OXFORD ECONOMICS

CLIMATE CHANGE AND FOOD PRICES IN SOUTHEAST ASIA

MARCH 2022

FOOD INDUSTRY ASIA

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3° Celsius

Average temperatures are three degrees warmer than pre-industrial period across Southeast Asia, and periods of extreme weather have become more frequent.

CLIMATE CHANGE IS CAUSING SOUTHEAST ASIA'S WEATHER TO BECOME HOTTER AND MORE VOLATILE

Southeast Asia's climate has become substantially warmer and more unpredictable in the last ten years. Mean temperatures are around 3 degrees Celsius higher than in the 1950-1980 period, and the range of temperatures has widened by around 2 degrees.

Some countries have been especially-heavily impacted. Increases in temperatures and temperature volatility has been greatest in Thailand and Vietnam, with Malaysia and Philippines also visibly impacted. Rainfall has on average trended down in recent decades, but volatility has increased, with far greater occurrences of higher-than-average rainfall months.

The Intergovernmental Panel on Climate Change finds that weather extremes will become far more likely in climate futures which have a higher degree of global warming. In a world which warms to 2 degrees above pre-industrial averages, extreme temperatures will occur around twice as often as they do now. However, even if global warming is successfully contained to 1.5 degrees periods of extreme weather will become increasingly common.

More extreme weather episodes

Even if the world manages to contain further global warming, extremes of temperature and rain will become more frequent.

OUR ESTIMATES INDICATE PERIODS OF EXTREME WEATHER HAVE BEEN RESPONSIBLE FOR MAJOR FOOD PRICE SPIKES ACROSS THE REGION

Climate change impacts on food production costs through a range of channels. The most-frequently discussed channel is through agricultural yields, where the consensus is that climate change will ultimately lower crop yields. But the impacts will vary over time and across countries, with modest gains to yields in the early decades of higher-emissions scenarios giving way to losses from the second half of this century.

But food producers have a range of other key cost factors, including the cost of energy and other products and services used in the manufacturing process, and the cost of labour. To isolate the potential role of climate we use an error-correction model to estimate the relative impact of each of these factors.

6% cost spike

Periods of extreme weather in the past decade have added as much as 6% to the producer cost of food in Southeast Asian economies and can be expected to occur more frequently.

We find that temperature volatility has a major impact to food price inflation across most of the countries in our study. In Thailand, Vietnam, and Indonesia a 1% increase in temperature versus the same period a year ago adds 0.5-0.8% to the rate of producer food price inflation. In recent instances of extreme weather these economies we estimate weather volatility has added as much as 6% to the rate of food price growth.

BUT WHILE CONTAINING PRICE SPIKES IS A PRIORITY, THE TRANSITION TO LOW-CARBON WILL HAVE A SUBSTANTIAL IMPACT ON FOOD BILLS

Food price spikes caused by extreme weather cause real hardship for poorer households, which spend around 10% more of their income on food than the average household. So governments have a key interest in limiting future weather volatility by doing their part to transition to lower-carbon economies. But this transition will have costs of its own, as big changes are made to the way we generate electricity in particular. Using macroeconomic forecasts from our *Global Climate Service*, we estimate producer food prices could be as much as 80% higher in Indonesia in a scenario where the government achieves net zero by 2050 but doesn't accompany this with measures to help mitigate the cost impact to the food supply chain. Governments across the region therefore need to think about how to *both* protect consumers from price spikes that will occur more frequently in the future regardless of what action is taken now, *and* to try and lower the cost to food prices of shifting to a lower-carbon future.

80% cost of transition

Achieving a transition to net zero could increase food production costs by up to 80% by 2050

GOVERNMENTS HAVE A RANGE OF POLICY MEASURES THAT CAN PROTECT CONSUMERS AND EASE THE TRANSITION.

Firstly, measures to reduce farmers' and consumers' exposure to weather volatility in the years ahead. Reprioritising public spending on farms and agriculture would help if more funds were diverted to supporting farmers adopting technologies that help improve resilience to extreme weather. At 2.5% of GDP, the scale of agricultural support in Philippines and Indonesia offers the greatest scope for redeployment. More can be done to support the adoption of agricultural insurance, which can help farmers restart production faster after losses, containing the impact of weather events on supply. Vulnerable households can be protected by prioritising the poorest in welfare spending, as well as raising the share of national income spent on social assistance to levels seen in other emerging economies around the world – many Southeast Asian nations currently spend around 0.5pp of GDP less in this area than middle-income countries elsewhere. Improving the monitoring and assessment of food prices would help governments target support for households more quickly and efficiently.

2.5% of GDP

Generous agricultural support in Indonesia and Philippines could be redeployed to more effective measures to improve resilience.

Secondly, to work to ease the costs of transition for the food manufacturing sector. Tackling energy use in the sector (including through microgeneration and waste-to-energy) would help lower the pass through from higher electricity costs to producer prices. Likewise, efforts to improve labour productivity in the sector – including by removing barriers to inward foreign investment – would help slow the pass through from rising wage costs to food prices. And finally, efforts to further harmonise standards and liberalise food trade around the region would boost investment in the sector and drive competition – both of which should keep prices lower.

0.5% of GDP

Closing the gap in social assistance spending compared to other emerging economies would provide a useful tool for governments to respond to food price shocks.

A CALL TO ACTION - FOR GOVERNMENT AND THE INDUSTRY TO WORK TOGETHER TO TACKLE THE IMPACT OF CLIMATE CHANGE TO FOOD COSTS

There is no escaping the need to transition Southeast Asian economies towards net zero as part of the global effort to limit climate change in the coming years. But we know this will entail substantial additional costs across the manufacturing sector, including food production. At the same time, consumers will face increasing food price volatility as weather conditions become more unpredictable. But there is a lot that can be done to protect consumers from volatility and help lower the cost of transition. We call on governments across the region to engage with the food industry, and collaboratively set out a strategy to deal with these twin challenges in the coming years.

1. CLIMATE CHANGE IN SOUTHEAST ASIA: THE EVIDENCE SO FAR

KEY INSIGHTS

- Southeast Asia's climate has become substantially warmer and more unpredictable in the last ten years or so compared to previous decades. Mean temperatures are around 3 degrees Celsius higher than in the 1950-1980 period, and the range of temperatures has widened by around 2 degrees.
- Some countries have been especially-badly impacted - increases in mean temperatures and temperature volatility has been greatest in Thailand and Vietnam, with Malaysia and Philippines also visibly impacted. Rainfall has on average trended down in recent decades, but again volatility has increased substantially, with far greater occurrences of higher-than-average rainfall months.
- The Intergovernmental Panel on Climate Change finds that weather extremes will become far more likely in climate futures which have a higher degree of global warming – for example in a world which warms to 2 degrees above pre-industrial averages, extreme temperatures will occur around twice as often as they do now.

1.1 INTRODUCTION AND OVERVIEW

"Human influence on the climate has been the dominant cause of observed global warming since the mid-20th century. The temperature rise to date has already resulted in profound alterations to human and natural systems, including increases in drought, flooding, extreme weather, sea level rises and biodiversity loss. These changes are causing an unprecedented increase in climate-related risks, with people in low- and middle-income countries most severely affected. Some countries are already experiencing a decline in food security, which in turn is partly linked to rising poverty and international migration."

Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C (SR1.5)[1]

Climate change, and the impact it is having and will have across all areas of human life, has risen to the top of the political agenda around the world. In this paper, we look at the impacts from climate change to the cost of producing food in five Southeast Asian economies – Indonesia, Malaysia, Philippines, Thailand, and Vietnam. In doing so we will look at how climate is changing in these countries, and the transmission mechanisms from climate change to food prices. We'll also consider the potential costs of transition for the sector, as efforts to shift the world onto a lower warming path gather pace, increasing the cost of key inputs to the production process.

[1] Available at https://www.ipcc.ch/sr15/

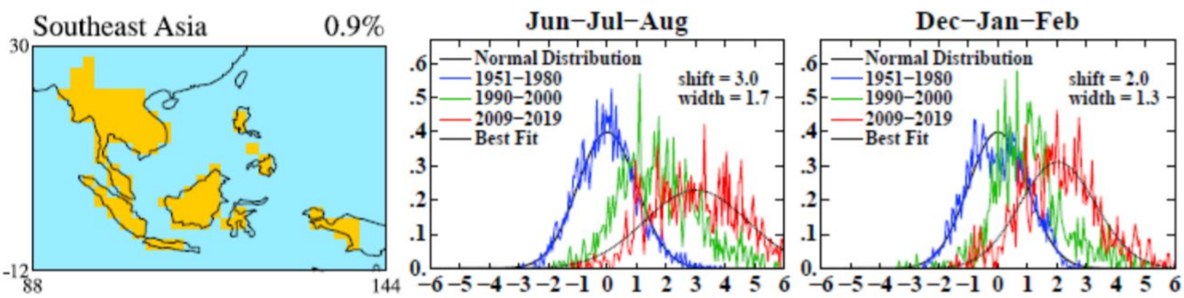
In doing so we find a trade-off that stakeholders across the food supply chain need to understand and engage with. On the one hand, climate change is already making food prices more volatile, with damaging welfare impacts for the poorest households. So limiting the future increase in global temperatures and associated extreme weather events is a key part of any efforts to tackle poverty and support living standards. But transitioning to a lower-carbon future will have substantial costs – so food prices may well be less volatile in the future under better climate outcomes, but they are likely to be higher.

