Climate impacts on food security and livelihoods in Asia

A review of existing knowledge

WFP Bangladesh
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Contents

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This primer aims to provide a summary of the available evidence of climate impacts on food security and livelihoods in Asia. The material has been collected from several sources, both peer-reviewed and not, and are acknowledged throughout the document.

The views expressed in this primer are solely those of the authors' and do not represent the views of the organizations involved.

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Introduction

There is agreement in the scientific community that the global food system will experience unprecedented pressure in the coming decades – demographic changes, urban growth, environmental degradation, increasing disaster risk, food price volatility, and climate change will all affect food security patterns.

Climate change can act as a hunger risk multiplier, exacerbating drivers of food insecurity. Climate change disproportionately affects the poorest and most food insecure through a combination of decreasing crop production, and changes in the frequency and intensity of climate-related hazards, all of which can result in more humanitarian and food security crises.

Climate change affects the different dimensions of food security in complex ways. The **availability** of food can be affected through variations in yields – especially in key producing areas – due to increasing temperatures as well as changes in the quantity of arable land and water available for agriculture. Changes in production, in turn, can affect the ability of households to **access** food and as such impact on dietary diversity. Moreover, changes in rainfall and temperature patterns directly impact livelihoods that depend on climate-sensitive activities, such as rain-fed agriculture and livestock rearing. Changes in the timing and availability of water may create sanitation problems and impact quality of available drinking water, leading to increased health concerns, including diarrheal diseases. Together with other vector-borne infections, it has the potential to increase malnutrition, and affect food **utilization**.

Extreme weather effects disrupt the **stability** of food supply as well as people's livelihoods.

Understanding the specific impacts of climate change on food security is challenging because vulnerabilities are highly contextual and are unevenly spread across the world. Ultimately, these vulnerabilities also depend on the ability of households, communities, and countries to manage risks. Under climate change, some regions of the world may experience gains in terms of food security outcomes, but the poorest and more isolated parts of the world tend to be more adversely affected in the absence of adaptation efforts.

The Asian continent is particularly vulnerable to climate change due to a combination of: high reliance on climate-sensitive livelihoods, high incidence of poverty and food insecurity, and high population densities in vulnerable and areas highly exposed to climate-related hazards such as floods, cyclones and droughts, and long-term climate change such as gradual changes in monsoon patterns, glacier melt and sea-level rise.

The purpose of this primer is to review the current state of knowledge on the relationship between climate change and food security, focusing specifically on the Asian context, to provide an evidence base for discussion and further analysis.

Myanmar
WFP Photo Library

Asia is a diverse continent

Asia is a highly diverse continent, with a complex geography, economy, and demographic and political characteristics. This complexity is also reflected in the differences in food security vulnerabilities across countries: countries like Japan, Malaysia, and Singapore have very low rates of food insecurity while countries like Afghanistan, the Democratic People's Republic of Korea, and Nepal have some of the highest rates of food insecurity – regionally and globally (FAO/IFAD/WFP, 2014).

A.
Laos
WFP Photo Library

The Asian continent has extremely diverse geographic features and climates. Asia has some of the highest peaks in the world (in the Himalayan range) as well as several low-lying coastal areas and islands. This also influences the differences in climate: very dry desert to wet and humid tropical regions, and hot and warm continental climates to cold polar and mountainous regions.

Some of the key river basins in the continent include the Ganges-Brahmaputra Basin, the Yangtze River Basin, and the Mekong River Basin – all of those are an important source of water and livelihoods in the region.

Asia currently hosts approximately 4 billion people, roughly 60% of the world's population. The region has some of the densest parts of the world, and hosts most of the world's largest mega-cities: Tokyo, Delhi, Seoul, Shanghai, Mumbai, Beijing, Osaka, Jakarta, Manila, Bangkok, and Dhaka. Many of these cities are located in coastal areas. Similarly, there are regions with very low population densities – particularly in the remote areas of Nepal, the Tibetan Plateau, Afghanistan, and western China.

The complexity of the continent is also reflected in the diversity of development levels: while some Asian economies rank among the most developed according to the Human Development Index (Japan, Singapore, the Republic of Korea, Brunei) others rank towards the bottom of the index (Timor-Leste, Nepal, Bangladesh) (UNDP, 2014).

Generally, South Asian countries have lower levels of development: Afghanistan, Pakistan, and Nepal all rank as countries with low development. India is the largest and fastest growing economy in the region, accounting for over 80% of the region's economy, and is therefore one of the key regional players.

Apart from Myanmar, most of the countries in Southeast Asia enjoy medium to high levels of development. In part, this has been the result of close links to European and Chinese markets, as well as rapid development in the 1970s and 1980s. The region's economy largely depends on agriculture, with rice, palm oil, and rubber being prominent exports, as well as manufacturing in the more industrialised countries.

East Asia has one of the most successful regional economies, including some of the largest and most prosperous economies at the global level such as China, Japan, and the Republic of Korea. A combination of natural resources, availability of labour, favourable political-legal environments, and integration of markets both regionally and globally have facilitated rapid economic development.

The continent is also rapidly developing: in the late 1970s the economy of Japan was larger than all of Asia's economic output combined, but several economies have developed since with China overtaking Japan as the largest economy in Asia, and some additional countries such as India projected to surpass Japan's gross domestic product by 2020 (UNDP, 2014).

These changing economic circumstances provide a background for understanding how countries remain vulnerable to food security and climate change challenges.

The region is also undergoing further rapid changes through urbanization and population growth, and environmental change. Some of the highest urbanization rates are in Asia, leading to large projections of urban population growth, especially in the Indian sub-continent. Asia is also experiencing rapid deforestation, fuelled by economic incentives, which are leading to a rapid transformation of the landscape and livelihoods of the continent. Against this background, the food security profile is likely to change dramatically over the coming years.

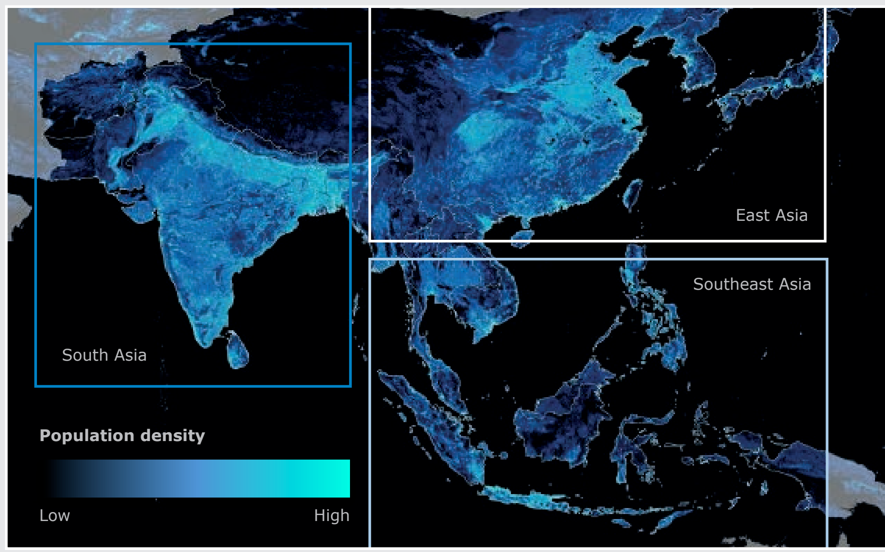
The regions of Asia

For the purposes of this primer, Asia refers to countries in South Asia, Southeast Asia, and East Asia as shown here.

South Asia, comprising of Afghanistan, Pakistan, Nepal, Bhutan, Bangladesh, India, Sri Lanka, and the Maldives, is home to over one fifth of the world's population – making it the most populous and most densely populated region of the world. South Asia has diverse geographical features ranging from glaciers, rainforests, valleys, deserts, and grasslands. The region is surrounded by three main water bodies, namely the Bay of Bengal, the Indian Ocean, and the Arabian Sea, all of which contribute to the varied climate zones experienced in the continent. The main rivers in the region include the Indus River and the Ganges which provide water for agriculture, fisheries, and industrial and domestic use. The climate of South Asia includes tropical monsoons in the south to temperate climates in the northern parts. In part, this is due to the complex topography of the continent but also due to proximity to three different water bodies. The southern part of the region is mostly hot and humid in the summer months (June-July-August-September) due to the monsoons. Cyclones generally coincide with the end of the summer months, forming between October and May, and bringing rainfall to parts of Southern India and Sri Lanka. The northern parts are cooler, especially in the mountainous regions which also receive snowfall.

