritech solution providers:

- Agri-intermediaries can help with streamlining supply chains and cutting out middlemen, allowing farmers to have better access to markets
- Digital solution providers can help to provide farm level insights and advisory, increasing the adoption of sustainable practices
- Data platforms and aggregators can gather farmgate data, enabling the development of alternative metrics to unlock financing and measure impact

US$2.8B

Raised by agritech companies and funds since 2013, with Singapore companies taking the lead[7]

Source: **1** ETC Group and GRAIN (2025): Top 10 agribusiness giants: corporate concentration in food & farming in 2025; **2** World Wildlife Fund (2021): Unlocking Smallholder Finance for Sustainable Agriculture in Southeast Asia; **3** CIIP (2024): Seeding the Future: Transforming Smallholder Farms for a Sustainable Tomorrow; **4** World Economic Forum (2023): 4 Ways to reduce food waste in Southeast Asia; **5** ASEAN Briefing (2025): Vietnam Cold-Chain and Agritech Opportunities for Foreign Investors; **6** Singapore Economic Development Board (2022): The future of agrifood tech in Southeast Asia: Agriculture in the digital decade; **7** Forward Fooding and Singapore Economic Development Board (2023): AgriFoodTech in Southeast Asia – 2023 Ecosystem Report.

A stack of solutions is needed to facilitate value chain transformation starting at the farmgate level

Solutions are non-exhaustive

1 Technical solutions	2 Ecosystem & business model enablers	3 Access to finance (OpEx & CapEx)	4 Financial resilience
On-farm and value chain innovations that improve productivity, resource efficiency, resilience to climate-related risks	Nodes and platforms that aggregate and connect producers to inputs, services, and markets	Solutions that address capital constraints across the agricultural cycle, ensuring that financing flows through to producers	Instruments that stabilise and diversify farmer incomes while protecting against shocks, especially climate-related risks
• Appropriate climate smart inputs (seeds, breeds, feed, fertiliser) • Efficient irrigation systems (drip or micro-irrigation, pump monitoring) • Soil & water conservation practices • Integrated pest management • Monitoring systems / traceability • Disease surveillance for livestock • Post-harvest infrastructure such as storage, logistics, and warehousing • Climate-controlled greenhouses • Digital farmer services (e.g., farm management, agronomy)	• Intermediaries supporting aggregation and logistics • Platforms enabling market access (e.g., D2C marketplaces) • Co-operatives improving production & input access • Shared services or centralised monitoring models • Aggregators providing cold storage and processing • Contracting and partnership structures with traders and processors • Farmer-to-farmer extension networks	• Working capital for inputs (seed, feed, fertiliser) • Warehouse receipts, outgrower schemes, leasing as collateral • CapEx loans for irrigation and mechanisation, post-harvest infrastructure • Financing for replanting • Financing for monitoring/traceability systems	• Credit and loans where repayment is tied to harvest cycles • Parametric insurance linked to climate indices • Bundled financing products • Valuing natural capital (e.g., carbon credits, biodiversity credits etc.) • Crop and livestock insurance

Public infrastructure

- **Community resources and infrastructure**, such as community fodder banks
- **Ecosystem services** which farmers and land stewards must be in charge of, but which are unlikely to achieve commercial viability
- **Policy and legal services** like land tenure clarification, establishment of land titles and ownership

Capacity building and training

- **Education on key skills for farmers**, such as financial literacy, risk awareness, and risk management
- **Knowledge tools** that help farmers understand and adapt to the new normal through global public goods such as extension and advisory services
- **Technical assistance** through phygital models, where agronomists and skilled experts facilitate skill transfer to farmers
- **Organisation, institutionalisation, and better governance** of Farmer Producer Organisations (FPOs), including co-operatives and other farmer aggregation groups

Technical solutions · Ecosystem & business model enablers · Access to finance (OpEx & CapEx) · Financial services · Public infrastructure · Capacity building & training

Bulk of CA&R funding flows to agriculture in SEA is going toward technical solutions

Figure 14. Global CA&R funding flows to agriculture solutions in SEA (US$M, 2021-2025)

Directional

Size of the circle denotes funding volume
Colour of circle shows # transactions
High (6+) · Medium (4-6) · Low (1-3) · No funding information available

Note: a This is an indicative and directional mapping that is not to be read as an assessment of funding viability, but as an estimation of average commercial viability of all solutions within agriculture and allied sectors; **b** Opportunities listed are indicative and do not replace formal due diligence. **Source: 1** Pitchbook data (2021-2025); **2** Dalberg analyses.

Case study examples: Agriculture – Solutions in SEA

Technical solutions · Ecosystem & business model enablers · Access to finance (OpEx & CapEx) · Financial services · Public infrastructure · Capacity building & training

	Technical solutions	Ecosystem & business model enablers	Access to finance (OpEx & CapEx); Financial services	Access to finance (OpEx & CapEx)
Organisation	**AgriG8:** Translating agronomic data into risk signals to bridge the gap between field and financial systems	**Aruna:** Empowering coastal communities through technology, market access, and sustainable practices	**Koltiva:** Reimagining agriculture supply chains to become more ethical, transparent, and sustainable	**PasarMIKRO:** Transforming agricultural and fishery supply chains through fair trade, responsible finance, and digital services
Year established	2021	2016	2013	2020
Geography	Southeast Asia	Indonesia	Global – SEA, Latin America, Europe	Indonesia, Singapore
Revenue/AUM	Pre-revenue	Not publicly disclosed	US$8M	US$3.05M (2025)
Key products	Gamified digital logbook for farmers, data and analytics dashboard for partners	Fishery e-commerce, market access for fisherfolk	Integrated approach combining technology, agricultural and climate services, and finance	Trade finance, credit & risk services, traceability & ESG solutions
Business model innovation	Built-in incentives in loan products for farmers, where farmers can unlock repayment discounts if certain sustainable practices (e.g., Alternate Wet-Dry) are adopted	Pilot affordable insurance models tailored to fishermen, using subsidies and village-level rollouts to build trust and encourage adoption	Offering affordable, well-timed loans to enable proactive risk reduction behaviours among smallholder farmers	Providing trade finance instead of conventional finance, in turn helping to strengthen supply chain resilience and protect both farmers and financiers
CA&R Impact	• Increase adoption of sustainable agricultural practices • Shifting of farmer behaviour through process-based rewards and financial incentives	• Protect fisherfolk from downsides of climate hazards and effects • Improve livelihoods of fisherfolk by enabling direct access to market through e-commerce	• Improve financial resilience of smallholder farmers through access to financing and bundling of micro-insurance • Increase protection of independent smallholder farmers - who otherwise lack access to early warnings and safety nets - against climate shocks	• Expand access to financial services for agricultural MSMEs and traders, and improve their financial resilience • Increase protection of both farmers and funders against sudden shocks and disruptions
Other impact	• Gather data on farm productivity and crop development, to allow for financiers to include into risk and credit assessment	• Improve stability of seafood production in Indonesia • Unlock export markets that demand certified, traceable, and sustainably sourced seafood	• De-risk smallholder farmers as a customer segment for investors and financiers • Strengthen global agriculture supply chains by ensuring that the producers are resilient	• Build behavioural change among borrowers through increasing regular interaction with the digital platform • Demonstrate feasibility of trade financing in agriculture to funding partners

Note: All examples are available as full case studies in the Climate Adaptation and Resilience in Asia Case Study Library (2026) by CIIP.