Fortunately, governments have a range of policy measures at their disposal to try and alleviate the impacts of volatility on consumers, and to try and make the transition lower cost. We discuss these policy options in the last section of our report.

1.2 HOW IS SOUTHEAST ASIA'S CLIMATE CHANGING?

In common with other parts of the world Southeast Asian countries have undergone significant and, in many cases unpredictable and volatile, changes to their climate through recent decades. The IPCC's Summary of Climatic Impact Drivers[2] for the Southeast Asia climate zone[3] finds that the region has undergone an upward trend in mean surface temperature *and* an increase in the frequency of extreme heat. The IPCC finds that mean precipitation levels for the region do not appear to have changed through recent decades, but heavy precipitation and pluvial flooding[4] have become more frequent, as have frequency and intensity of tropical cyclones. And sea levels in the region have risen, a key risk for a region where most capital cities and other major population centres are at sea level in coastal regions. More positively, the IPCC finds no clear evidence that the incidence of agricultural drought has increased in the region – this is mainly a concern for sub-Saharan Africa and Central Asia.

FIGURE 1 – DISTRIBUTION OF TEMPERATURES IN SOUTHEAST ASIA



Source: Regional Climate Change and National Responsibilities, Hansen and Sato, July 2020

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[2] "Climatic impact-drivers (CIDs) are physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems. Depending on system tolerance, CIDs and their changes can be detrimental, beneficial, neutral, or a mixture of each across interacting system elements and regions. CID types include heat and cold, wet, and dry, wind, snow and ice, coastal and open ocean". IPCC Climate Science 2021 Summary for Policymakers. South East Asia summary is available here.

[3] One of 45 climate zones the IPCC analysis divides the world into for climate analysis.

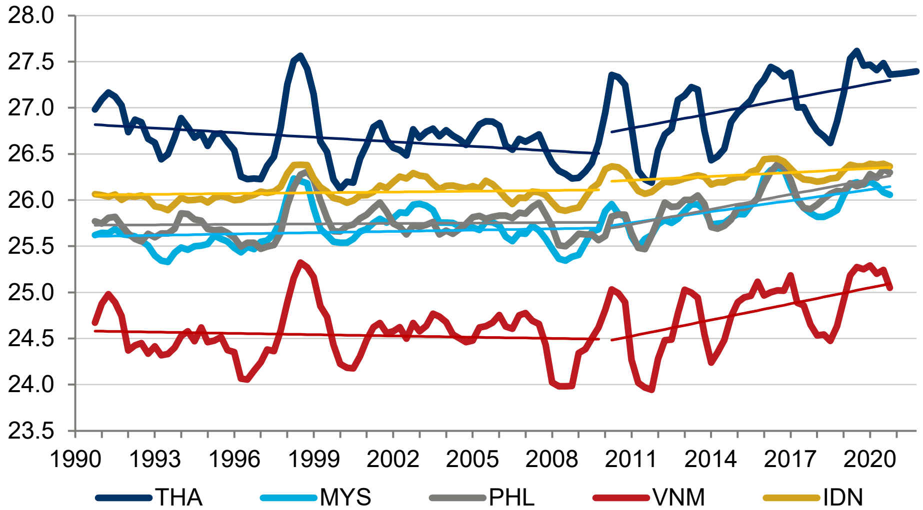
[4] A pluvial flood occurs groundwater drainage systems are overwhelmed, typically because of higher rainfall.

Figure 1 shows how in recent decades temperature conditions across the region have 1) on average become substantially hotter, 2) but with uneven impacts across the seasons, and 3) with a greater degree of unpredictability. The mean temperature for the Jun-Aug quarter had shifted around 3 degrees Celsius higher by the 2009-2019 decade compared to 1950-1980, but only 2 degrees Celsius higher for the Dec-Feb season. And the volatility of temperatures around the mean has increased substantially – with the range of temperatures experienced during the Jun-Aug quarter from 2009-2019 widening by 1.7 degrees compared to the 1950-1980 period.

The increase in mean temperature and temperature volatility has not been witnessed uniformly across ASEAN economies though. Figure 2 shows rolling 4-quarter average temperatures as well as linear trends in the average for the 1990-2009 and 2010-2020 periods. Thailand and Vietnam have clearly seen the most pronounced rises in average temperatures as well as the greatest increases in volatility. Philippines and Malaysia have seen less pronounced (but still clearly noticeable) trend increases in average temperatures and in volatility terms, while Indonesia's average temperature looks to have been only modestly impacted by regional standards.

FIGURE 2 – AVERAGE QUARTERLY TEMPERATURES

4-quarter rolling average daily temperature, degrees Celsius

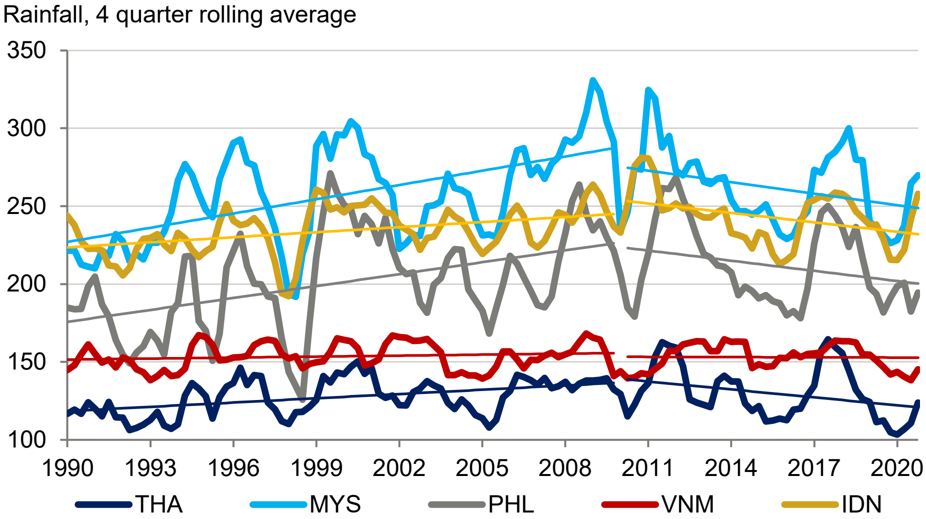


Source: Oxford Economics\Haver Analytics/Climate Change Knowledge Portal

Figure 2 was presented simply in quarterly average terms it would be more difficult to discern both the clear change in trend between the 1990-2009 period and the most recent decade *and* differences in the same quarter year on year. But looking at monthly data there is an increasing incidence of unseasonably hot weather in the worst-impacted ASEAN economies. Since 2010, there have been no fewer than eight occasions where the monthly average temperature in Thailand was more than 2 degrees higher than the same month a year earlier, having had only three such instances through the 1990s and just one during the 1980s. A similar pattern is seen in Vietnam, where the temperature was 2 degrees higher than the same month a year ago on four occasions in the past decade, compared to once or twice per decade from 1980-2010. Malaysia, Philippines, and Indonesia have not experienced this degree of volatility in monthly temperatures.

The picture is less obvious in terms of average quarterly rainfall (Figure 3). In line with the IPCC's findings, our data show that most countries in the region have exhibited either stable or modestly declining trend levels of rainfall (over a four-quarter rolling period) through the last decade. And the volatility of the cycle around this trend also looks relatively stable.