Southeast Asia includes Myanmar, Thailand, Cambodia, Lao P.D.R., Vietnam, Malaysia, Singapore, Indonesia, Timor-Leste, Brunei Darussalam, and the Philippines. One of the key geographic features in continental Southeast Asia is the Mekong River, which influences the regional availability of water for consumption and use in agricultural activities. Geologically, this is one of the most volcanically active regions of the world – both the Malay and the Philippine archipelagos experience some of the highest seismic activity globally. The climate of this region is predominantly tropical, with plentiful rainfall, leading to abundant rainforests. The majority of the region experiences wet and dry seasons caused by monsoon shifts. Typhoons also bring rains as well as strong winds to the Philippines and parts of Vietnam; historically typhoons coincide with the monsoon season but in recent years more typhoons have been recorded outside of the monsoon period. The mountain areas in northern Myanmar and Vietnam are the only parts of this region which experience milder and drier climates.

Finally, East Asia consists of the People's Republic of China, Japan, Mongolia, the Democratic People's Republic of Korea, the Republic of Korea, Mongolia, and the Republic of China. The main water body is the Yangtze River which is becoming an economic hub for the sub-region. East Asia is home to over 1.5 billion people and it is one of the most populated places of the world. The climate is temperate, with cold winters and warm summers with most of the rainfall occurring during the summer months (June-July-August-September) as a result of the monsoons.



Food security in Asia is changing

Food security in Asia is highly diverse: some countries in the region experience some of the worst under-nutrition rates in the world, and others experience high obesity rates (FAO/IFAD/WFP, 2014).

The challenges of achieving food security are diverse. In the Far Western region of Nepal, because of the remoteness of some communities access to markets is a critical issue; in the Democratic People's Republic of Korea ensuring sufficient production while also maintaining dietary diversity is one of the key challenges; in Cambodia, meeting self-sufficiency while also satisfying increasing rice export demands compound the challenge of ensuring food security.

Food production

Rice is the key staple, providing around a third of energy to diets in Asia. Given the importance of rice, several countries are aiming to be self-sufficient in rice over the next few decades, and some are even aiming to become net exporters.

Wheat is also grown and consumed, particularly in China and Japan (primarily in noodle form) and in South Asia (as bread). Soybean and soybean products contribute to Asian diets, particularly in eastern and southeastern Asia. Other crops such as potato and barley are consumed in colder, mountainous climates. Diets are supplemented with vegetables and fruits. Recently, demand for meat has increased with pork, chicken and beef being preferred in eastern and southeastern Asia.

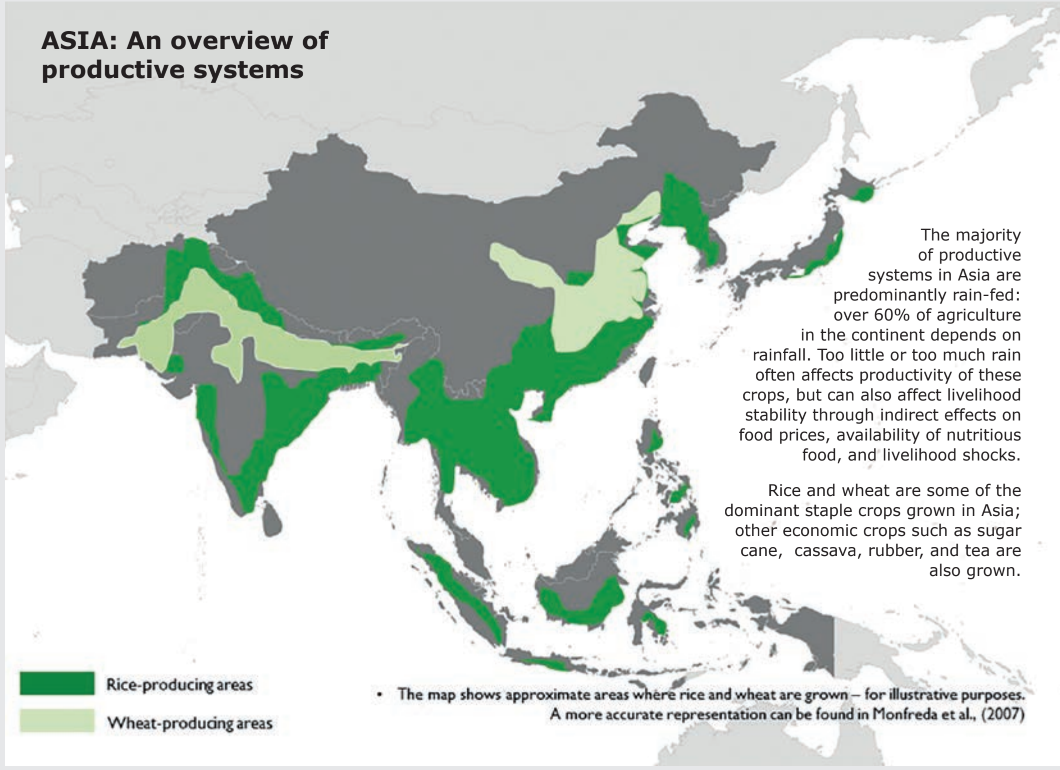
Food access

Poverty is often closely linked to food insecurity. Participatory assessments of poverty consistently identify the poor in terms of food availability—the rich are those who own land and can produce enough food to support the household for a full year, while the poor are landless labourers who rely almost exclusively on food purchases, food wages, or gifts (Gill et al., 2003).

Poverty is also linked to the types of livelihoods people engage in. Across Asia, livelihoods remain highly sensitive to climate, with several rural communities engaged in rain-fed subsistence farming. Rapid urbanization rates, especially in countries like China, India, the Philippines, and Indonesia have partly led to diversification in livelihood options with several households engaging in factory work or the service industry.

As Asian countries continue to develop so will livelihood options, allowing households to have higher incomes and therefore greater ability to purchase sufficient food. For example, in Cambodia, the expansion of urban areas near Phnom Penh has led to an increase in garment factories—which has helped rural households diversify their sources of income and increase their incomes.

A



Wheat is a key crop in the northern parts of South Asia and Eastern China

Rice is the main crop in Asia, contributing to the diets of most of the population

This map shows approximate where wheat and rice are grown – for illustrative purposes. A more accurate representation can be found in Mondfreda et al, (2007)

In India, the transition towards an increasingly service-based economy will also help poor households diversify their livelihoods. However, in the absence of equitable development, urbanization and other processes will not be sufficient to increase people's access to food.

Food utilisation

Malnutrition is a persistent challenge. Almost two thirds of the world's undernourished population live in Asia. This trend is the result of: widespread contamination of drinking water and poor sanitation which contribute to nutrient loss; lack of protein-efficient foods; and a wide range of beliefs, practices, and preferences.

While under-nutrition has historically been one of the key obstacles in promoting food security, in recent years obesity has increased. Changing lifestyles, owing to urbanization and higher demand for fast food, are responsible for the rapid rise in obesity rates. In China, preference for meat and oil in every meal, together with higher availability of kilo-calories have resulted in a more than twofold increase in overweight and obesity rates between 1991 (12.9%) and 2004 (27.3%) with obesity being more prominent in urban areas (Popkin, 2007). In India, too, obesity is more prominent in urban areas and slums, followed by rural settings (Yadav and Krishnan, 2008).

This trend is mirrored by other countries in the region such as the Philippines and Indonesia. In some of these countries, however, populations face both under-nutrition (in the form of low height-for-age) combined with over-nutrition (overweight or obesity). Therefore, tackling the problem of malnutrition requires addressing under-nutrition as well as the emerging challenges of overweight and obesity.

B

C

A. Laos
Ruangdech Poungprom

B. Democratic People's Republic of Korea
Michael Dunford

C. Afghanistan
Silke Buhr

Food security and livelihoods in Asia are sensitive to climate

The climate can affect food production

Evidence from across the continent suggests that increases in temperature have already had impacts on crop production, and in the absence of sufficient adaptation efforts, this trend is expected to continue under climate change.

Agricultural production is facing unprecedented challenges in the Asian continent: lower availability of natural resources such as land and water, environmental degradation, demographic pressures, and rapid urbanization, among others, all impact on agricultural production.