Case study examples: Ventures from Rest-of-Asia

Technical solutions · Ecosystem & business model enablers · Access to finance (OpEx & CapEx) · Financial services · Public infrastructure · Capacity building & training

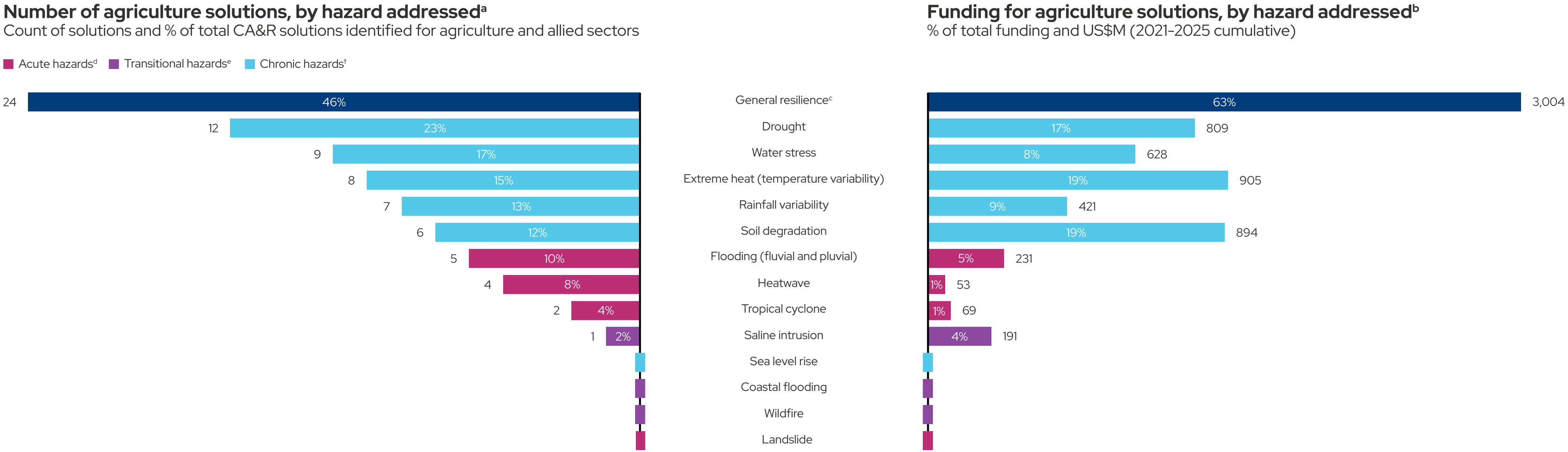
	Technical solutions; Ecosystem & business model enablers	Technical solutions; Access to finance (OpEx & CapEx); Financial services	Access to finance (OpEx & CapEx); Financial services	Access to finance (OpEx & CapEx); Financial services	Financial services
Organisation	**Akshayakalpa:** Regenerative farming that includes dairy production	**DigiVriddhi Technologies (DGV):** Reimagination of financing, insurance, and marketplace access for dairy farmers	**Sarvagram:** India's first rural household-centric platform for financial services, risk mitigants, and farm productivity tools	**Samunnati:** Consolidation of farmers and intermediaries across the agricultural value chain	**Tian Tian Xue Nong:** Improving sustainable agriculture by bringing agronomy knowledge to all
Year established	2020	2019	2018	2014	2017
Geography	India	India	India	India	China
Revenue/AUM	US$46M	US$475,000	US$42M	US$41M	Not publicly disclosed
Key products	Organic milk and value-added dairy products	Digital dairy loans, digital bovine health certification and insurance, online marketplace, integrated dairy tech platform	Customised financial and capacity building solutions, including Farming-as-a-Service (FaaS)	Embedded finance and trade solutions, climate-smart interventions	Educational videos on agriculture, agronomy AI feature
Business model innovation	Regenerative dairy model, which integrates climate-resilient fodder management, practices that improve soil health, focuses on efficient water usage, and improved manure management	Simplifying credit for dairy farmers via end-to-end digital process, alternate data, and an integrated ecosystem	Emphasis on "staying with the household" for multiple crop cycles to understand the long-term repayment capacity and behaviour of smallholder farmers	Streamline FPOs' access to intermediaries through ALMA Approach: Aggregation, Market Linkage, Advisory	Enable system-level shift by improving agricultural knowledge across all stakeholders
CA&R Impact	• Improved milk productivity, resulting in increased farmer household incomes • In-house fodder management reducing external dependence • Adoption of manure management practices resulting in biogas production at farms with implemented infrastructure	• Increase insurability of bovines, which are key assets for dairy farmers • Increase access to financing for dairy farmers, and improve financial resilience	• Increase ability of rural households to adapt to climate changes through providing access to credit and financial tools • Enable farmers to invest in climate-smart and sustainable agricultural technologies	• Improve market efficiency through digital integration • Increase adoption of climate-resilient technologies, such as drought-tolerant seed varieties	• Increase the adoption of sustainable agriculture practices • Ensure that agricultural knowledge is accessible and easily understood by all
Other impact	• Ensure stable and quality supply of organic, sustainably produced dairy products • Assure offtake for farmers, leading to steadier and more predictable incomes	• Create a feasible financial fallback for smallholder farmers in times of a climate shock where crops are wiped out. Dairy income can be a safety net as bovines are less affected by climate effects	• Collect household-level financial data to better design suitable financial products that align with actual household needs and expenditure patterns	• Increase capabilities of FPOs in areas such as business planning, financial management, and marketing; therefore establishing FPOs as a viable asset class and increasing their bankability	• Make farming more accessible and attractive to a younger generation of farmers • Enable equitable growth and common prosperity across the agricultural value chain

Note: All examples are available as full case studies in the Climate Adaptation and Resilience in Asia Case Study Library (2026) by CIIP.

Directional

Current funding clusters around chronic hazards, leaving acute and heat related risks under-served

Figure 15. Agriculture solutions and funding obtained, according to hazard type[1, 2, 3]



- High-impact acute hazards such as floods, cyclones, and heatwaves account for ~15% of solutions, but only account for 5% of funding, suggesting **limited coverage of shock-driven risks**
- **Almost half of all current funding is concentrated in solutions that address the most critical hazards** for Agriculture (drought, water stress and soil degradation); but overall funding remains 80-90% below need, indicating **systemic underinvestment**
- ~40% of funding is classified under "general resilience", indicating that a **significant portion of capital is not directed toward specific hazards**

Note: a Solution is double-counted if a solution addresses multiple hazards; **b** Funding is double-counted if a solution addresses multiple hazards; **c** 'General resilience' refers to solutions that do not address one specific hazard directly but deliver cross-hazard resilience benefits (e.g., multi-hazard risk registries, multi-hazard insurance, farmer-to-farmer extension networks); **d** 'Acute' hazards refer to short-term, event-driven climate risks (e.g., floods, cyclones); **e** 'Transitional' hazards refer to hazards that begin as discrete, but are moving towards chronic; **f** 'Chronic' hazards refer to longer-term, gradual climate shifts (e.g., water stress, sea level rise). **Source: 1** Climate Policy Initiative (2026): Global Landscape of Climate Finance Data Dashboard; **2** Pitchbook data (2021-2025); **3** Dalberg analyses.

Further, CA&R agri-funding is concentrated upstream and in pre-resilience, reflecting the critical needs in these segments

While agriculture solutions and funding is concentrated in upstream segments of inputs and growth...

Figure 16. Solutions and funding across agriculture value chain[1,2,3]

- **~80% of solutions and funding are focused on upstream segments** – Inputs and Growth solutions such as climate-smart crop diversification (US$280 million) and farmer extension networks (US$1.6 billion); **post-harvest** (Storage, Transport and Market access) **remain under-addressed**
- Almost half of all solutions address **more than one stage of the value chain**
- The concentration of funding in the upstream segments signals that these areas have the **greatest need and the greatest opportunity**

...solutions may not be adopted at scale, and the flow through of financing to agri-SMEs and smallholder farmers remain challenging

2-6x lower

Production yields for most important agricultural commodities in SEA and South Asia are still lower than highest-yielding producers[4]

>50%

Drop in venture capital (VC) deal count across SEA agritech from 2022 to 2025, as VCs pulled back, reflecting both risk-off conditions specific to the industry and broader caution across the VC landscape[4]

US$189B

Smallholder farmer adaptation finance needs in SEA, across the following categories:[5,6]

- Short-term agricultural finance, i.e.,seasonal working capital for inputs like seeds, fertilisers, pesticides, and basic labour
- Long-term agricultural finance, i.e.,multi-season investments such as irrigation systems, mechanisation, and storage or processing facilities
- Non-agricultural finance, i.e., livelihood diversification, education, healthcare

Note a Sum of solutions may not add up as solution is double-counted if a solution applies to multiple stages of the value chain or impact pathway, **b** Funding data is partial for 2025 and should be interpreted directionally.
Source: 1 Climate Policy Initiative data on climate funding flows; **2** Pitchbook data (2021-2025); **3** Dalberg analyses; **4** Beanstalk and Briter (2026): The Opportunity for AgriTech Investment in Southeast and South Asia; **5** Family Farmers for Climate Action (2025): Feeding the World in a Changing Climate; **6** ISF Advisors (2025): Beyond the frontier: Decoding viability in smallholder finance.