FIGURE 3 – AVERAGE QUARTERLY RAINFALL



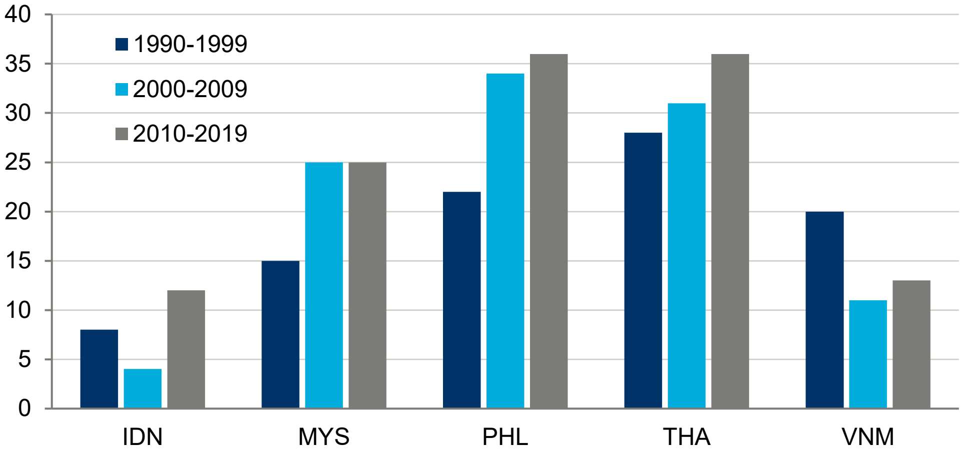
Source: Oxford Economics\Haver Analytics\Climate Change Knowledge Portal

But on a monthly basis, the increased volatility in precipitation levels becomes clearer (Figure 4). In all but one of our countries the number of high precipitation months increased substantially between the 1990s and the last decade, with Philippines and Malaysia most heavily impacted. Indonesia also saw an increase in higher-rainfall months, but from a much lower starting point, while Vietnam looks to have seen fewer higher-rainfall months in the last ten years than in previous decades.

Of course, extremes of precipitation matter because of the potential for flooding, with devastating social and economic impacts. The most powerful example of this in the region in recent years was seen in Thailand when rainfall was consistently 20-70% higher than the relevant monthly average for six consecutive months from March 2011. According to the Emergency Events Database (EM-DAT), the floods took an estimated 813 lives and cost US$ 49 billion in economic damage. Over 20,000 square kilometres of farmland was damaged, creating a loss in agricultural output of THB 25bn (approximately US$ 1bn) according to subsequent government estimates. Major transportation routes across the country were unpassable. The floods had a substantial impact to the cost of doing business across the economy, including for food producers. Producer price inflation for food accelerated from just 5% in late 2010 to a peak of almost 11% in late 2011, with consumer food prices following a very similar path.

FIGURE 4 – VARIABILITY IN MONTHLY RAINFALL VS 1990-2019 PERIOD

Number of months where precipitation was at least 20% higher than the 1990-2019 average for that month



Source: Oxford Economics\Haver Analytics\Climate Change Knowlege Portal

So the Southeast Asia region has seen substantial changes to climate conditions through the past three decades. Most clearly average temperatures have risen across the five countries in our study, with the fastest rises in Thailand and Vietnam, which are also experiencing the greatest increase in temperature volatility and associate heat stress. Malaysia and Philippines have seen the greatest increases in rainfall volatility, with almost twice the rate of heavy-rainfall months in the last ten years compared to the 1990s. On temperature and rainfall metrics Indonesia has seen greater climate stability than its neighbours. In the next section of this chapter, we examine two alternative global climate scenarios, and how they might be expected to impact on average conditions and volatility in Southeast Asia.

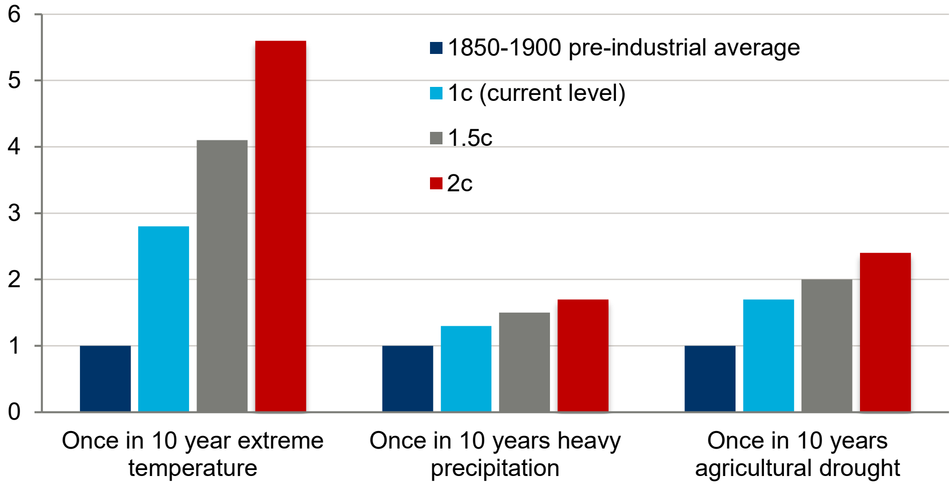
1.3 POTENTIAL GLOBAL CLIMATE FUTURES

There are a potentially infinite set of outcomes for the global climate in the coming decades, and the impact to Southeast Asia. These scenarios depend on a wide variety of political, economic, technological, and scientific factors. But ultimately it is the impact of climate to everyday life that matters. In this respect the IPCC's Physical Science Basis[5] report from 2021 is sobering reading. The IPCC demonstrate that highly damaging climatic-impact drivers have already become increasingly common around the world (Figure 5). At the global level a once-in-ten-years heatwave by 1850-1900 standards is now occurring around three times as often, while instances of agricultural drought are already twice as common now as they were in the pre-industrial era.

[5] https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/

FIGURE 5 – FREQUENCY OF EXTREME CLIMATE OUTCOMES IN DIFFERENT GLOBAL WARMING SCENARIOS

Frequency of a once-in-ten-year event by1850-1900 standards



Source: Oxford Economics\Intergovernmental Panel on Climate Change

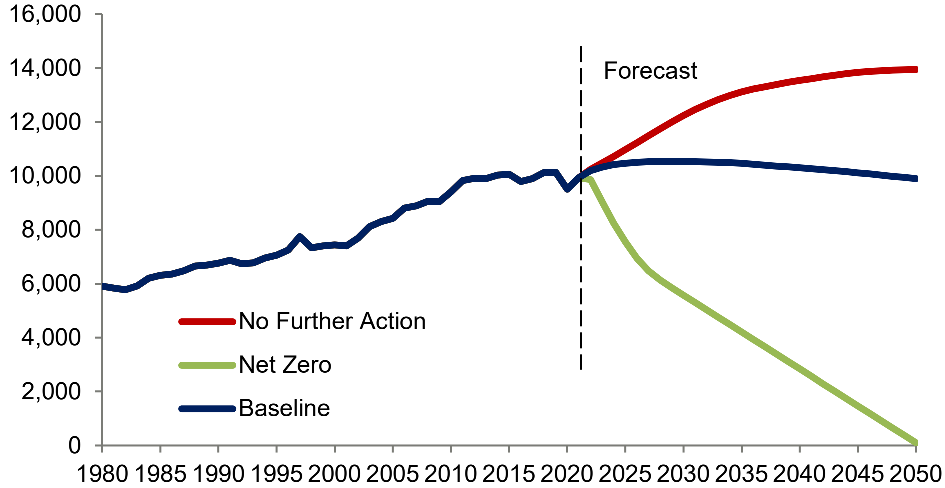
The IPCC find that the increase in climate volatility can be expected to worsen at higher levels of global temperature increase. At 1.5c the once-in-ten years heatwave is expected to happen four times per ten years. At 2c, what was previously a once-in-ten-year heatwave will happen more years than not. Containing the impact of climate change to everyday human life therefore clearly relies on keeping global temperature increases to a minimum. To this end the Paris Agreement committed countries around the world to limit global warming versus the pre-industrial era to 2 degrees or below, and preferably to no more than 1.5 degrees.

In our *Global Climate Service* (GCS), Oxford Economics simulates alternative paths for global climate policy and associated climate outcomes. Our baseline scenario assumes all governments around the world deliver on their *stated policy goals* for reducing emissions over the coming decades. In this scenario, temperatures are 2c higher by 2050 than they were in the pre-industrial period. In an alternative scenario where all governments achieve carbon *net zero* by 2050 (with varying degrees of policy effort required depending on country-specific circumstances), temperatures settle 1.5c higher in 2050. But in a scenario where all governments only deliver policies currently implemented, hence take *no further action*, temperatures can be expected to be well above 2c higher by 2050. The interaction between emissions and temperature change in GCS is shown in Figure 6 and Figure 7[6].