Agricultural systems are highly sensitive to climate given the high reliance on rain-fed production. Changes in rainfall patterns can increase the likelihood of crop failure and result in production declines. Higher temperatures in key producing areas typically result in reduced yields of desirable crops whilst extreme weather events such as droughts, floods, and storms can exacerbate food security problems.

In a changing climate, production gains are projected in some regions but the overall net effect on agricultural production is expected to be negative in Asia, particularly over the long term (cf. Lobell et al., 2011). The effect is expected to be especially significant in South Asia (Lal et al., 2011; Stefanski and Sivakumar, 2011): some estimates suggest that climate shifts will reduce production by up to 40 per cent, compared to current conditions, by the end of the century (Nelson et al., 2009).

Changes in the timing, frequency and intensity of precipitation can also have an impact on agricultural production – especially in vulnerable areas that are rain-fed. Changes in rainfall affects water quality and availability for agriculture, especially in a context of rapid population growth and urbanization. Over 60% of all agriculture in Asia is rain-fed and therefore remains highly sensitive to changes in rainfall patterns (IWMI, 2010; Krishnamurthy et al., 2013). Given this sensitivity, changing rainfall patterns are projected to impact on rice, a key staple in the region.

Based on projected rainfall and temperature changes, some studies suggest a potential future where South and Southeast Asia experience losses in suitability for bean production although parts of central India may be more suitable in the future (Yadav et al., 2011). Given that bean is an important source of vegetable protein in the region, reductions in its production could exacerbate malnutrition problems in the region. On the other hand, there may be potential increases in the suitability of cassava production in the northern parts of Southeast Asia. As cassava is mainly grown as an industrial crop in Southeast Asia, such changes may have significant economic impact. (Suitability for cassava is projected to decrease under climate change in northern India – however, cassava is not grown in these areas and therefore this is not a significant trend).

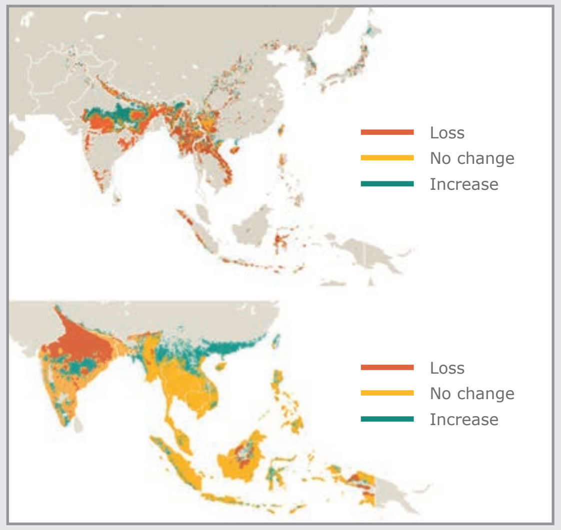
A similar study focusing on the Lower Mekong Basin identified similar potential changes in patterns of shifting crop suitability under climate change between current conditions and 2050: while some areas may become increasingly suitable for some crops, other areas will become less suitable (ICEM, 2013). Soybean may experience significant losses in suitability across most of the basin, especially in northern and eastern Cambodia, as well as parts of Lao PDR and Viet Nam. Industrial crops that are economically important such as rubber and coffee may experience losses in the southern parts of the basin, but potential increases in the northern highlands. Finally, rice production is expected to become more suitable across most of the basin, largely as a result of increased availability of rainfall and river flow. This is significant, as future climatic shifts may influence the profitability and feasibility of different livelihood systems.

A.
Democratic People's Republic of Korea
Krishna Krishnamurthy

Beyond impacts at the national level, lower crop production due to climate change can have detrimental effects on food security at regional and global scales. In exporting countries, particularly, lower food production in key producing regions of the world can drive food prices up, reducing the purchasing power of the poorest communities. For example, the 2010 Pakistan floods resulted in wheat losses of around half a million tonnes; simultaneous droughts in Russia and the Ukraine also resulted in wheat losses at the global level (USDA, 2010). Together with market speculation, this led to significant price increases globally.

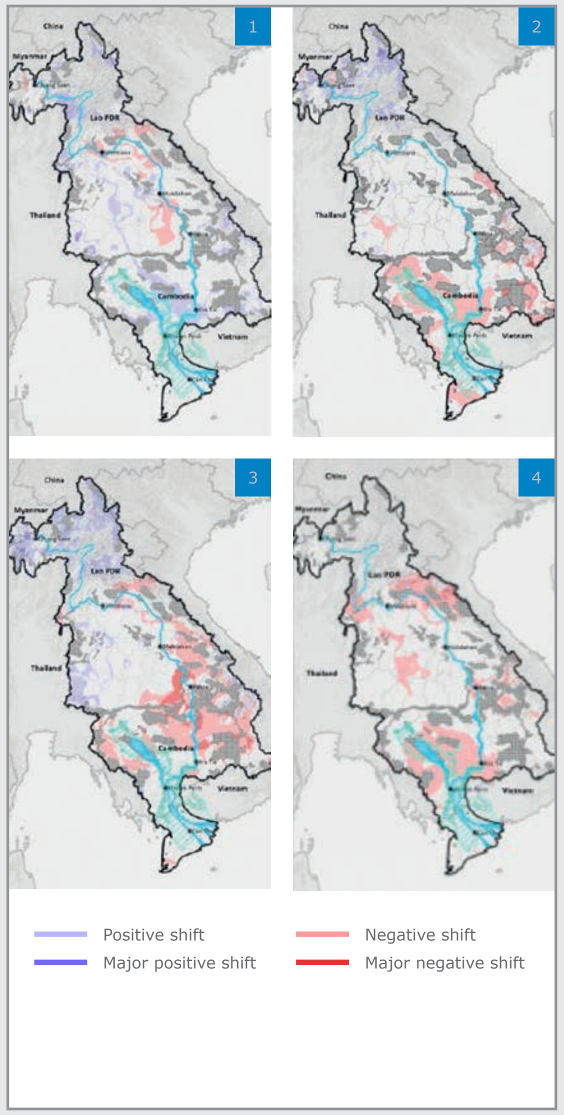
Crop and climate models based on historical data suggest that, for every degree Celsius increase in temperature, between 4 and 5 million tonnes of wheat are lost in South Asia (cf. Kumar et al., 2011). This is especially the case if increases in temperature coincide with key stages of crop development (Wollenweber et al., 2003). Recent evidence corroborates these findings. The 2002 drought in India was linked to a reduction of more than 15 percent in rice production—a loss of this relative size which had not been seen since the 1980s. More recently, in 2004, temperatures in the Indo-Gangetic Plains were higher by an average of 3-6 degrees Centigrade during the cropping season. This trend caused wheat to mature between 10 and 20 days earlier resultingin decreases in production of up to 4 million tonnes in the region (Aggarwal and Kumar, 2011).

While relationships between climate and agricultural production can be identified in broad geographical areas, the complex topography of Asia means that there are significant variations at the local level. For instance, an analysis of the historical link between climate variables (namely temperature, rainfall, wind speed, and humidity) and wheat production in Pakistan show that changing climatic conditions have improved wheat production in the Punjab and Sindh regions, but have also resulted in losses in Khyber Pakhtunkhwa and Balochistan (Khattak and Shabbir, 2012).



SUITABLITY OF BEAN

SUITABLITY OF CASSAVA



1.RICE
Suitability shift

2. COFFEE
Suitability shift

3. RUBBER
Suitability shift

4. SOYBEAN
Suitability shift Soya

Climate variability can impact food access and livelihoods

Variable weather patterns and extreme climate-related events could affect households' ability to access food through increases in food prices and impact on livelihood activities.

Climate also affects food access – that is, the ability of households to obtain sufficient quantities of nutritious food. The specific relationships between climate and food access are complex.

One of the most direct effects of climate on food access is through impacts on the feasibility of certain livelihoods. Changes in rainfall and temperature affect the suitability of certain areas for crop production thereby resulting in significant shifts in livelihoods (Yadav et al., 2011).

A


Another impact of climate is through changes in food prices through impacts on production of staple crops. Any rise in prices is especially detrimental for the poorest households. Some studies have attempted to quantify the potential impacts of rising temperatures on food prices at the global level (e.g. Fischer et al., 2002; Nelson et al., 2009). The studies suggest that food prices are expected to rise moderately in line with moderate increases of temperature – after 2050, however, food prices are expected to increase more rapidly as the level of climate change increases further. Quantifying the climate change impact on food prices is complex and results in a range of projected values; however, there is a clear signal for future changes in the climate to result in food price increases (Nelson et al., 2010; Hertel et al., 2010). Furthermore other socio and economic factors may reduce or exacerbate these impacts.