Agricultural research also remains underfunded, affecting innovations, development of agronomy knowledge, and alignment in measurement and reporting

Investing in agricultural research can help to drive agricultural productivity and help to enhance food security while reducing the environmental impact of agricultural production.[1]

0.33%

SEA's regional average investment in agricultural research, which is below the 1% investment target recommended by the United Nations[2]

- There is an opportunity to increase agricultural research funding and intensity, to maximise the potential that research can bring to the region. With improved research intensity and data collection, **baselines and counterfactuals for agriculture and climate adaptation can be better established**
- It is projected that prioritising agricultural research in value chains like livestock and aquaculture can achieve faster growth in countries like Indonesia, Malaysia, and Vietnam for the next thirty years[1]

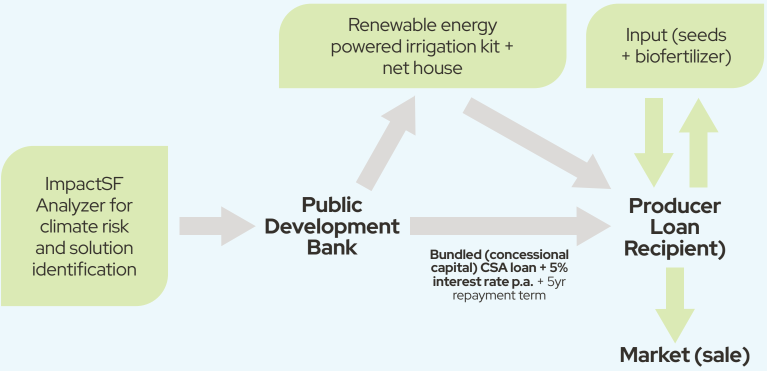
Similarly, robust R&D can also help to make agriculture more investable.

According to ImpactSF:

- Traditionally, climate financing tends to fund larger ticket sizes with metrics that are clearly measurable, as seen from the experience of climate mitigation
- However, it has been challenging to align KPIs and metrics for CA&R. This is where the **scientific community has both the opportunity and the responsibility to play a significant role in bridging this gap**. By defining common metrics for CA&R, costs for measurement and reporting can be reduced, while still ensuring social and environmental outcomes can be achieved

Expanded capability for a female vegetable producer

Expansion of vegetable producing area thereby contributing to improved nutrition of buyers
Expansion using renewable energy powered irrigation kit
Net house and irrigation respond directly to risks identified in the farmer location

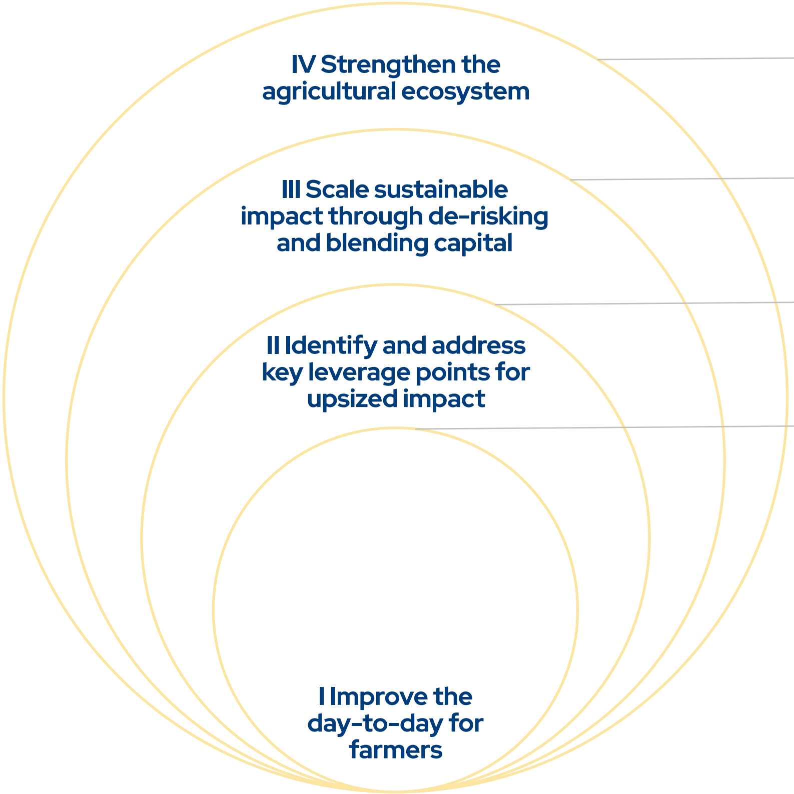


Example: Improving **bankability of a female vegetable producer** by unlocking financing from a public development bank, for a **solution that specifically addresses predicted weather risks**, while generating **social and environmental impacts** for the farmer.

Source: CGIAR Hub for Sustainable Finance (Impact SF): Science for Sustainable Food Investment.

Source: **1** van Dijk et al. (2025): A global dataset of public agricultural R&D investment: 1960-2022; **2** ASTI (2020): Agricultural Research in Southeast Asia: A Cross-Country Analysis of Resource Allocation, Performance, and Impact on Productivity.

To address this, a step change in thinking is required, where the public, private, and philanthropic sectors work in sync to enhance agricultural financing and improve adoption of better practices



- **IV:** Improve farmer training and education, improve policy ecosystem and governance, and strengthen the overall capacity of the agricultural system
- **III:** De-risk of agricultural financing, to allow for blending of finance across the capital stack, and over time
- **II:** Reimagine the agricultural value chain and existing business models, implementation of sustainable value chain financing
- **I:** Provide accessible and affordable working capital to smallholder farmers for the adoption of better practices and equipment, and shift mindsets by enhancing farming operations and efficiency

Challenges in the adaptive capacity of producers

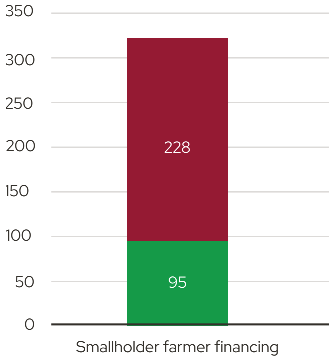
- **Economic:** Lack of financial resilience (poor livelihoods, limited access to financing, limited downside protection)
- **Social:** Rural-urban migration, ageing farmer populations
- **Institutional:** Lack of land ownership, need for more cross-sector collaboration
- **Technological:** Lack of farmer capacity, unsustainable practices

There is a role for every stakeholder to play in this systemic transformation of the agri-food sector

Action	Philanthropy	Private industry	Public sector
I **Improve the day-to-day for farmers**	• Pilot implementation and embedding of crop or climate insurance at producer level • Improve access to agronomy knowledge	• Provide discounts or benefits to encourage practice adoption and behavioural change of farmers within value chain • Develop financial products that are relevant and appropriate to smallholder farmers and agri-SMEs	• Provide subsidies to offset cost of practice adoption • Provide incentives to encourage behavioural change
II **Identify and address key leverage points for upsized impact**	• Improve market access for smallholder farmers and agri-SMEs by connecting them with agri-corporates • Bundle private-sector loans with technical assistance or insurance to improve bankability of value chain	• Implement value chain financing • Provide offtake agreements • Increase adoption of digital tools to collect data, track supply chains, and streamline value chain financing	
III **Scale sustainable impact through de-risking and blending capital**	• Provide guarantee / first-loss capital to de-risk initiatives that are encouraging behavioural change and practice adoption • Establish data infrastructure that enhances credit risk analysis for smallholder farmers and agri-SMEs		• Create supportive regulatory environment for innovative and blended finance • Establish data infrastructure that enhances credit risk analysis for smallholder farmers and agri-SMEs
IV **Strengthen the agricultural ecosystem**	• Implement programmes that help to build farmer capacity and education • Build capacity of FPOs, such as co-operatives; to increase farmer governance and organisation	• Implement guidelines and education on sustainable and resilient agriculture for producers throughout value chain	• Create a conducive policy ecosystem for land management, adoption of better agricultural practices, and overall sectoral transformation

Approach I: Provide accessible and affordable financing to smallholder farmers, for the adoption of better practices and equipment

There is a significant gap in smallholder farmer financing...