[6] Even the relationship between emissions and temperature increase is subject to substantial uncertainty. One driver of this is the degree to which permafrost thaws, irretrievably releasing previously-frozen carbon and methane into the atmosphere, contributing to more warming and more permafrost thawing. For more on permafrost thawing and its relationship to climate change, see https://www.carbonbrief.org/guest-post-the-irreversible-emissions-of-a-permafrost-tipping-point

FIGURE 6 – WORLD NET EMISSIONS IN POLICY SCENARIOS

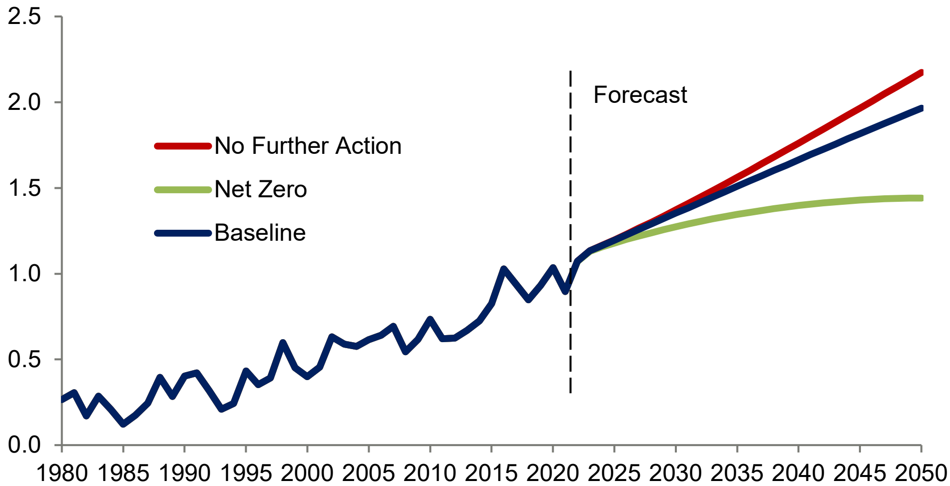
World net carbon dioxide emissions, million tonnes



Source: Oxford Economics

FIGURE 7 – WORLD TEMPERATURE IN POLICY SCENARIOS

World temperature anomaly versus 1950-1980



Source: Oxford Economics

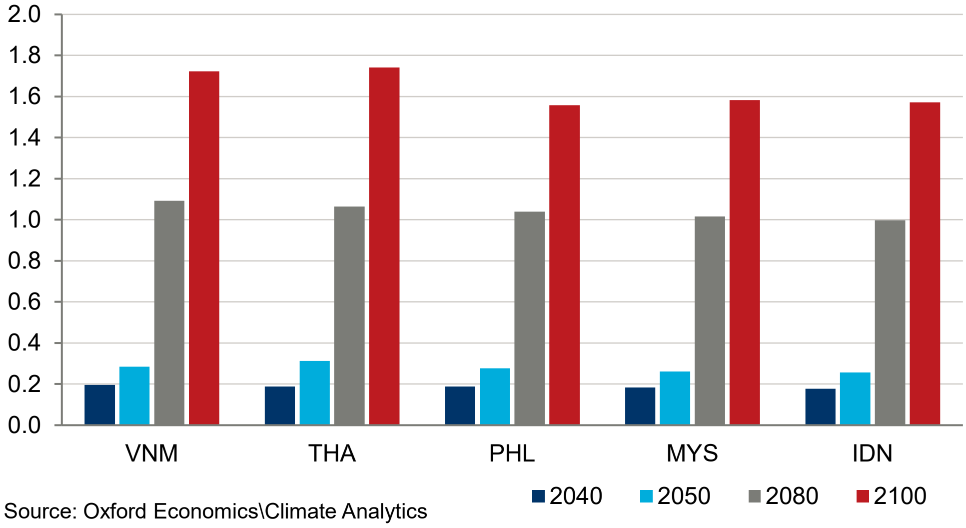
1.4 POTENTIAL CLIMATE FUTURES FOR SOUTHEAST ASIA

The impact of future global warming on climate conditions will vary markedly across different regions though. The impacts will be greatest in the polar regions where temperature increases will typically be three times greater than those experienced at the equator. The parts of the world where drought is most likely to become a problem are those parts into which the subtropical deserts are likely to expand – chiefly the western US and eastern Australia, but also southern Mediterranean Europe, central Southern Africa, India, southern China, and subtropical Latin America. By contrast, Southeast Asia should experience *modestly* less-severe climate impacts than the global average. The IPCC find (with high confidence) that future warming for the region will be slightly less than the global average.

In Figure 8 and Figure 9 we show expected climate outcomes for the region in a global current policies scenario (i.e. no further action other than what governments are already implementing) versus a net zero scenario, as produced by Climate Analytics[7]. The bulk of both temperature increases occur in the second half of this century, with Vietnam and Thailand witnessing greater increases in temperature than other countries in the region by 2100. Mean rainfall increases are modestly weaker in Malaysia and Indonesia than in other countries, but again mainly occur in the second half of the century.

FIGURE 8 – TEMPERATURE CHANGE IN SOUTHEAST ASIA

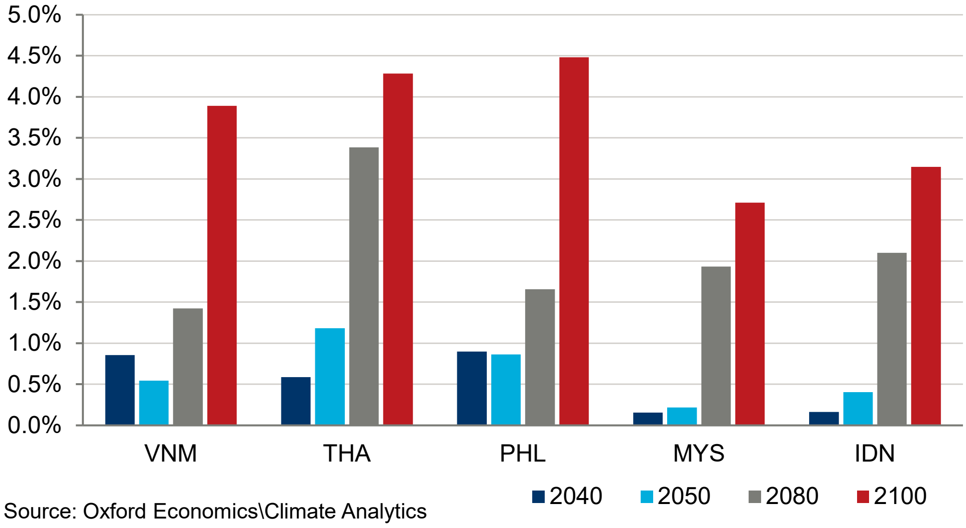
Mean temperature in a Current Policies scenario compared to Net Zero scenario



Source: Oxford Economics\Climate Analytics

FIGURE 9 – RAINFALL CHANGE IN SOUTHEAST ASIA

Mean rainfall in a Current Policies scenario compared to Net Zero scenario



Source: Oxford Economics\Climate Analytics

7 https://climateanalytics.org/about-us/

However, the impact of climate change to economies is not simply about the change in average climate conditions. Levels do matter, especially in higher-emissions cases such as the current policies scenario in Figure 8 and Figure 9. But damage to everyday health and economic activity comes from surges in climate conditions outside of what is anticipated and what can be coped with. In the case of food supply chains this could include temperature extremes outside of the normal living conditions for livestock or growing conditions for crops, or prolonged heavy rainfall which overwhelms drainage systems on farms and elsewhere around the supply chain. As we saw in section 1.2 and 1.3, these extreme weather events have become more frequent in Southeast Asia and can be expected to become more so – even in a net zero scenario. In the next section we explore the transmission from climate conditions and volatility to food production prices and assess how food price levels and food price inflation can be expected to evolve over the coming decades under different climate policy scenarios.

2. THE IMPACT FROM CLIMATE CHANGE TO FOOD PRICES IN SOUTHEAST ASIA

KEY INSIGHTS

- Climate change impacts on food production costs through a range of channels. The most-frequently discussed channel is through agricultural yields, where the consensus is that climate change will ultimately lower crop yields. But the impacts will vary over time and across countries, with modest gains to yields in the early decades of higher-emissions scenarios giving way to losses from the second half of this century.

- But food producers have a range of other key cost factors, including the cost of energy and other products and services used in the manufacturing process, and the cost of labour. To isolate the potential role of climate we use an error-correction model to estimate the relative impact of each of these factors.

- We find that temperature volatility has a major impact to food price inflation across most of the countries in our study. In Thailand, Vietnam, and Indonesia a 1% increase in temperature versus the same period a year ago adds 0.5-0.8% to the rate of producer food price inflation. In recent instances of extreme weather these economies we estimate weather volatility has added as much as 6% to the rate of food price growth.

- Food price spikes caused by extreme weather cause real hardship for poorer households, which spend around 10% more of their income on food than the average household. So, governments have a key interest in limiting future weather volatility by doing their part to transition to lower-carbon economies. But this transition will have costs of its own – producer food prices could be as much as 80% higher in Indonesia in a scenario where the government achieves net zero by 2050 but doesn't accompany this with measures to help mitigate the cost impact to the food supply chain.

2.1 INTRODUCTION

Climate change is already impacting the cost of doing business across sectors around the world, and food production is no exception. Changing climate conditions impacts the cost of producing food through a range of channels, with varying impacts over time. And there are important trade-offs to be aware of when thinking about the potential climate transition towards a more sustainable net zero world. In this section we examine these impact channels more closely with the aid of an econometric estimation and produce illustrative projections of the potential impact of climate change on food production costs.