Rising prices will be especially detrimental for the poorest households who spend most of their income on food. For instance, in the westernmost mountainous regions of Nepal, households spend a significant proportion of their income on food during the winter months due to lower production in this period. Studies using remote sensing analysis suggest that the winter months have become more intense and longer between 1976 and 2005, with impacts on local agricultural production (Marahatta et al., 2009). Given that households purchase most of their food during these months, prolonged winters mean that households often spend additional income on food or even become indebted in order to afford food (Krishnamurthy et al., 2013).

Weather patterns can also affect rural incomes. Given that these incomes depend on activities that depend on reliable rainfall patterns such as farming and livestock rearing, climate variability could affect the income earning potential of rural households. Fluctuating yields and crop losses on a long-term and regular basis threatens small-holder farmers' household incomes, perpetuating a cycle of poverty and distress. With variable or low incomes, farmers have less disposable cash to spend on food and invest on their farms, and are therefore more vulnerable to shocks.

Climate extremes, too, can have a long-term impact on the ability of at-risk households to obtain food. The 2013 typhoon Haiyan in the Philippines illustrated the potential impacts of large-scale hazards on food access. In the immediate aftermath of the typhoon, the most affected households in coastal areas reported that they were unable to obtain food either because they had no disposable income, or because markets were destroyed, out of stock, or inaccessible (MIRA, 2013).

B


C


Climate trends can impact food utilization and nutrition

Climatic changes can affect nutrition through impacts on food security, care practices, and health. Although quantifying the effect of a changing climate on nutrition is difficult, recent evidence suggests that climate-induced crop and livestock failure, and climate extremes are associated with negative outcomes on nutrition.

The relationship between nutrition and climate is extremely complex. Directly, changing climate patterns can result in crop and livestock production failure and therefore affect calorie consumption, diet quantity, and diet diversity. Climate-related shocks also impact on dietary diversity and reduce overall food consumption with overall long-term detrimental effects on stunting (Silventoinen, 2003). Indirectly, a changing climate can exacerbate health concerns through changing disease patterns, as well as inadequate care practices due to livelihood pressures on mothers.

Climatic changes can impact on calorie consumption, diet quantity, and diet quality

In recent decades, crop or livestock failure resulting from temperature and precipitation changes has been associated with impacts on food availability and therefore on the ability of households to produce or purchase a diversified diet. For instance, evidence from Indonesia indicates that the death of animals due to erratic weather in the early part of the 21st century led to lower consumption of animal products and higher instances of iron deficiencies (UNICEF, 2011).

There is evidence that in a warmer climate, higher carbon dioxide concentrations are linked to decreased protein and mineral nutrient concentrations, as well as altered lipid composition, even if carbon fertilisation may lead to higher yields (daMatta et al., 2010). For rice, wheat, and barley, grain protein is projected to decrease by 10% to 15% under elevated carbon dioxide concentrations (Taub et al., 2008). Therefore, higher carbon dioxide concentrations have the potential to significantly reduce the nutritional value of crops.

Rising temperatures and carbon dioxide concentrations have been shown to increase aphid (Newman, 2004) and weevil larvae (Staley and Johnson, 2008) incidence. In addition, higher temperatures have been linked to reduced mortality of aphids and larger dispersions (Zhou et al., 1995) as well as higher incidence of potato blight in Bangladesh (Luck et al, 2011) – although at much higher temperatures above acceptable thresholds, pest incidence and aphid populations may decrease. Studies of crop behavior under different temperature scenarios suggest that higher temperatures or prolonged drought can reduce crop resistance to diseases (Gregory et al., 2009). Increases in pest incidence and disease outbreaks affect the nutritional content of crops and would increase the consumption needs of households.

High food prices also affect household decisions to purchase nutritious food items. Historically, food price increases in Asia have been associated with an increase in 10-20 per cent in maternal anemia incidence due to a lower intake of iron-rich foods. This trend results in increases in low birth weight, stunting, and wasting rates (Bhutta et al., 2009).

D


A. Pakistan WFP Photo Library

B. Afghanistan Silke Buhr

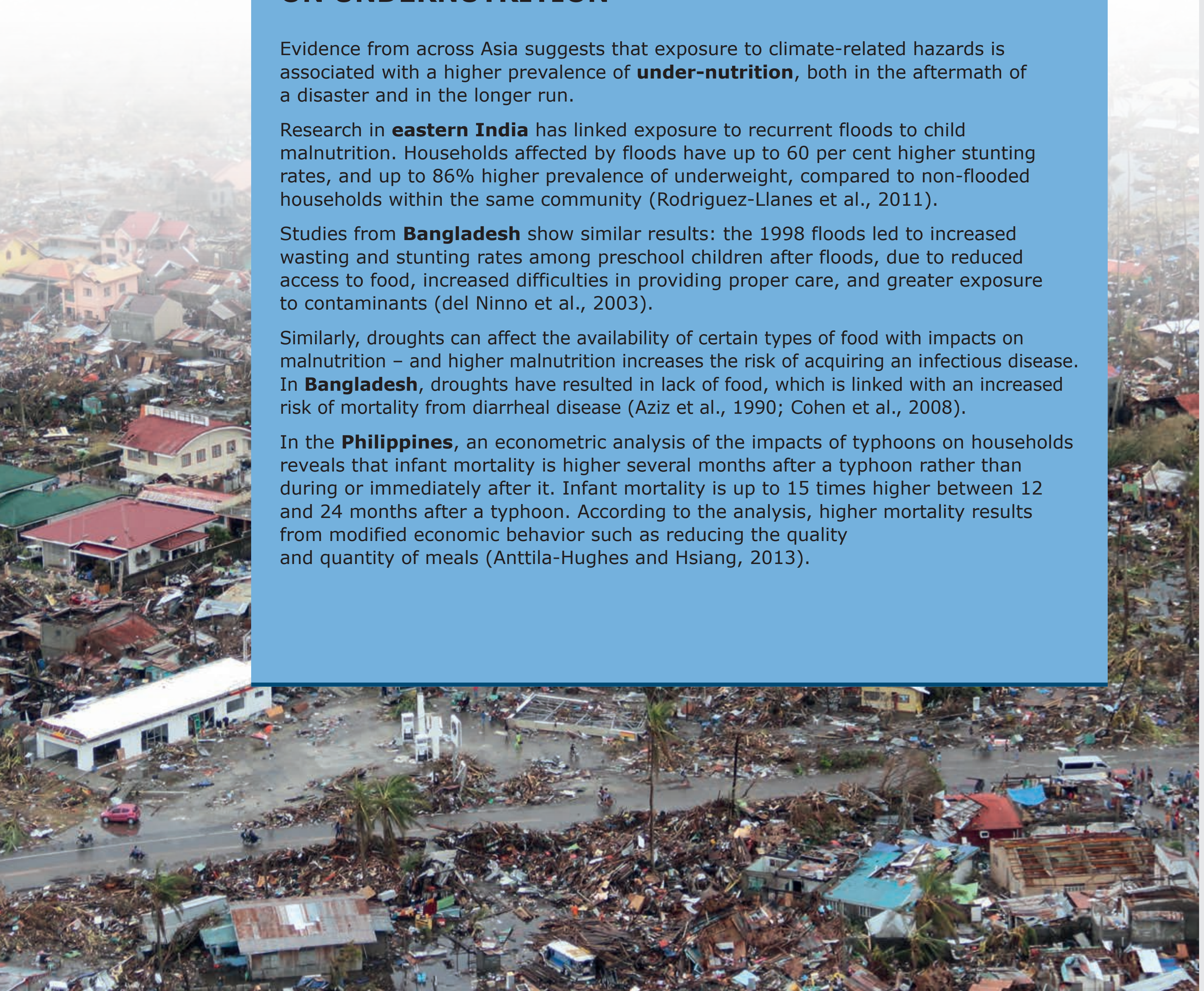
C. Afghanistan Hukomat Khan

D. Philippines Veejay Villafranca

The climate can impact health and care practices

Climate is also linked to health, both through changes in nutritional needs and through impacts on nutrient absorption. For example, higher temperatures can place additional stress on people who are affected by diseases – and nutritional requirements increase as a result (McMichael et al., 2006; also Patz et al., 2005). The climate affects sanitation systems, and water quality and availability.