- Globally, the demand for smallholder farmer financing **exceeds US$323 billion annually**, including short- and long-term agricultural and non-agricultural financing
- However, current financing supply is only at US$95 billion annually; with an **unmet gap of more than US$200 billion**

And climate change will widen this gap

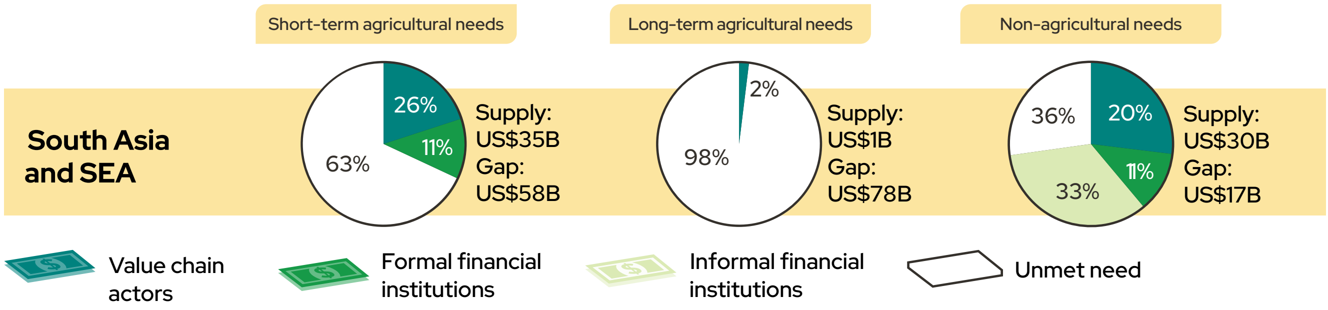
Decrease in financing supply as lenders become more risk-averse

If left unaddressed, this gap is projected to increase by another US$100-130 billion annually

Increase in adaptation-related financing (e.g., better seeds, better irrigation etc.)

Provision of working capital (for both OpEx and CapEx) to smallholder farmers can help to break the cycle and build resilience

Figure 17. Finance gap by region and type of financing need



- For export-oriented crops such as coffee, cocoa, and palm, there is a significant financing gap for credit, specifically for **replanting**. Capital is also needed for the **adoption of better practices** (e.g., inputs, pest management etc.) across all crops
- **Linking market access with finance** creates opportunities to **embed risk mitigants**, which can lead to increases in lending too
- There is also a need to consider whether insurance could address this financing gap

"Most market sizing exercises only estimate the overall financing need, but not the actual demand. This is because the price point for solution adoption is too high for farmers, and the returns are not immediately commensurate with the initial investment. For instance, there is low demand from farmers to invest in irrigation pumps in maize, as the price point is too high and the returns are not sufficient for them to make the decision. Demand from farmers need to be improved through changing mindsets and proving that adopting these new practices can bring about better efficiency and cost-savings overall."

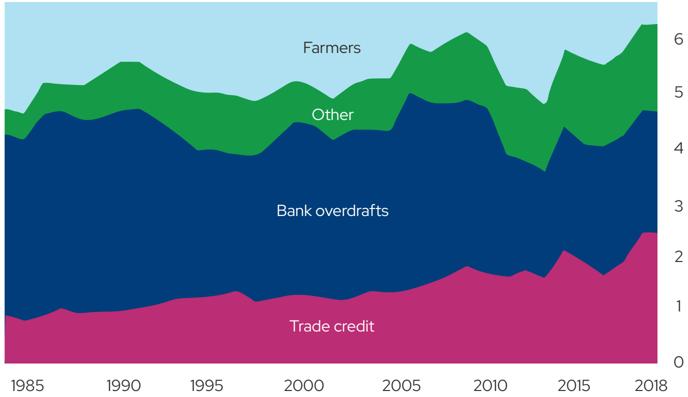
- Clara Colina, Director, ISF Advisors

Source: 1 ISF Advisors (2025): Beyond the frontier: Decoding viability in smallholder finance.

Approach II: Address key leverage points and create upsized impact through value chain financing

- **Value chain financing** is defined as the full range of activities that are required to bring a product or service from conception, **through the different phases of production** (involving a combination of physical transformations and the input of various producer services), **to delivery to the final consumer**[1]
- More financiers are adopting value chain financing and other forms of trade and supply chain financing due to their convenience and efficiency. Digitalisation also helps to lower costs and risks of conducting such financing, as supply chain tracking can be automated and more streamlined

Figure 18. Trade credit as a portion of agricultural financing, from 1985-2018[1]



Comparison between traditional lending and value chain financing[1]

Concepts	Traditional lending	Value chain financing
Lending	Asset-based or counterparty's cash flow	Cash flow based (receivables, contracts)
Know your customer (KYC)	Relationship banking	Know the value chain
Credit risk	Traditional assessments, needs sufficient client information	Improved systems for managing risk and information through value chain, digitalization leading to better transfer of information, predictability of demand, quality, flow and pricing
Risk mitigation	Careful client selection	Portfolio diversification, risk sharing, insurance, hedging
Client type	Commercial farmers or established commodities	Anchor company such as commercial SMEs, pools, co-operatives
Term	Varied	Commodity/harvest cycle (sometimes long term)
Capability building	Clients have the knowledge	Additional knowledge on agricultural techniques and financial management provided to farmers, including technical assistance
Market access	No connection to corporates for offtake agreements	Anchor company could either be an offtaker themselves, or are able to secure offtake agreements

Source: 1 World Bank (n.d.): Sustainable Agricultural Banking Program.

Approach II (continued): Value chain financing in practice – de-risking the value chain against climate risks and ensuring financing flows

Business-as-usual: Self-financed, climate-exposed value chain

- Due to the limited financing available from financial institutions, offtake/aggregators step in to provide financing to their value chains
- In addition to pre-existing risks (such as weather hazards), offtake/aggregators intensify the risk by committing their business capital
- In a good season, offtaker/aggregators make profits with such a system, but **in events of weather shocks and impacts they lose much more**, jeopardising the farmer incomes as well as their business (and even existence)

Total de-risking: Improving bankability of the value chain

- If financial institutions (FIs) are provided with insights on climate risk and appropriate risk mitigation approaches, FIs can **do targeted lending to offtake/aggregators**
- Through targeted lending, loan proceeds should be used to embed specific climate adaptation strategies that help maintain the health of offtake/aggregator business in the face of weather hazards and climate impacts **(operational de-risking)**
- For the remaining residual risk, loans should be further bundled with insurance and technical assistance (TA) **(structural de-risking)**
- This will **reduce transaction costs for financial institutions yet enable value chain actors to receive the necessary financing** to invest into climate resilient solutions for their farmer suppliers and improve linkages to market opportunities

Value chain aggregator / Off-take financing

- Farmers that supply are rejected by traditional financial institutions (FIs)
- Therefore, the aggregator/offtake is forced to pre-finance farmers
- Aggregator/offtake is exposed to climate shocks of their farmer suppliers and their own business
- Because of these risks, aggregator/offtake does not risk investing upfront into improving the climate adaptation of farmers

Financial institutions (FIs)