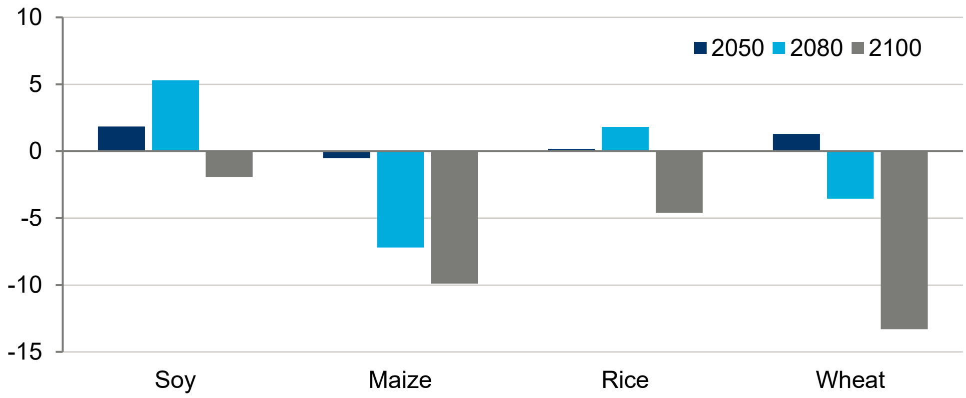
2.2 HOW CLIMATE CHANGE IMPACTS ON FOOD PRODUCTION COSTS

Most of the existing academic literature on the impact of climate change to food supply focuses on the relationship between average temperature and agricultural productivity, specifically crop yields. Key contributions to the literature find that on balance the impact of rising average temperatures to crop yields are modestly negative. Schleussner et al[8] find the mean impact of global temperatures being 2c higher than pre-industrial levels[9] on yields across four key crops[10] to lie between 0 to -5% at the global level - albeit with quite substantial confidence intervals around these central estimates.

Focussing on Southeast Asia specifically, Figure 10 shows the impact on crop yields of a current policies scenario (i.e., no further policy action) versus a shift to net zero by 2050 (consistent with a warming of 1.5c). The evidence is mixed up to 2050, with modest gains in yields in soy and wheat yields and negligible impacts to maize and rice. By 2080 and beyond though the impact is more clearly negative, with yields across all four staples lower by 2100.

FIGURE 10 - IMPACT ON CROP YIELDS IN SOUTHEAST ASIA FROM A CURRENT POLICIES SCENARIO VS NET ZERO 2050

Difference in yields in Current Policies scenario versus Net Zero scenario (unweighted average across 5 economies, +ve = crop yields higher under Current Policies than Net Zero)



Source: Oxford Economics\Climate Analytics

Lower crop yields are one key driver of a loss in agricultural productivity, and increased food costs. But increased heat stress amongst workers is also relevant in higher-temperature scenarios. Climate Analytics estimates the average loss of labour productivity (defined as output per worker) will be around 2 percentage points under a current policies scenario relative to a net zero world, with the differential widening to as great as 10 percent by 2100. Moreover, this is likely to be greater for agricultural workers, given the physical nature of their work and the time spent outdoors.

[8] https://iopscience.iop.org/article/10.1088/1748-9326/aab63b/pdf

[9] 1c of which has already occurred.

[10] Wheat, maize, soy and rice, of which maize, soy and rice are widely grown in Asia.

As we saw in chapter 1 though, it is not only average climate conditions which are changing – the climate is also becoming more volatile. Prolonged periods of extreme temperatures (outside the normal growing conditions for crops, for example) can be expected to impact yields even if periods above normal temperatures are offset in average terms by periods below. Likewise, periods of intense precipitation which cause crops to become waterlogged or block key transport routes. Extreme weather patterns will become more frequent (Figure 5), meaning not only weaker yields and more stressed workers, but also the greater likelihood of major weather events with shock impacts to prices.

Set against these impacts from *physical climate risk* though, are the *transition costs* that would need to be borne by business and consumers if a successful transition is to be made towards net zero. For example, the IEA estimates that global investment in renewable energy needs to triple by 2030, reaching $4trn per annum, if the world is to achieve net zero by 2050. This investment will ultimately need to be funded by either governments (and ultimately taxpayers), or through increased business and household energy costs.

To understand the impact of these various factors on food prices, we undertook a bespoke econometric estimation for producer food prices in our five economies. This included a range of standard drivers of food production costs, including the cost of agricultural commodities, fuel and electricity prices, labour and other non-labour costs, and exchange rates. Additionally, though, we incorporated a range of climate terms into our analysis, which help us understand the impact of longer-term climate change and the impact of increasing volatility. More detail on our methodology is presented in Box 1, and the key insights from our analysis and their implications for prices are set out in the final section of this chapter.

2.3 CLIMATE CHANGE AND FOOD BILLS IN SOUTHEAST ASIA

Our long-run equations find some common themes across four of the five countries in our study[11], but also key variations in the relative size of impacts. In all our countries, the cost of labour, energy, and other manufacturing costs plays an important role in determining the long-term trend in producer food prices. For example, our analysis finds that over the long-run, a 1% increase in the cost of electricity in Indonesia increases producer prices by 0.44%, but for Malaysia and Thailand the broader producer price index is a more reliable guide to food production costs: a 1% increase in the whole economy producer price index increases food costs by 0.16% and 0.52% respectively. Labour costs are also key drivers of food production costs in the long term, passing through to producer prices for food with a coefficient varying between 0.2-1 across the four economies we estimated equations for.

In our long-run equations we also tested the significance of climate conditions – specifically the rolling four quarter average of temperature, and the same metric

[11] Estimating a reliable econometric equation was not possible for Philippines owing to a lack of a Producer Price Index for Food with a suitable length of time series. Efforts were made to estimate a relationship using the Wholesale Price Index, which has a time series beginning in 1990, but the results were not satisfactory. It seems unlikely though that food production costs in the Philippines are not impacted by climate change in a similar manner to other economies in the Southeast Asia region.

for rainfall. Including these variables in our equation allows us to assess the quantitative impacts of climate change to food production costs which we discussed in section 2.2. We find that in the long run a 1% increase in the average temperature in Vietnam and Thailand increases food producer prices by 2%, and in Indonesia by closer to 3%. Average temperatures in Thailand and Vietnam increased by around 5% over the 2011-2020 period, meaning climate effects added around 10% to food prices in these two economies over this decade. Producer prices for food rose by a total of around 20% over the decade in these two economies - so climate change has driven around half of all food price growth over the period. In Indonesia, the estimated climate coefficient for food prices is even greater, but temperature change through the past decade has been much more modest (just 1%), while our estimations do not find a significant role for temperature in Malaysia.

TABLE 1 - ECONOMETRIC DRIVERS OF FOOD PRODUCER PRICES

		IDN	MYS	THA	VNM
Short-run equation - impact on year on year growth	Lagged food price inflation				0.2**
	World food prices in local currency	0.2**			
	Manufacturing wage costs	0.31**		0.37	
	Producer price index (whole economy)	0.42	0.05	0.43*	1.04*
	Average earnings		0.15*		
	% change in temp OYA	0.74***		0.47*	0.5**
	% change in rain OYA		0.01		
	ECM term	-0.27***	-0.17*	-0.44*	-0.15#
	R^2	0.36	0.49	0.50	0.94
Long-run equation - impact in levels	World food prices in local currency	0.37*			
	Manufacturing wage costs		0.95*	0.56*	0.18***
	Electricity prices	0.44*			
	Producer price index (whole economy)		0.16***	0.52*	
	Average earnings	0.45*			
	Domestic fuels price				
	Goods import prices				0.86*
	Average temperature	2.82**	0.78	2.24*	1.89***
	Average rainfall		0.11**		
	R^2	0.98	0.93	0.87	0.96

* Variable significant at 1% probability
**Variable significant at 5% probability
***Variable significant at 10% probability
\# Coefficient imposed

The impact of climate change to food prices in a long-term fundamental sense is clearly a particular concern for Thailand and Vietnam. But as we explored in section 1.2, climate conditions across the region have become more volatile. Our short-term equation allows us to test the role of climate volatility in driving short-term changes in food prices, specifically the relationship between changes in climate conditions versus a year ago and the rate of producer food price inflation. We find that changes in temperature feed through to food price inflation with a coefficient of 0.5-0.7 across Vietnam, Thailand, and Indonesia, while in Malaysia changes in rainfall versus a year ago feed through to food price inflation with a coefficient of 0.1.

Box 1: Using an error-correction mechanism to model the impact of climate on food prices

Our econometric estimation of the drivers of producer prices for food products uses an error-correction model (ECM). An ECM consists of a long-term relationship in levels (which determines where the dependent variable heads in a "fundamental" sense) and a short-term relationship which plots the dependent variable's response to shocks, and the path back to the long-run trend.