Some studies have quantified the relationship between high temperatures and common forms of food poisoning: salmonellosis incidence, for example, increases lineally for each degree increase in temperature (D'Souza et al., 2004; Kovats et al., 2004). Similarly, increases in temperature have been associated with increased episodes of diarrhea in adults and children: several studies report a strong correlation between monthly temperature and diarrhea episodes (e.g. Singh et al., 2001). Diarrhea, acute respiratory infection, measles and meningitis are all major food security and nutrition-related diseases. These increase the nutritional needs of affected people while simultaneously reducing the absorption of nutrients and their utilization by the body. Increasingly poor health in a community also leads to a loss of labour productivity and a higher dependency ratio (Mao, 2009).



Philippines
Anthony Chase Lim

IMPACT OF CLIMATE-RELATED HAZARDS ON UNDERNUTRITION

Evidence from across Asia suggests that exposure to climate-related hazards is associated with a higher prevalence of **under-nutrition**, both in the aftermath of a disaster and in the longer run.

Research in **eastern India** has linked exposure to recurrent floods to child malnutrition. Households affected by floods have up to 60 per cent higher stunting rates, and up to 86% higher prevalence of underweight, compared to non-flooded households within the same community (Rodriguez-Llanes et al., 2011).

Studies from **Bangladesh** show similar results: the 1998 floods led to increased wasting and stunting rates among preschool children after floods, due to reduced access to food, increased difficulties in providing proper care, and greater exposure to contaminants (del Ninno et al., 2003).

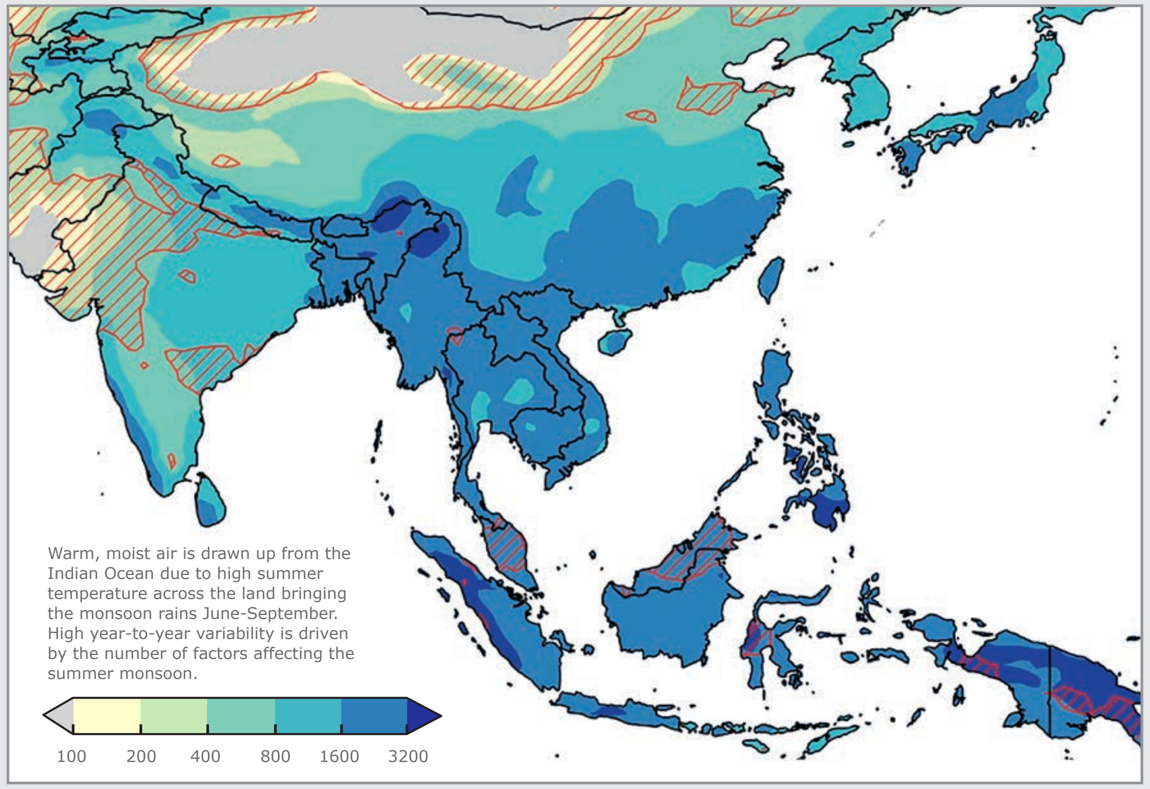
Similarly, droughts can affect the availability of certain types of food with impacts on malnutrition – and higher malnutrition increases the risk of acquiring an infectious disease. In **Bangladesh**, droughts have resulted in lack of food, which is linked with an increased risk of mortality from diarrheal disease (Aziz et al., 1990; Cohen et al., 2008).

In the **Philippines**, an econometric analysis of the impacts of typhoons on households reveals that infant mortality is higher several months after a typhoon rather than during or immediately after it. Infant mortality is up to 15 times higher between 12 and 24 months after a typhoon. According to the analysis, higher mortality results from modified economic behavior such as reducing the quality and quantity of meals (Anttila-Hughes and Hsiang, 2013).

The climate of Asia is driven by several processes

The climate of Asia is highly diverse, ranging from polar and sub-Arctic climates in northern Asia, arid and semiarid climate in central Asia, humid subtropical in East Asia and parts of South Asia, and tropical climate across South and Southeast Asia.

Precipitation in Asia is predominantly driven by the monsoon winds. Monsoons account for a significant proportion of total rainfall across the continent (Vatta and Sen, 2014). Given the high dependence on rain-fed agriculture in the region, delays in the onset of the monsoon as well as variations in the distribution of rainfall can have significant livelihood repercussions The monsoon systems in Asia are influenced by a number of climate processes – at the continental level, the El Niño/Southern Oscillation and the Inter-Tropical Convergence Zone are some of the key drivers of climate variability. At sub-regional levels, other smaller-scale processes also have an influence on rainfall.

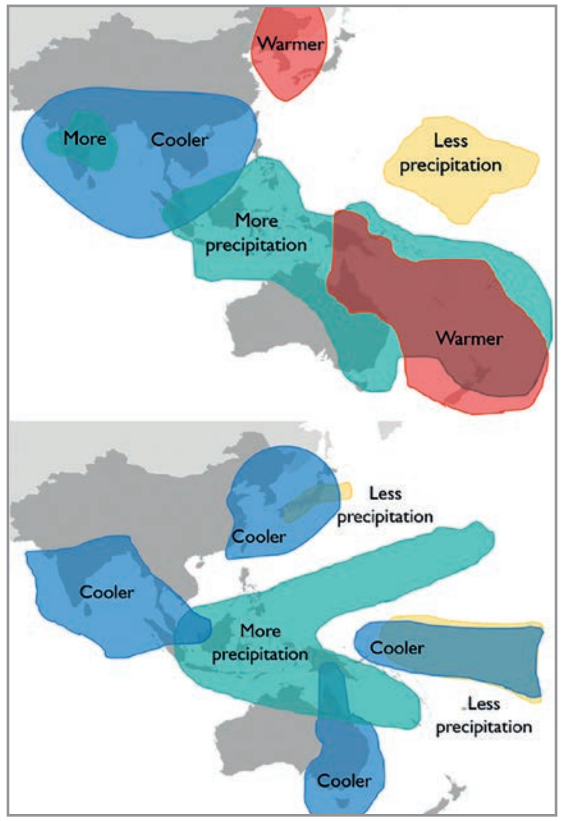


Average annual rainfall (1981-2010, mm). Red hatched areas indicate regions of high year-to-year variability

[Source: Dee et al. (2011)]

Cold continental winters followed by warm and hot summers. The majority of rainfall is concentrated in the summer months and linked the East Asian monsoon, the ITCZ and sea surface temperatures in the western Pacific.

Low latitude tropical regions are warm and wet throughout the year. Rainfall is strongly linked to the seasonal migration of the ITCZ and sea surface temperatures in the western Pacific.



Typical El Nino effects for Asia, June–August (top) and December-February (bottom).