- Farmer suppliers do not pass the due diligence as climate risk cannot be priced (and hence assume to be high)
- Since the risk cannot be priced, FIs are uncertain what to finance and on what basis
- There is a lack or absence of a dedicated climate risk-transfer mechanism

Value chain financing focused on de-risking

- Converting an unbankable value chain into a financeable, climate-resilient system
- Building farmer, supplier, and aggregator business resilience

Structural de-risking (parametric insurance)

- Access to insurance encourages smallholder farmers to increase farm investments by 30%[1]

Operational de-risking (OpEx + CapEx + TA)

- Higher spatial and temporal resolution climate data to both the FI and the offtake/aggregator
- Provision of TA (e.g., agronomy plans) to farmer suppliers of the loan recipient
- Financial health monitoring/traceability of the loan recipient in the context of climate risks

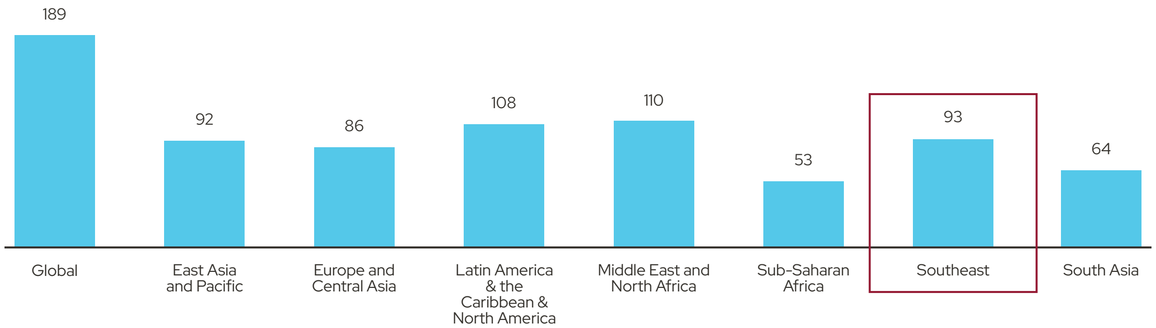
Source: 1 The MRR Innovation Lab (2022): Evidence landscape for microinsurance and other risk management instruments.

Approach III: Enable blending of finance across the stack and across time

The state of blended finance for sustainable agriculture in Southeast Asia:

Currently, deal sizes of blended finance deals in agriculture in SEA are **half that of the global average.**

Figure 19. Average transaction size of blended finance deals in agriculture (US$M)[1, 2]



Sustainable agriculture is among the top 5 sub-sectors for blended finance funding in the region, and also more broadly across Asia.

Top 5 subsectors in SEA

1. Water/Sanitation infrastructure
2. Nature-based Solutions (NbS)
3. Fisheries and aquaculture
4. Green Finance[a]
5. Climate-resilient/sustainable agriculture

Top 5 subsectors in Asia

1. Water/Sanitation infrastructure
2. Microfinance/Retail banking
3. Agriculture inputs/farm productivity
4. Climate-resilient/sustainable agriculture
5. Nature-based Solutions (NbS)

Agriculture and allied sectors

Nonetheless, there is significant opportunity for blended finance to play a more upsized role in SEA:

Figure 20. Ratios for blended finance deployment (all themes and segments)[1]

	SEA	South Asia	Asia	Global
Ratio of capital crowded in by concessional[a]	2.56	2.54	3.65	3.96
Private sector capital mobilisation ratio[b]	1.54	1.44	2.28	2.49

a Noted as 'leverage ratio' by Convergence Blended Finance, which shows how much total cash is crowded in by concessional capital; measures general efficiency of concessional funds
b Private sector mobilization ratio shows how much private interest is sparked, measures success in 'de-risking' for the market

To do so, there are several key issues that needs to be addressed:

- Long structuring and implementation timelines, coupled with high costs
- Lack of familiarity by funders towards agricultural projects
- Credit to higher risk sectors such as smallholder farmers still inadequate
- Poor funder response to "return enhancement" instruments

Note: a"Green Finance" follows World Bank's definition: Finance that addresses environmental objectives, such as climate change mitigation and adaptation, natural resource conservation, biodiversity conservation, and pollution prevention and control. **Source: 1** Convergence Blended Finance data, as of 2026; **2** CIIP analysis.

Approach IV: Strengthening the agricultural ecosystem through capacity building and infrastructure

Concentration of smallholder farmers

Inputs & enabling services	Production & on-farm management	Harvesting & collection	Storage & processing	Transport & aggregation	Markets & consumption
Land ownership • Only 8% of global land (~1 billion ha) have clear ownership rights. In SEA, **9% is privately held, with the state holding 51%**[1] • **Land tenure insecurity is acute in this region,** specifically among female landowners[1] • Securing land titles is **key to long-term livelihood stability for smallholder farmers**, enabling collateral use and access to financing	**Mechanisation**	• Asia's farmer population is ageing and shrinking, urging the agriculture sector to **reduce labour reliance and attract younger generations of farmers**[2] • SEA **averages ~1.8 horsepower (hp)/ha mechanisation** (measured as the ratio between the amount of power (hp) of agricultural machinery against the area of agriculture), far below Japan (16 hp) and the US (17 hp).[3] Yet, **automation technologies is highly capital-intensive, which prohibits farmers from adopting them**			
	Agronomy training and upskilling	• Demand for agroforestry experts is rising, but supply is limited in SEA • There has been a **downward enrolment trend** in agroforestry courses and programmes too - in the Philippines, agroforestry students fell ~13% to ~1,106 in 2020[4] • **Digitalisation and digital platforms can help to spread agronomic training to more farmers despite a smaller pool of experts**. For instance, using smartphones to capture pictures of crop failure, to be analysed by an in-built software in an application, with data uploaded to the cloud for the agronomist on the other end to analyse and advise further			
	Financial inclusion and literacy	• Financial exclusion limits smallholders' access to capital for improved practices, inputs, and equipment; older farmers (~50% in SEA) are most affected. In countries such as Indonesia and the Philippines, older farmers are often excluded by government-backed loan programmes (which are typically built for mid-to-large scale, formally employed farmers), as these programmes require bank accounts, formal income, or collateral[5] • Additionally, an **improvement in financial literacy significantly increases the likelihood of adopting both climate credit and adaptive savings behaviour**. Farmers with access to financial education (e.g., risk management, savings, budgeting) are better equipped to make sound financial decisions too[6]			

● Infrastructure enhancement ● Capacity building

Source: 1 FAO (2026): The Status of Land Tenure and Governance; **2** Stockholm Environment Institute (2019): "How investing in smallholder farms is investing in our society"; **3** Wijaya & Nurcahyo (2022): Agricultural Mechanisation in Indonesia and Comparison to Southeast Asia Countries; **4** World Agroforestry (2021): "More agroforestry education needed in Southeast Asia"; **5** Asian Development Bank (2025): "Mechanisation and Financing Can Extend Older Farmers' Working; **6** The MRR Innovation Lab (2025): Climate financing for climate change adaptation: the impact of financial literacy on credit and savings behaviour of smallholder farmers in rural Indonesia.