In the long run, the cost of producing food is clearly related to the price of various inputs to the production process, including agricultural commodities, energy and transportation, and labour. As these costs rise in the long-term, food manufacturers need to increase prices to remain financially viable.

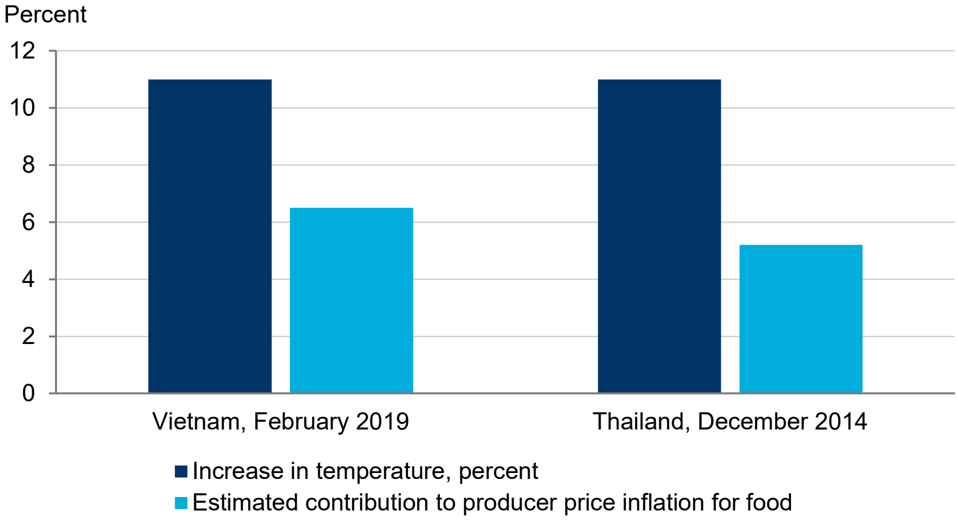
In the short-term, prices charged by food producers may deviate from this long run relationship. For example, if input costs increase, producers might temporarily try to absorb them via lower profit margins to avoid losing market share. Alternatively, if input costs fall, producers may avoid passing on the savings to customers, choosing to build profits instead.

But in either situation the producer's response is only temporary. Producers need a stable profit margin to gather funding for future investment, as well as pay dividends to shareholders. So a lower profit margin cannot be a permanent solution. And in a competitive market, producers will not be able to keep profit margins higher indefinitely, as competitors will seek to undercut prices and take market share. Prices will revert towards the level consistent with the long-run relationship.

The ECM captures this dynamic by using the deviation in prices from the long-run trend as an input to the price inflation equation. The coefficient on the ECM term shows how much of the difference is narrowed each period – e.g., a coefficient of -0.5 indicates that if prices are 10% below where they should be on a fundamental basis, they will rise by 5% in the next period.

These are serious and unpredictable impacts on food price inflation during periods of extreme weather. For example, in Thailand the monthly average temperature spiked 11% higher in December 2014 compared to the previous December. According to our estimates, this would have contributed 5.2 percentage points to producer price inflation for food in December 2014. In Vietnam, we estimate the 11% increase in temperatures during February 2019 versus a year earlier would have contributed 6.5 percentage points to producer price inflation for food in this period. In Malaysia, where rainfall was 102% higher in January 2009 than it was a year earlier, we estimate this contributed to a spike of 3 percentage points in producer price inflation for food.

FIGURE 11 – ESTIMATED IMPACTS OF EXTREME HEAT EVENTS IN VIETNAM AND THAILAND



Source: Oxford Economics\Haver Analytics

2.4 THE COSTS OF CLIMATE TRANSITION

The impact from climate change to food prices in long-term levels and in driving inflationary shocks is clear. And episodes of food price stress will become more frequent in the coming decades as periods of extreme weather occur more often - especially in higher-warming scenarios (Figure 5). Stabler food prices are therefore just one incentive for governments in the region to do their part in the global transition towards net zero.

But there will be major costs to this transition – particularly in the cost of energy, where consumers will be expected to bear the cost of emitting carbon (via a carbon tax), or the cost of making the transition to a lower or zero carbon energy source. This will directly impact on food producers through higher electricity bills. But energy is a key input across the manufacturing sector, so the energy transition will also impact on the cost of just about all the manufactured inputs food producers use to create food products. The same is true for all the logistics services food producers use – warehouses will need to be refrigerated using cleaner electricity and transport firms will need to invest in electric fleets to cut vehicle emissions. The cost of producing and transporting just about everything will become more expensive during the energy transition. And this will also transmit to labour costs – workers will demand higher wages to keep up with the increased cost of living.

Food producers can therefore expect substantial additional cost pressures from a successful transition to net zero. In Table 2 we use scenario projections from Oxford Economics' *Global Climate Service* (GCS) to illustrate the scale of these cost increases in Indonesia over the coming three decades[12]. We find that shifting from our baseline (which assumes Indonesia's government successfully implement their *currently stated* policies, consistent with global warming of 2c by 2050) to being consistent with net zero will increase electricity costs by over 100%, within the next decade. Global commodity prices for food will also rise substantially, as the cost of energy used in agriculture worldwide also increases, and there is a 10% increase in wage costs by 2030, rising to 30% by 2050.

Overall, we estimate producer prices for food in Indonesia could be as much as around 80% higher in a scenario where both Indonesia and the world have successfully transitioned to net zero by 2050, than in a scenario where only currently stated policies are implemented, and no policies have been taken to mitigate the impact to food producers.

TABLE 2 – THE COST IMPACT OF A SUCCESFUL TRANSITION

Indonesia: Drivers of Producer Food Prices, % differences, Net Zero compared to Baseline (Stated Policies)				
	LR equation coefficient	**2030**	**2040**	**2050**
Producer prices for electricity	0.44	110	134	117
World food commodity prices in local currency	0.37	16	35	47
Average earnings	0.45	9	22	30
Average temperature	2.82	0	-1	-1
Total impact to producer prices for food		**58**	**79**	**80**
Comparators				
Consumer prices index		12	26	33
Average nominal earnings		9	22	30

Source: Oxford Economics Global Climate Service

2.5 SETTING EXPECTATIONS AND POLICY

As we explored in section 2.2, much of the research undertaken into the impact of climate change to food costs has focussed on the impact from climate conditions to agricultural production, with a broad consensus emerging that rising temperatures negatively impact yields. It might therefore be understandable if policymakers anticipated that food prices would be lower in a lower-warming world. But this overlooks the costs of achieving that transition, which will be significant.

Stakeholders across the food supply chain (including farmers, producers, distributors, consumers, and government) should therefore set their expectations for substantial increases in food costs as part of the transition to net zero. But the benefits of this transition should also be appreciated – fewer occasions where prices surge unpredictably because of climate volatility, with potentially painful social costs.

Nevertheless, these spikes will still occur with greater frequency than in the past, even in a net zero world. In the final chapter we examine some of the policies governments might consider to mitigate the impacts of climate change on food

[12] Our GCS currently covers eight Asian economies, but only Indonesia out of our five countries. Future editions of GCS will broaden country coverage to Malaysia, Philippines, Thailand, and Vietnam.

prices in the near term, and help the sector make a lower-cost transition towards a net zero world.

3. HOW CAN GOVERNMENTS RESPOND?

KEY INSIGHTS

- To mitigate the impact of climate change and transition efforts to food prices, policymakers should focus on two key priority areas in the coming years.
    - **Firstly, measures to lower producers and consumers exposure to weather volatility in the years ahead**. This can be done by prioritising the poorest in welfare spending and improving monitoring and assessment of food prices so a rapid response to support consumer incomes is possible. Reprioritising public spending on farms and agriculture would also help, if more funds were diverted to supporting farmers to adopt technologies that improve resilience to extreme weather. And more can be done to support the adoption of agricultural insurance, which can help farmers restart production faster after losses, containing the impact of weather events on supply.
    - **Secondly, to work to ease the costs of transition for the sector**. Tackling energy use in the sector (including through microgeneration and food waste-to-energy) would help lower the pass through from higher electricity costs to producer prices. Likewise, efforts to improve labour productivity in the sector – including by removing barriers to inward foreign investment– would help slow the pass through from rising wage costs to food prices. And finally, further liberalising trade in agriculture and food around the region would boost investment in the sector and drive competition – both of which should keep prices lower. RCEP provides a step in the right direction, but much more potential remains.