[Source: NCSU, 2014]

EL NIÑO/SOUTHERN OSCILLATION (ENSO) is one of the key climate processes at the global level and is linked with sea surface temperatures in the eastern Pacific Ocean. In Asia, direct effects of the warm phase of El Niño include drier conditions leading to a delay in the onset of the agricultural season, worsening haze, and forest fires. La Niña, the 'cold phase' of ENSO, is associated with a westward movement of tropical cyclones and rainfall in Asia, primarily increasing rainfall in China, the Philippines, and Malaysia. ENSO episodes typically occur every 3-5 years. According to a recent study by FAO (2015), El Niño can affect agriculture in different ways depending on cropping cycles. In areas where crops are planted earlier in the year (China), agricultural stress is higher towards the end of the crop season, whereas in countries where planting occurs in November (Indonesia, Sri Lanka), agricultural stress is high during the whole ENSO cycle.

The **Inter-Tropical Convergence Zone (ITCZ)** is another key climate process at the global level. The ITCZ occurs in the areas near the equator where the northeast and southeast trade winds converge, following the movement of the sun such that it shifts northwards and southwards depending on the position of the sun. It is associated with heavy rainfall, particularly in equatorial countries. In Asia, the ITCZ influences the onset of the wet and dry seasons. Rainfall in South Asia is dominated by two monsoon systems: the summer monsoon, which occurs between June and September and brings the majority of rainfall, and the winter monsoon, which contributes to some rainfall in southeastern India, Sri Lanka, and the Maldives.

In addition to the ENSO and ITCZ drivers, other factors such as Indian ocean sea surface temperatures and natural variability within the atmospheric circulation can also impact the climate over Asia on monthly to seasonal time scales.

Climate variability and climate change

Climate variability refers to the ways in which climate signals such as temperature or precipitation fluctuate above or below a long-term average value. These differences have significant effects on populations on seasonal and annual scales: for instance, a delay in the onset of the rainy season accompanied by lower rainfall during the season can result in significant declines in crop production. Understanding whether these types of events are isolated or part of a trend are important to help guide risk management decisions.

In contrast, climate change is a long-term continuous change in average weather conditions or the range of weather. The effects of climate change are relevant over much longer timescales – usually decades or centuries. For example, a gradual decline in rainfall may result in permanent shifts of agricultural land. The current concern with climate change is related to the rate of climate change; i.e. how fast it is occurring, and the implications for vulnerable communities.

The climate is already changing and will continue to change

Given the relationship between climate trends and food security in Asia, future changes can create a new risk environment.

Climate change can be understood in terms of:

- **Long-term climate trends**
- **Seasonal variability**
- **Climate extremes**

These signals are explored in further detail in this section.

Long-term climate trends

Trends and projections in temperature. Evidence indicates that annual temperatures have increased in the 20th century over most of the Asian continent. This trend has been accompanied by an increase in the number of both warm days and warm nights. Temperatures are expected to continue increasing, leading to accelerated glacier melt and higher risk of drought when combined with lower rainfall periods. Significant shifts in temperature can affect the quality of crops and the availability of water for livestock or personal use (Christensen et al., 2013).

Historical trends suggest that mean annual temperatures have increased over much of South Asia, especially during the winter months. Climate models indicate that this trend will continue to increase as a result of higher carbon dioxide concentrations with the most significant changes over northern India (Christensen et al., 2013).

Over Southeast Asia, temperature has been increasing significantly, with more frequent hot days and warm nights. According to climate projections, temperatures will continue to increase by the end of the century, depending on commitments to mitigation (Christensen et al., 2013). Temperatures in East Asia have increased faster than the global average. This is particularly the case in northern China and parts of Japan, where more extremely hot days and nights are expected (Christensen et al., 2013).

A. Afghanistan
Diego Fernandez

Trends and projections in rainfall. Precipitation trends in Asia are characterized by large variability due to the complex topography of the region, which includes large mountain ranges, archipelagos, and deserts – all of which also contain microclimates.

Generally, in South Asia, the historical record shows that seasonal mean rainfall is decreasing. At the same time, this has been accompanied by an increase in extreme rainfall events due to more concentrated rainfall events (Kulkarni, 2012).

A

In Southeast Asia, by contrast, the trend indicates an increase in annual rainfall as well as more extreme events, particularly during the wet season. Projections suggest that the trends will continue, but that variability in rainfall will increase leading to drier dry seasons and wetter wet seasons across most of the continent. This may lead to more intense dry spells, longer droughts, and more intense floods (Caesar et al., 2011).

In East Asia, both the summer and winter monsoon circulations have experienced weakening since the 1970s, leading to more extreme precipitation along the Yangtze River Valley but deficits in northern China (Christensen et al., 2013).

Sea level rise. Sea level is projected to increase by 0.57-1.10 metres globally by the end of the 21st century, with some areas experiencing even higher rates of sea-level rise (Jevrejeva et al., 2014). Such increases in sea levels would increase soil salinity, thereby reducing the quality of soil and water available for use. Sea level rise could increase the risk of storm surges as well as coastal flooding. Changes in sea level can severely affect vulnerable populations living in low elevation coastal areas. Estimates suggest that sea levels increased by 0.17 mm per year in the period 1901-2010; and between 1993 and 2010, the rate of sea level rise has increased to 0.32 mm per year. The faster increase in sea level rise in recent decades is attributable to both thermal expansion (due to higher ocean temperatures) as well as snowmelt (Rhein et al., 2013).

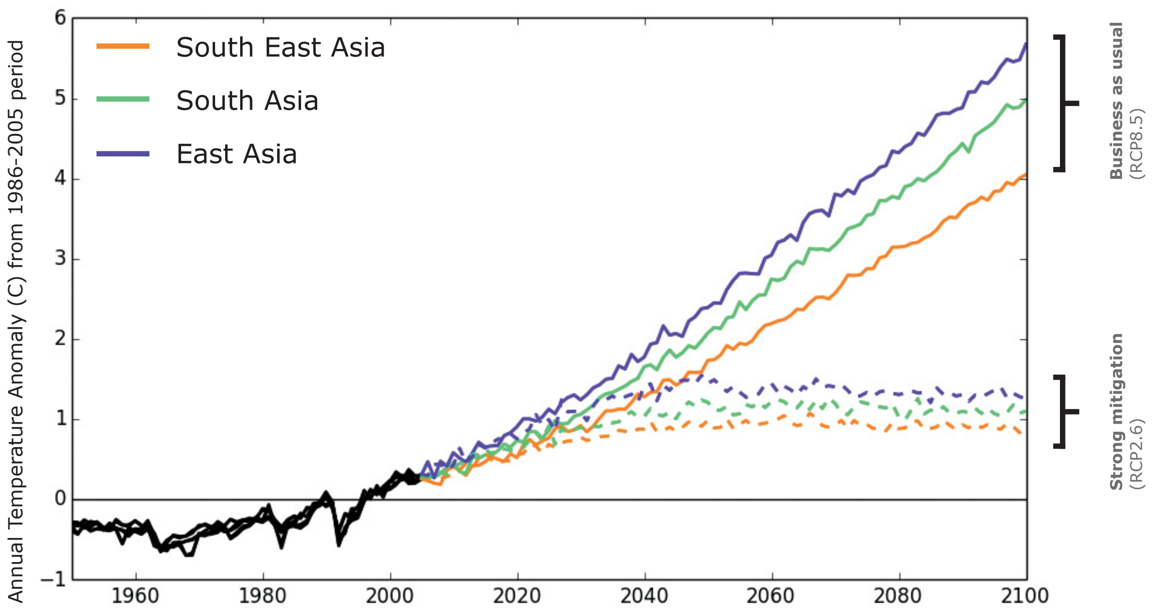
Over 480 million people in Asia live in low elevation coastal zones below 10 metres above sea level, and are at risk of rising sea-levels (McGranahan et al., 2007). With population growth, the number of people at risk could increase.

Glacier melt. Reliable supply of water from glacier melt is essential, as glacier melt directly provides water to communities in the Himalayas, and indirectly by feeding into the Indus, Ganges, and Brahmaputra Rivers. Under higher temperatures, glaciers could melt at a faster rate with more frequent floods. However, in the long run, this would result in a lack of water due to insufficient water replenishment. This type of flood event therefore requires scientists and practitioners to think about two risks simultaneously (Zemp et al., 2008).

Average annual temperatures (difference from 1986-2005 average) over Southeast (orange), South (green) and East (purple) Asia. Data from 1950-2005 is shown in black. Porjections are the average from a range of climate models (IPCC ARS).

[Source: IPCC WGI Annex I. Regional Climate Porjections.]

Over the next 10-30 years, there are generally small differences in temeperature between future greenhouse scenarios. However, towards the end of the century, temperature differences are much larger depending on emissions.