Case study examples: Agriculture – Corporates and funders

Technical solutions · Ecosystem & business model enablers · Access to finance (OpEx & CapEx) · Financial services · Public infrastructure · Capacity building & training

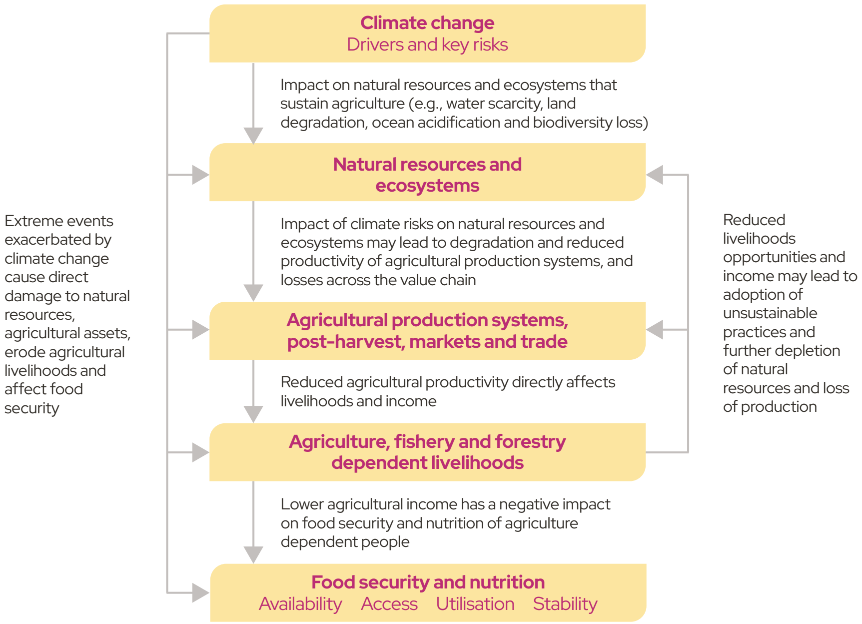
	Corporates		Financial institutions		Philanthropy
	Technical solutions	Capacity building & training	Access to finance (OpEx & CapEx)	Access to finance (OpEx & CapEx)	Technical solutions, Access to finance (OpEx & CapEx), Financial services, Capacity building & training
Organisation	**Thai Wah:** Improving climate resilience for farmers within supply chain	**Yara:** Strengthening the entrepreneurial acumen of farmers	**Agriculture and Rural Development Bank (ARDB):** Boost climate adaptation and resilience for farmers through lending operations	**Norinchukin Bank:** Co-operative-owned financial institution investing in sustainability and technology adoption in agriculture	**Temasek Foundation:** Supporting sustainable agriculture in SEA
Year established	1947	1905	2019	1923	2007
Geography	Cambodia, China, India, Indonesia, Vietnam	Global	Cambodia	Japan	SEA
Revenue/AUM	US$326M	US$15.7B	US$31M	US$558.4B	Not publicly disclosed
Key products	Tapioca starch and starch-related products	Inputs and crop nutrition (e.g., fertilisers)	Loans for agriculture and rural development	Investment and corporate finance	Grants, guarantees
Business model innovation	Created its own bio-fertiliser composed of by-products from its factories' manufacturing processes, distribution of this bio- fertiliser to farmers in their supply chain	Equipping smallholder farmers and MSME retailers with entrepreneurial training and practical business management skills	Utilised a weather and climate risk tool to co-design and launch a climate-smart agriculture loan product	Working with a consortium of value chain partners to improve sustainable practice and technology adoption by ageing farmers	Leveraging philanthropic capital as a loan guarantee to unlock private capital for sustainable agriculture and smallholder farmer financing
CA&R Impact	• Increase adoption of sustainable inputs at production stage • Reduce wastage produced from agricultural residue and processing waste	• Improve productivity and profitability for MSME retailers, allowing them to better withstand market and climate-related shocks	• Improve financial access and protection to farmers who are predicted to be more exposed to key weather hazards • Improve adoption of climate-smart agriculture solutions	• Increase the adoption of sustainable agriculture practices • Increase efficiency through technology adoption • Strengthening food resilience	• Improve adoption of sustainable replanting practices • Increase access to financing for underbanked and underserved smallholder farmers
Other impact	• Coupled with disease-resistant stems, the bio-fertiliser ensures that crop yields are more resilient. This helps to improve financial resilience for farmers, especially against climate shocks	• Enhance efficiency and sustainability of food production • Collect data on goods movement, demand signals, and climate effects	• Enable the bank to report to regulator and development finance institutions on environmental impacts • Streamline due diligence on farmers through the use of technology	• Addressing barriers to sustainable financing and technology adoption for ageing farmers • Increased incomes for farmers, fishers, and foresters	• Demonstrate that with various safeguards in place, lending to smallholder farmers is commercially viable

Note: All examples are available as full case studies in the Climate Adaptation and Resilience in Asia Case Study Library (2026) by CIIP.

Measuring impact in agri-food systems with a climate adaptation lens would require a multi-faceted viewpoint and approach

In understanding the link between climate change and agriculture, the Food and Agriculture Organisation (FAO) proposes the following impact pathway:

Figure 21. Climate change impact pathways in agriculture: from climate change to food security[1]



This pathway can be translated into action through implementing suitable indicators

An example from ImpactSF's impact reporting platform:

	Impact indicator		Unit	Proxy, % @	Activity data (to be collected per year)
Enhanced food security & nutrition	II.3.	Volume of increased crops /foods	t		Volume
	II.4.	Volume of diversified crops /foods	t		Volume
	II.5.	Number of crops	#		# Of crops
	II.6.	Food loss	t	x	Volume
	II.7.	Food waste	t	x	Volume
	II.8.	Volume of crops/foods with improved nutritional content	t		Volume
	II.9.	Volume of less harmful crops/foods	t		Volume
Improved livelihoods	II.10.	Number of jobs	#		Employees (by gender)
	II.10.1.	Thereof permanent jobs	%		
	II.10.2.	Thereof seasonal jobs	%		
	II.11.	Income level of farmers	US$		Farmers, volume
	II.12.	Income level of farmers supplying to agri-SME	US$		Farmers, purchase from agri-SME
Climate-smart agricultural value chains	II.13.	Number of farmers who adopt climate-smart agriculture (CSA) practices & technologies	#		Farmers (by gender)
	II.14.	Greenhouse gas emissions	t CO_2e	x	Volume, area
	II.15.	Area under improved soil and crop management practices	ha		Area
	II.16.	Water demand	m3	x	Water consumption
	II.17.	Energy demand	MJ		Electricity and fuel consumption (heat and transport)
	II.18.	Conserved forest or natural habitat	ha		Area
	II.19.	Regenerated/restored habitat	ha		Area

Focus

Multiple indicators are used to assess investor impact, but calculating them increases transaction costs for both investors and investees. By combining scientific proxies with operational data (e.g., volumes, farmer counts, land area) to estimate complex metrics such as food loss reduction, emissions avoided, and water use, more standardised metrics can be developed to support consistent impact reporting across stakeholders.

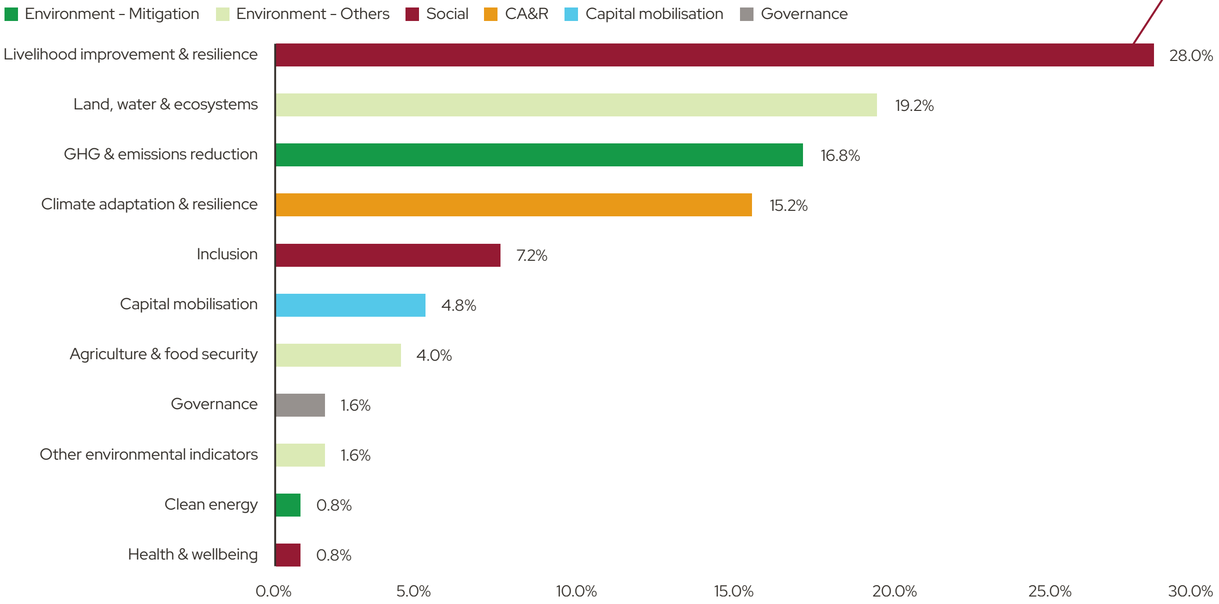
Source: 1 FAO (2017): Tracking adaptation in agricultural sectors.