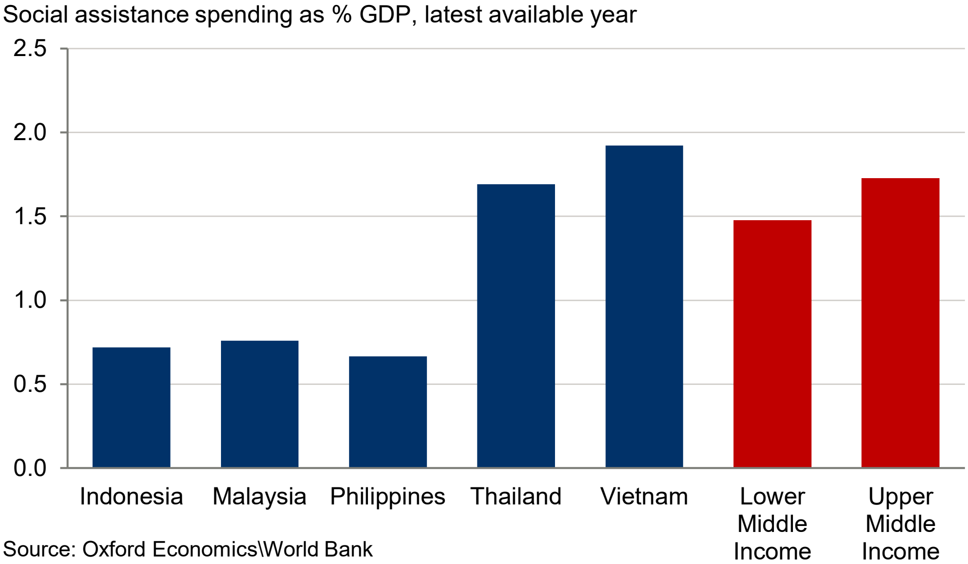
3.1 INTRODUCTION

We see key priority areas for policymakers regarding the impact of climate change and climate transition to food prices in the years ahead. Firstly, because we know that climate volatility will continue to worsen regardless of which global climate outcome is achieved (Figure 5), governments should examine ways to mitigate the impact of climate volatility on producers and consumers. Second, because achieving the transition to net zero is non-negotiable, governments should explore how the food sector can be supported to make the transition at lower cost.

3.2 PRIORITY 1: MITIGATING PHYSICAL RISK IMPACTS

Protecting vulnerable consumers – with food accounting for over half of the poorest households' total spend, it is critical that governments put in place effective rapid responses to spikes in food prices. This might require more resources to be allocated to social assistance. Indonesia, Malaysia, and Philippines spend only half as much of their GDP on social assistance for the poor as other lower and upper middle-income economies. Raising the share of national income spent on social assistance to levels comparable to other emerging economies would open a valuable source of flexible funding to help the poorest households during periods of extreme weather and food price volatility. Thailand and Vietnam spend more in line with peer economies, but a large portion (0.4% of GDP and 0.7% of GDP respectively) is accounted for by public sector pensions. In Vietnam, these are largely to be benefit of higher-income workers who worked in the formal economy, rather than those most in need of assistance.

FIGURE 12 – SOCIAL ASSISTANCE SPENDING IN MIDDLE-INCOME ECONOMIES



Source: Oxford Economics\World Bank

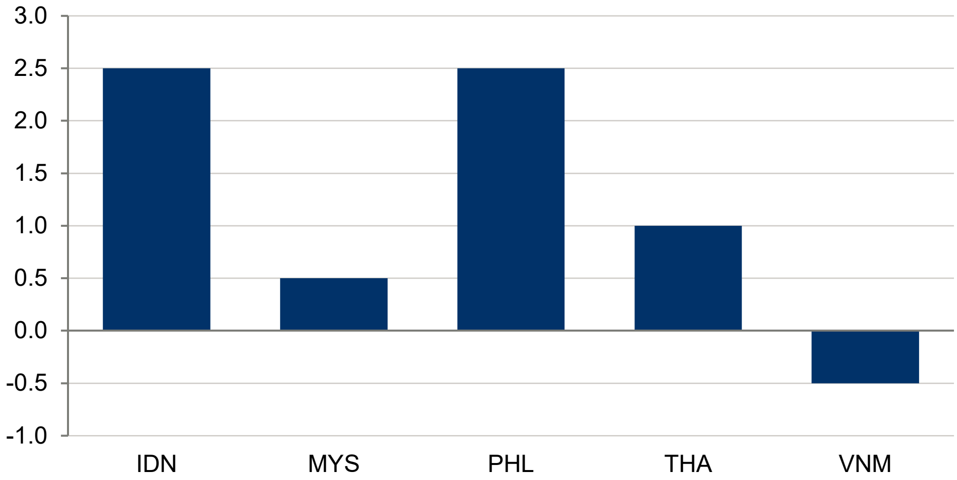
Two key proposals from the Asian Development Bank's study on food security in the Asia-Pacific region are relevant here[13]. Firstly, to improve governments' ability to monitor food prices in real time and with greater local detail. And second, to respond swiftly with cash transfer programmes or food-in-kind policies to alleviate the impact of price spikes on the very poorest households.

Improving the efficiency of agricultural support. In Indonesia and the Philippines, the government spends around 2.5% of GDP on support for the agricultural sector, substantially more than other countries in the region (Figure 13). There is substantial scope to reorient this spend towards areas which will help farms become more resilient to physical climate risk.

[13] https://reliefweb.int/sites/reliefweb.int/files/resources/food-security-asia-pacific.pdf

FIGURE 13 - GOVERNMENT SUPPORT FOR AGRICULTURE

Percent of GDP spent on agricultural support, latest available year



Source: Oxford Economics\OECD\FAO

In Philippines, one key agricultural policy objective is currently to support rice farmers' incomes by buying stocks for stockpiling at guaranteed prices – over US$ 700m was spent on rice support in 2019. But the OECD finds this policy has inhibited the farm sector from diversifying and moving up the food value chain, as well as artificially inflating rice prices and contributing to under-nourishment amongst low-income households[14]. More generally, research into stockpiling around Asia[15] finds several problems with using stockpiling as a means of sheltering consumers from price hikes. These include; the temptation for government to use the programme to boost farmers income in pre-election years, fiscal costs of the programmes at anything between 0.5-2% of GDP (operating the stockpile alone accounting for 50% of the cost), and the damage to private sector activity and investment from additional volatility in farm output prices due to unpredictable government interventions.

Reorienting this spend towards measures which help protect farms from physical risk would support farm incomes in a more sustainable manner. The International Food Policy Research Institute[16] proposes several potential priority areas for funding to help tackle physical climate risk, including selective investment in irrigation expansion, greater investment in research and development, and support for real-time weather information for farmers.

In Indonesia around a third of the total agriculture budget is spent on subsidizing fertiliser production and sales – US$2.6bn was spent in 2019. But this has resulted in excess use, and the widespread use of fertilisers which are not tailored to local conditions[17]. The OECD proposes deploying some of this funding to support capital investment (including in areas such as climate resilient crops

[14] https://www.oecd-ilibrary.org/sites/2cb7b858-en/index.html?itemId=/content/component/2cb7b858-en

[15] https://www.files.ethz.ch/isn/191682/PB150603_Public-Stockpiling.pdf

[16] https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/130837/filename/131048.pdf

[17] https://www.oecd-ilibrary.org/sites/9e2cf2f4-en/index.html?itemId=/content/component/9e2cf2f4-en

and irrigation solutions) as means of equipping Indonesian farmers to better-deal with climate volatility.

Supporting the uptake of farm insurance. The Asian Development Bank finds that "insurance has been widely recognised as an important tool for climate change adaptation"[18]. Farmers who are swiftly compensated for the failure or loss of crops can restart production faster, as well as invest in technologies that mitigate the risk of future failures. But as of 2021, only Philippines, Thailand and Vietnam had official national schemes for crop insurance in place[19]. Moreover, in both Philippines and Vietnam participation in the scheme is voluntary, leading to adverse selection (i.e., only farmers who know themselves to be at high risk participate). Expanding the coverage of farm insurance, as well as potentially linking coverage to investment in climate resilient technology, could provide a useful guard against physical climate risk to food prices in the coming years.

3.3 PRIORITY 2: EASING THE TRANSITION TO NET ZERO

Addressing energy use in food manufacturing. The energy-intensive nature of food manufacturing means the sector is especially exposed to more expensive energy as part of the transition to net zero. But governments can work to tackle energy use in the sector, weakening the pass through from energy costs food prices. In Vietnam for example, the UN proposes the roll-out of energy audits[20] to help manufacturers identify potential energy savings. And microgeneration also has a key potential role – National University of Singapore is exploring the potential for food waste to be a source of electricity[21]. Given the inevitable food waste that occurs through the food manufacturing process, this could be a particularly valuable opportunity for the sector to reduce its exposure to rising energy costs.