Loss & damage: unavoidable impacts of climate change

Despite the potential for adaptation to reduce overall vulnerability, under climate change, adaptation may become too expensive or unfeasible.

Extreme weather events and gradual climate change can therefore result in significant loss and damage in some parts of Asia. For instance, typhoons, floods, and droughts can result in crop losses and can damage agricultural land. Typhoon Haiyan illustrated the potential impact of extreme weather events on food systems by destroying crops as well as agricultural land. The losses resulting from the typhoon also extended to the following season, as some of the land was unsuitable for rice cultivation.

Gradual changes in seasonality can also result in loss and damage through devastation of livelihoods. For example, if seasons become shorter and more intense, agriculture-based livelihoods may not be feasible in some areas. While farmers may be able to change the crops they grow to adapt to higher temperatures, after certain thresholds agriculture may become entirely unfeasible.

In these cases, unavoidable loss and damage may occur. Understanding where and when these thresholds may occur and how populations can adapt to these changes will be increasingly important in the context of managing climate change.

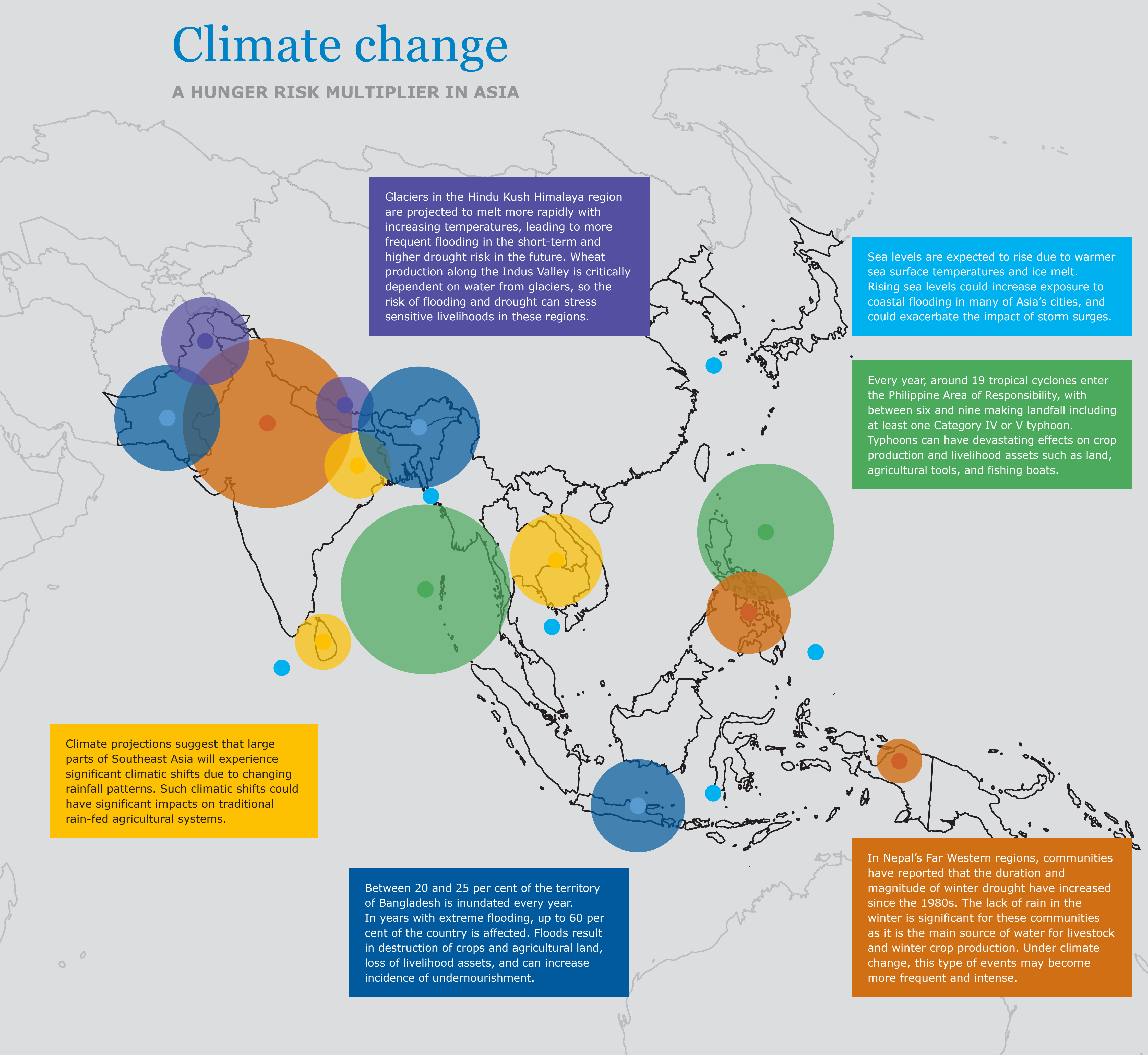
A. Cambodia
Krishna Krishnamurthy

B. Philippines
Marco Frattini

B

Climate change

A HUNGER RISK MULTIPLIER IN ASIA



Glaciers in the Hindu Kush Himalaya region are projected to melt more rapidly with increasing temperatures, leading to more frequent flooding in the short-term and higher drought risk in the future. Wheat production along the Indus Valley is critically dependent on water from glaciers, so the risk of flooding and drought can stress sensitive livelihoods in these regions.

Sea levels are expected to rise due to warmer sea surface temperatures and ice melt. Rising sea levels could increase exposure to coastal flooding in many of Asia's cities, and could exacerbate the impact of storm surges.

Every year, around 19 tropical cyclones enter the Philippine Area of Responsibility, with between six and nine making landfall including at least one Category IV or V typhoon. Typhoons can have devastating effects on crop production and livelihood assets such as land, agricultural tools, and fishing boats.

Climate projections suggest that large parts of Southeast Asia will experience significant climatic shifts due to changing rainfall patterns. Such climatic shifts could have significant impacts on traditional rain-fed agricultural systems.

Between 20 and 25 per cent of the territory of Bangladesh is inundated every year. In years with extreme flooding, up to 60 per cent of the country is affected. Floods result in destruction of crops and agricultural land, loss of livelihood assets, and can increase incidence of undernourishment.

In Nepal's Far Western regions, communities have reported that the duration and magnitude of winter drought have increased since the 1980s. The lack of rain in the winter is significant for these communities as it is the main source of water for livestock and winter crop production. Under climate change, this type of events may become more frequent and intense.

Climate-related risks

Droughts result from a combination of insufficient rainfall and high temperatures, and can impact agricultural production if drought conditions coinicide with key agricultural activities. There is insufficient long-term data to determine whether droughts are likely to become more intense although the majority of models suggest higher intensity and duration of drought in parts of South Asia, Indonesia, and the Phillippines.

Floods have become more frequent and intense since the 1960s as a result of heavy precipitation events. Large parts of Asia are likely to experience more frequent and intense floods due to shorter but more intense rainy seasons. Glacier melt, sea-level rise, and more intense tropical storms can also lead to increased flood risk.

Tropical storms have the potential to devastate large areas. Models suggest that tropical storms will become less frequent but more intense under climate change.

Climatic shift due to changing rainfall and temperature patterns is expected over large parts of Asia, including the Mekong Basin and parts of South Asia. Such shifts may render traditional, climate-sensitive livelihoods such as farming and fishing unsustainable.

Glacier melt feeds water to rivers in the Indus and Ganges-Brahmaputra basin. Accelerated glacier melt would result in changes in the availability of water: in the short-to medium-term, melting glaciers can lead to excess water (floods), while in the longer-run they can exacerabte drought risk.

Sea-level rise is another serious concern. Sea levels are expected to rise by 57-100cm by the end of the century, thereby exacerbating coastal flooding risk as well as the impact of storm surges.

Legend – Colour of circle indicates type of climate-related risk. Relative size of circle indicates number of people potentially at risk. This is illustrative and not to scale.

Seasonal variability

Seasonal rainfall in Asia is driven by major monsoon systems. Variations in seasonal rainfall result in substantial fluctuations in heavy and low rainfall incidents, causing extreme wet (flood) and dry (drought) conditions, especially in Southern Asia. Recent long-term statistical analyses show two key trends in monsoon rainfall: first that peak-season precipitation is declining, and second that this decrease coincides with increases in daily rainfall variability (Christensen et al., 2013). These two trends have resulted in more frequent but less intense dry spells, and more intense wet spells. The implications are significant as they influence the feasibility of rural livelihoods for more than one sixth of the world's population.