Through our survey, funders that invest in agriculture prioritise a range of impact metrics from both social and environment dimensions; livelihoods top

Based on the Asia Funder Impact Survey conducted by CIIP for the Climate Adaptation and Resilience study, metrics that are currently tracked by funders who deploy capital into agriculture are varied and piecemeal. Considering the co-benefits of adaptation and agriculture, livelihoods and social metrics are the most frequently mentioned overall.

Figure 22. Number of entries mentioning metrics within specific categories

Q: What are the most important impact metrics your organisation tracks when it comes to CA&R? Please list up to 5. Please leave blank if no impact metrics tracked. Number of funders that indicate agriculture as an investment thematic = 84



Metrics within the **Livelihood improvement & resilience** category included:

Outputs

- **Households / people impacted**
- **Number of persons in local communities engaged in sustainable agriculture and restoration activities**

Outcomes

- **Improved quality of lives**
- **Improved livelihoods (jobs or income)**
  - Improved income / disposable income
  - Increase in earnings per person
  - Job creation
- **Number of beneficiaries with increased resilience**
  - Economic resilience created (such as cost savings, revenue enabled, jobs created)

From the perspective of outcomes, livelihoods and resilience are key metrics of concern to funders who are interested or active in agriculture

Note: Survey findings are directional and indicative only, drawn from a non-random sample using purposive and snowball sampling; findings were not tested for statistical significance. For detailed methodology, please see Annex in main report, Climate Adaptation & Resilience in Asia: Pricing Risk Sizing Opportunities, Financing Solutions, CIIP (2026). **Source:** 1 Asia Funder Impact Survey (2026) by CIIP in collaboration with SVCA.

Zooming in, a metric that addresses various dimensions within climate adaptation and agri-food resilience would be the livelihoods of smallholder farmers

Farmer livelihoods

Livelihood protection

- Protecting livelihoods against climate effects and downside risks (e.g., decline in health, leading to loss of income), increasing the buffer of smallholder farmers
- Increase awareness of climate change and associated risks
- Interventions include: climate/crop insurance, access to recovery capital post-hazard, education

Efficiency improvements

- Increasing yields and reducing wastage, ensure optimal production and maximum efficiency of inputs
- Establishing access to offtake and market, direct engagement with consumers for demand feedback
- Unlocking higher price points for agricultural produce, through packaging or branding, or both
- Interventions include: agronomy advisory, better inputs and better practices, D2C platforms, linkage with offtakers, branding of low emission/ organic crops to cater to premium price point

Income diversification

- Enabling alternative streams of household income for smallholder farmers, additional to net farm income
- Opening new areas of value addition, such as moving further down crop value chain (from raw to processed, such as from fresh fruit bunches (FFBs) to processed oil in palm)
- Interventions include: revenue from biochar, carbon credits, involving farmers in processing

Long-term sustainability

- Ensuring the continuation of the agricultural trade through reducing reliance on labour at the farmgate
- Improving access to growth capital to enable farmers to leverage good harvests and invest further
- Adoption of sustainable and regenerative agricultural practices, improve productive capacity of farmland
- Interventions include: automation, mechanisation, attracting more younger farmers to join, financial inclusion, increase investors' understanding of how to finance farmers and agriculture

Framework derived from several sources: 1 Sustainable Food Lab (n.d.): Living Income Community of Practice; **2** Sustainable Food Lab (n.d.): Small-Scale Farmer Livelihoods; **3** Han et al. (2023): Improving Farmer Livelihood Resilience to Climate Change in Rural Areas of Inner Mongolia, China.

Improving livelihoods can lead to better outcomes such as increasing producers' adaptive capacity while also lowering climate Value-at-Risk (cVaR) for financiers

Producers' adaptive capacity can be enhanced...

Adaptive capacity is the **"potential or ability of a system, region, or community, to adapt to the effects or impacts of climate change"**. Determinants of adaptive capacity relate to the **economic, social, institutional, and technological change**.[1]

Economic
Income stability, ability to repay

Social
Changing demographics, labour force resilience

Institutional
Policy and system changes

Technological
Automation, mechanisation

Environmental[a]
Sustainability, resilience

Livelihood protection

Efficiency improvements

Income diversification

Long-term sustainability

... while financiers reduce their portfolio risk.

Climate Value-at-Risk (cVAR) is **a forward-looking and return-based valuation assessment to measure climate related risks and opportunities in an investment portfolio.**[2] This is typically calculated through estimating the expected costs associated with climate impacts on an asset, portfolio, or company, and comparing these costs to the total value of the underlying asset.[3]

Improving livelihoods of smallholder farmers can lead to adoption of more sustainable agricultural practices, lower emissions, stronger resilience against climate shocks, greater supply chain stability (against both climate and demographic effects), and bring new opportunities for companies through innovation and diversification.

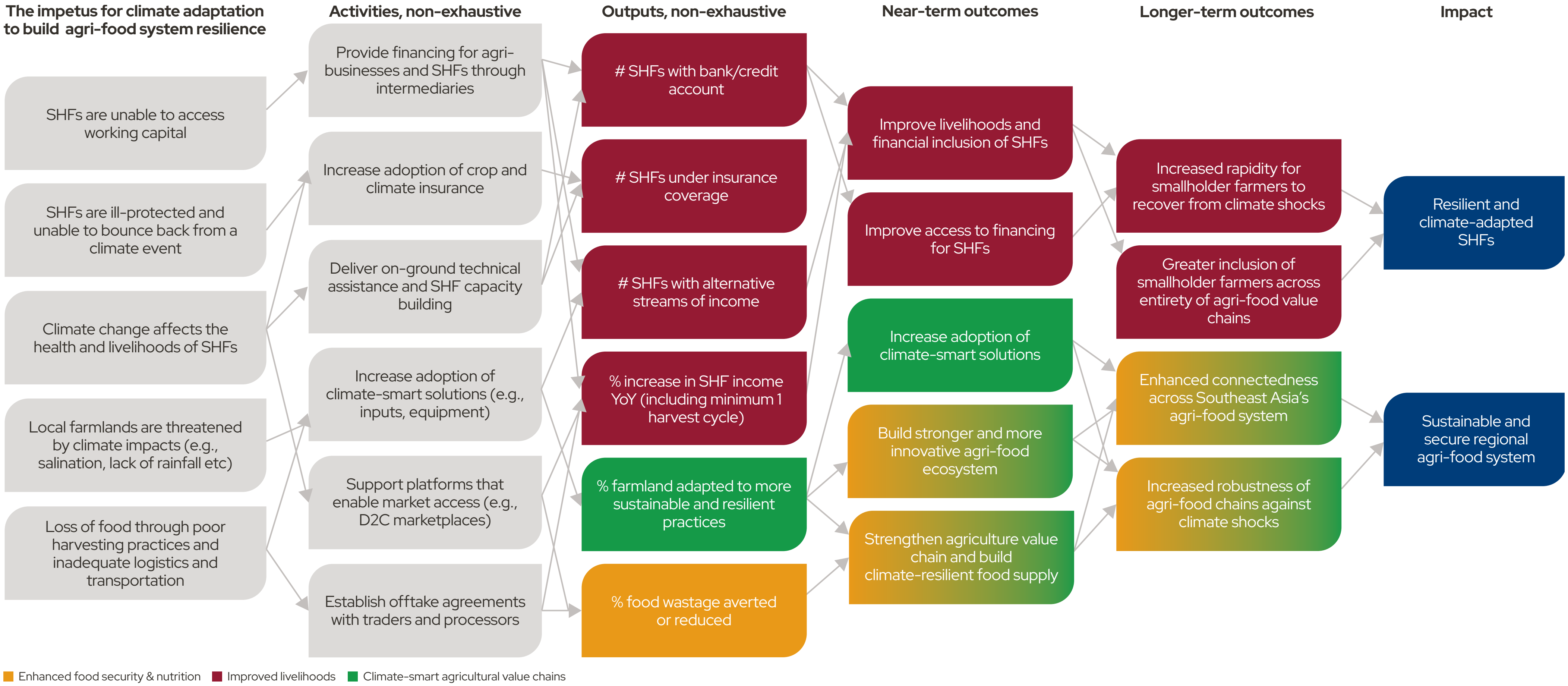
Return enhancement
Value chain impact (e.g., Scope 3)

Technology opportunities
New revenue and patents

Physical risk reduction
Climate and weather hazards

Note: a Dimension added by CIIP. **Source: 1** IPCC (2001): Climate Change 2001: Impacts, Adaptation, and Vulnerability; **2** MSCI (2024): MSCI Climate Value-at-Risk (VaR) Methodology; **3** SAP (2024): Part 2: Climate Risk Management – Methodology and Assumptions.