Enhancing productivity in the sector through greater investment: Our analysis found a central role for wage costs in the food manufacturing sector, so the sector's costs will be impacted by the generalised increase in wage demands during a net zero transition. But this can be eased by efforts to improve labour productivity in the sector. Like all manufacturing sectors, food manufacturing has the potential for productivity gains from additional capital investment. This is particularly the case when open to greater foreign direct investment (FDI), where technology and additional management know-how are also transferred. Governments (especially in those countries which lag the furthest behind regional leader Vietnam, Figure 14) should examine whether more can be done to support investment in the sector, and whether current FDI laws inhibit investment into the sector. Unleashing the potential of FDI in the sector in Asia could have a substantial impact on the sector's potential - a study of global value chains in agri-food by the OECD[22] found "evidence of a positive and significant

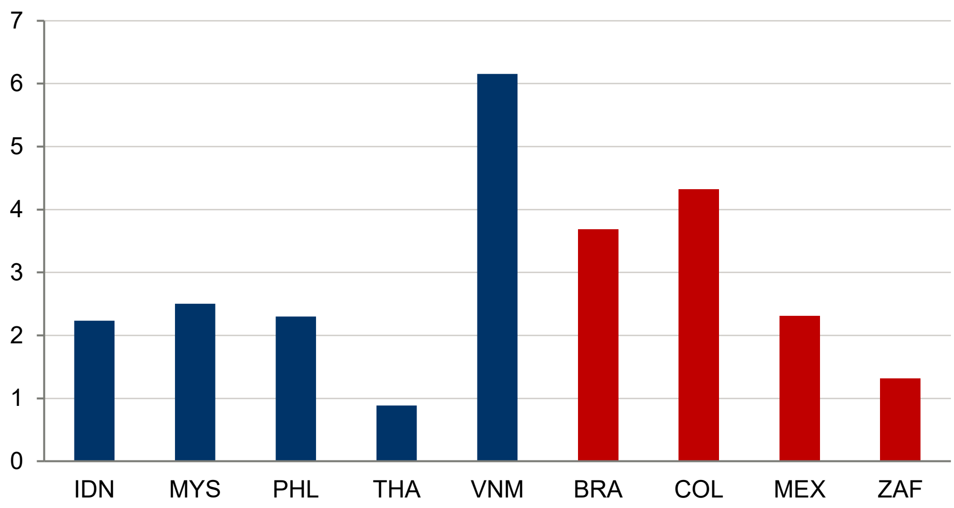
[18] https://www.adb.org/sites/default/files/institutional-document/731791/adou2021bp-climate-change-agri-insurance-asia-pacific.pdf
[19] https://www.adb.org/sites/default/files/publication/726556/ado2021-update-theme-chapter.pdf
[20] https://www.weadapt.org/sites/weadapt.org/files/legacy-new/placemarks/files/53062259aef78c937491c128df8bac1257680004b3188-full-report.pdf
[21] https://news.nus.edu.sg/nus-researchers-lead-effort-to-turn-food-scraps-into-green-energy-resource/
[22] https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=TAD/TC/CA/WP(2019)2/FINAL&docLanguage=En

link between FDI and indicators of participation and domestic value-added creation in agro-food GVCs".

For example, in Indonesia any foreign investor in the wholesale distribution of food is currently under an obligation to cooperate with at least 100 Indonesian SMEs suppliers and/or retailers yearly, along with providing training and development. These types of barriers seem to be harming, rather than supporting, the development of the wholesale food sector. The OECD found in its 2020 review of Indonesia's investment climate that "FDI restrictions … might deter GVC integration and development by hampering the development of competitive services and downstream manufacturing activities"[23]. If governments' priorities are in ensuring a modern, efficient, and responsive food supply, they should look again at restrictions which make it less attractive for leading foreign food manufacturers to invest in their economies.

FIGURE 14 – INBOUND FDI STOCKS ACROSS MIDDLE INCOME ECONOMIES

Inward FDI stock as % GDP, 2019



Source: Oxford Economics\World Bank

Opening to trade. In our previous work with the FIA[24] we explored the evidence on how trade liberalisation can lead to lower and more stable food prices. Extreme weather events can be highly-localised – so the ability to source from alternative suppliers can help offset interruptions to local supply. A range of studies published by the Asian Development Bank[25] make several key findings about the costs of barriers to trade in food, and the potential gains to future liberalisation. In an assessment of "food security" policies and their impact on food supply and price volatility ADB authors found that measures aimed to diversify supply sources reduced vulnerability to shocks.

[23] https://www.oecd-ilibrary.org/sites/70aed0d7-en/index.html?itemId=/content/component/70aed0d7-en
[24] *Mapping Asia's Food Trade, and the Impact of COVID-19*, Oxford Economics and FIA, July 2020
[25] *Bilateral Trade and Food Security*, Asian Development Bank Economics Working Paper, September 2013.

Complementing this conclusion, a 2017 study found that expanding the current ASEAN free trade area to incorporate China, India, Japan, Korea, New Zealand, and Australia would result in an increase in agricultural output in “ASEAN 6” countries of one-sixth, thanks to the comparative advantage ASEAN economies have in land-intensive sectors vis-à-vis more densely population East and South Asian economies. Expanding the capacity of the food sector across the region would also provide additional future sources of supply to offset localised disruptions. The agreement of RCEP is a positive step in the right direction, but many sectors remain protected, meaning there remains plenty of potential for further gains from trade.

4. CONCLUSION: A CALL TO ACTION

There is no escaping the need to transition Southeast Asian economies towards net zero as part of the global effort to limit climate change in the coming years. The five countries in our study account for over 7% of the world's population, and as emerging economies we can expect rising prosperity in each of the five to result in greater demand for energy-intensive goods and services. But if Indonesia, Malaysia, Philippines, Thailand, and Vietnam are to continue to enjoy the benefits of economic development, they will need to do so in less carbon-intensive ways than countries which have moved up the income ladder before them.

We know this will entail substantial additional costs across the manufacturing sector though, raising the cost of everything that is produced and consumed in these economies. This is an unavoidable consequence of the need to invest in new clean energy sources, as well as other areas of infrastructure and technology to make production and consumption more sustainable. At the same time, consumers will face increasing food price volatility as weather conditions become more unpredictable however much ambition governments show in achieving a transition over the decades ahead.

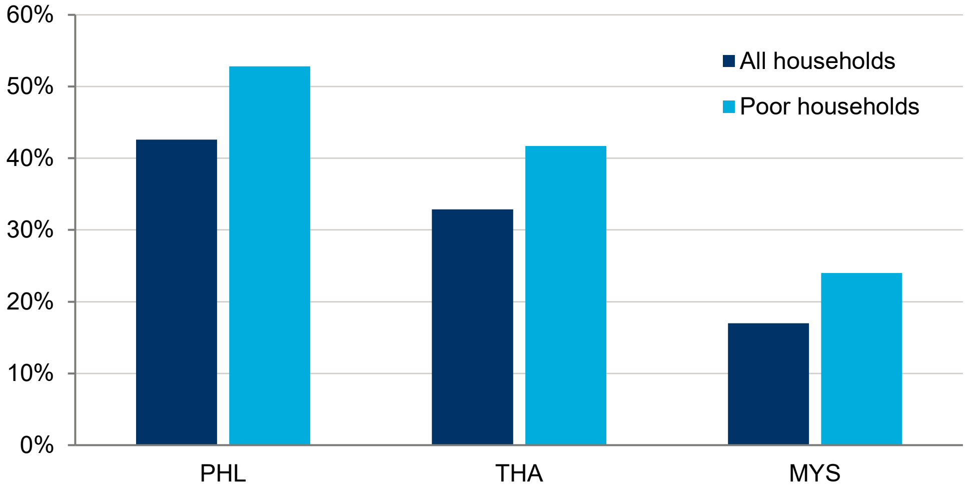
But there is a lot that can be done to protect consumers from volatility and help lower the cost of transition for a sector that generated 127 million jobs across four economies in 2019[26]. We have set out two priority policy areas, and three specific policy options in each, which can help protect households from price volatility in the coming years and ease the cost of transition in the medium term. The challenge is urgent, given the portion of households' income which is spent on food in the region (especially the poorest households, see Figure 15) and the impact that extreme climate outcomes are found to be having on food production costs in recent years.

We call on governments across the region to engage with the food industry, and collaboratively set out a strategy to deal with these twin challenges in the coming years. We acknowledge that policy options additional to those we have set out will also be relevant, and that the challenges and appropriate responses will be different in each of the five economies we have analysed. But we look forward to using our analysis - in this paper and in future work - to instigate and inform dialogue between government and industry on how to keep food affordable during the climate transition.

[26] https://www.oxfordeconomics.com/recent-releases/The-Economic-Impact-of-the-Agri-Food-Sector-in-Southeast-Asia

FIGURE 15 – SHARE OF HOUSEHOLD EXPENDITURE ACCOUNTED FOR BY FOOD

Percent of total household expenditure accounted for by food



Source: Oxford Economics\National statistics agencies

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