An illustrative Theory of Change for climate adaptation to build systemic agri-food resilience

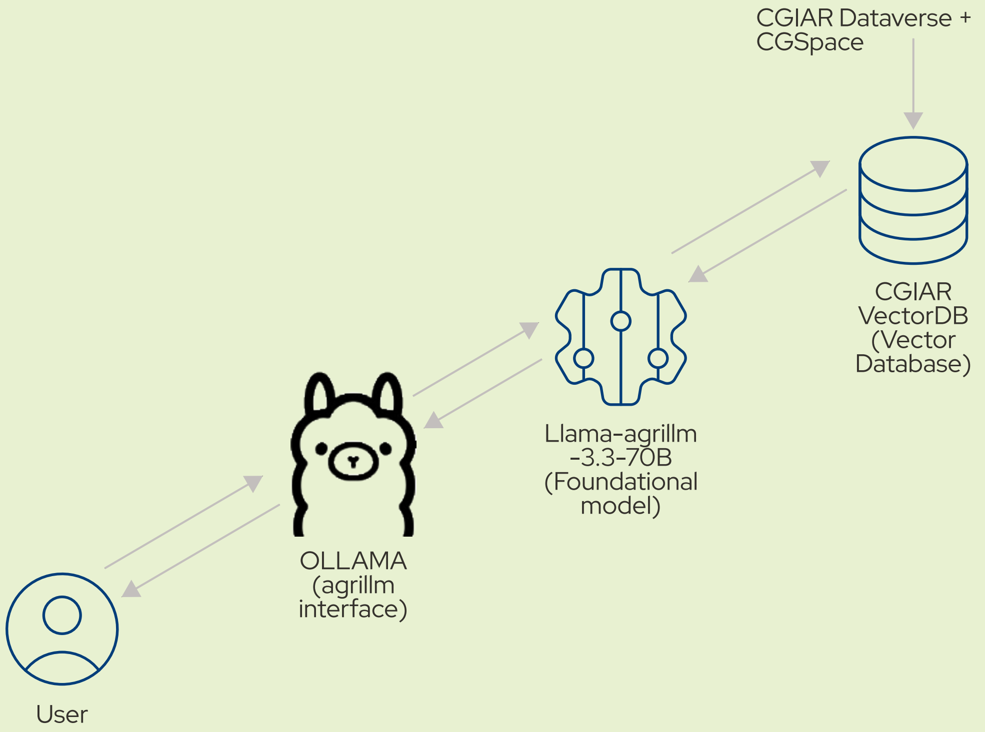


Note: **a** SHFs = Smallholder Farmers; **b** Characteristics and outcomes are based on World Bank's Resilience Attributes.

Note on methodology (1): Enriched Large Language Models (LLMs) to tap into CGIAR research and data

- Artificial Intelligence powered assistants (AI-assistants powered by LLMs; including conversational chatbots such as ChatGPT and Claude) were trained to learn from a wide range of topics. Their versatility makes them useful for assisting the public with solutions for addressing general and everyday queries. However large language models are unable to provide high resolution, in-depth and sector specific insights on south-east asian agriculture and food systems that was necessary for this study. This is because the underlying AI models "struggle" with 2 key challenges – "Hallucinations" and "Out-of-context" reasoning[1,2]
- To limit the impact of these risks , CGIAR and international development partners led by ai171 developed the AgriLLM suite of language models that have been fine-tuned to have an improved contextual understanding of agriculture and food systems[3]
- CGIAR repositories (Dataverse and CGSpace) hold a combination of published research papers, non-peer reviewed articles etc. derived from CGIAR research. A corpus of ~66K articles (as of September 2025) was transformed into a vector database and was provided as learning material for the AgriLLM model.[4,5] Post-learning, the model was prompted with questions through the OLLAMA interface, and the responses generated were used for this study
- In contexts wherein necessary insights were not obtained from the AgriLLM model, resources such as Consensus and BohriumAI were used to supplement the requirements for this study
- Prompts used to query the AgriLLM or Consensus or BohriumAI are mentioned in the reference section of the slides under Agri deep dive

Data connection between AgriLLM and CGIAR vector database



Source: **1** Alansari and Luqman (2025): Large Language Models Hallucination: A Comprehensive Survey; **2** Hu et al. (2024): Large Language Models are Limited in Out-of-Context Knowledge Reasoning; **3** Alaoui et al. (2025): AgriLLM; **4** CGIAR and SCIO (n.d.): A Curated Research Corpus for Agricultural Advisory AI Applications; **5** Jing et al. (2025): When Large Language Models Meet Vector Databases: A Survey.

Note on methodology (2): Analysis using FAOSTAT and FishStatJ

About the datasets

- **FAOSTAT** is the free food and agriculture database by the Food and Agriculture Organisation of the United Nations (FAO). The database covers over 245 countries and territories, and covers all FAO regional groupings from 1961 to the most recent year available[1]
- **FishStat (by FAO)** is the leading source of global fishery and aquaculture statistics, covering data from 1950-2024 (as of latest release date in March 2026)[2]

Extraction methodology

1. As FAOSTAT does not cover aquaculture data, further data needs to be gathered from FishStat to provide a comprehensive picture on total agricultural production value of SEA.
2. The most recent Global Aquatic Trade data available on FishStat is from 1976-2023. To derive the most recent five-year average, the analysis covers **2019-2023**.
   - The specific workspace consulted is "FAO Global Aquatic Trade Statistics", version 2025.1.0.
   - For ease of analysis, commodities are grouped and extracted according to the International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) groupings[3]
3. Aligning with this timeline, data on food and agriculture from 2019-2023 is extracted from FAOSTAT
   - The specific data domain consulted is "Crops and livestock products" under Trade category.
   - All commodities within "Crops and livestock products" and "Live animals" subcategories are included.
4. The data included for analysis met the following criteria:
   - Official figures reported by respective countries (i.e., no estimates, no third-party reporting)
   - Only Exports and corresponding value in US$ (i.e., no imports, no re-exports)
   - Data is from eleven SEA countries – Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, Vietnam

Analysis methodology

1. Further coding was applied to FAOSTAT data to create broader categories for each commodity. For example, Palm would include all products, such as palm kernels, palm oil, palm kernel oil, and other by-products at the first offtake (milling) level. The same categorisation method is applied to other key crops, including rice, soya, sugarcane and maize
2. Further coding was also applied to FishStat data to consolidate all items into distinct categories of Shellfish, Seaweed, Freshwater Fish, Marine Fish, Prawns, Squids, Sponges, Pearls, Corals, and Miscellaneous
3. Both coded and cleaned FAOSTAT and FishStat data were merged into one dataset. From this merged dataset, we derived the five-average for each commodity group, broken down by the eleven SEA countries

Source: **1** FAO (n.d.): FAOSTAT database; **2** FAO (n.d.): FishStat database; **3** FAO (2000): The current International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) in use from 2000.

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