Monsoon circulation is driven by the difference in temperature between land and sea. Under climate change, land temperatures are projected to increase more rapidly than sea surface temperatures, leading to more total rainfall during the monsoons. These changes in temperature can also influence changes in the location of rainfall, with some areas receiving a lot more rainfall and others receiving less. For instance, since the 1970s, the East Asian monsoon has become more intense in terms of absolute rainfall, but this has manifested itself through increasing drought risk in northern China but higher flood risk in the Yangtze River Valley in the south (Hijioka et al., 2014).

Under climate change, it is projected that global monsoon precipitation will strengthen in the 21st century, while extreme rainfall events and consecutive dry days will both increase in frequency. In addition, the Asian monsoon onset is projected to be slightly early (or not change much) while the retreat is expected to be delayed resulting in longer monsoons (Hijioka et al., 2014). This trend can affect rural livelihoods by increasing uncertainty about the appropriate timing for crop planting.

Historically, the Indian summer monsoon has undergone abrupt shifts resulting in prolonged and intense drought (Sinha et al., 2011). In recent climatology, however, the Indian monsoon has included more extreme rainfall events (Goswami et al., 2006; Rajeevan et al., 2008).

The East Asian monsoon is characterized by a wet season in the summer and a dry, cold season in winter. The monsoon has experienced weakening between the 1960s and 1980s, resulting in below-average rainfall in North China and excessive rainfall in central East China. The circulation appears to be recovering so that large-scale droughts and floods are becoming less common in China. This is associated with natural variability.

A

B

Community perceptions of changes in seasonality

Communities across the continent have reported changes in seasonal patterns, which exacerbate their vulnerabilities.

For example, in Pakistan, communities in the Shigar Valley in northern Pakistan reported that there has been a drastic reduction in the amount of rainfall since the mid-1990s. In the past, snowfall would begin in November and continue until January or February. Snow cover on the ground used to be at least 1 metre thick and would start melting in April or May. However, in recent years, there is hardly any snowfall in the valleys (IUCN, 2008).

Similar results were reported by communities in Nepal's Far Western Himalayan and hill regions. There, communities have observed a change in the type of precipitation—from snow to rain. Communities also report that the duration and magnitude of winter drought have increased in recent years compared to the 1980s and 1990s, while the intensity of monsoon rains has increased and the timing of rains has become increasingly erratic and unpredictable, with implications on livelihoods and food security (Gurung et al., 2010).

In Bangladesh, communities from the Rajshahi district in northern Bangladesh and from the Khulna district in the south both report that even though winters are getting warmer, they are experiencing very erratic and severe cold for a period of 5-7 days each winter, which temporarily restricts their activities. They also affirm that this unpredictable cold period has a very destructive effect on agricultural production and their health, especially on children and the elderly (Haque et al., 2012).

D

A. Laos
Ruangdech Poungprom

B. Cambodia
Krishna Krishnamurthy

C. Nepal
James Giambrone

D. Malaysia
Eddie Gerald

C

Bangladesh
Marcus Prior

Disaster trends in Asia

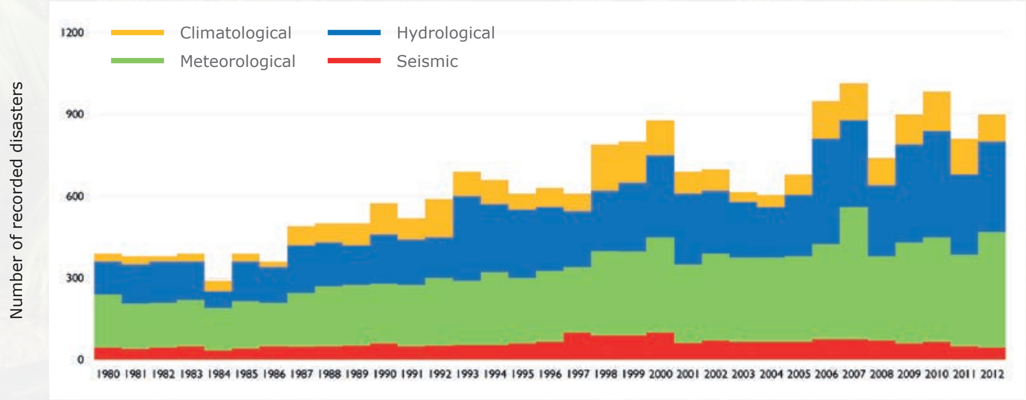
Between 1980 and 2012, the number of climate-related disasters in the region has increased from 100 to over 300, affecting over 230 million people every year, and accounting for 51 percent of the world's reported fatalities (1.16 million people).

Extreme weather events have significant impacts on food security and livelihoods. Between 2002 and 2011, droughts, floods and storms in the continent have resulted in losses of more than US$ 60 billion every year (Guha-Sapir et al., 2013). In 2011 alone, climate-related disasters forced over 10 million people out of their homes in Asia (ADB, 2012).

To illustrate, in Myanmar, Cyclone Nargis (2008) resulted in significant societal losses. Communities and regions up to 40 km inland were inundated due to storm surges (Webster, 2008); soil salinization rendered 20,200 hectares of rice cropland unfit for planting (Stover and Vinck, 2008); and rice seeds, fertilisers, farm machinery and valuable land were lost, thereby affecting the winter 2008/2009 rice crop (FAO/WFP, 2009). The Pakistan floods (2010) which resulted from heavy monsoons, affected about 20 million people, mostly due to loss of property, assets, and infrastructure, with a death toll of close to 2,000 (Oxfam International, 2011).

More recently, super typhoon Haiyan (local name: Yolanda) which hit the Philippines in November 2013 demonstrated the destructive potential of climate-related hazards. Estimates from the Philippine Department of Agriculture indicate that typhoon Haiyan resulted in significant agricultural losses: over 130,000 hectares of farmland were destroyed, resulting in losses of145,779 metric tonnes of rice, and financial losses of 9.089 billion Philippine pesos, almost US$200 million (Casayuran, 2013). Moreover, households that depended on farming and fishing were severely affected by the typhoon: wind damage and powerful storm surges destroyed or damaged key assets and disrupted livelihood activities, resulting in income losses of up to 70 per cent. Most agricultural households estimated that it would take them between 6 and 8 months to recover from the typhoon impacts (MCNA, 2013).

The evidence indicates that the magnitude, frequency, intensity, or duration of some extreme climate-related hazards will likely increase as a result of climate change. Current preparedness measures may be insufficient for dealing with projected increases in the magnitude of disasters. Combined with rapid population growth in vulnerable areas exposed to storms and floods, this scenario highlights the need for better understanding of how climate extremes impact food security as well as the need for better preparedness and adaptation.



Global disaster trends, 1980-2012. Hydrological, meteorological, and climatological hazards are increasing in frequency.

[Source: Adapted from MunichRe NATCATService, 2013].

Climate extremes

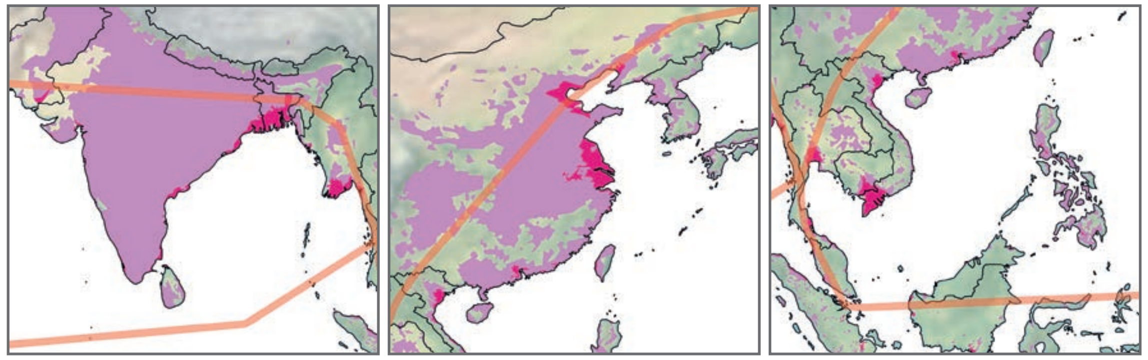
Asia is highly vulnerable to the impact of extreme weather events. A recent assessment on extreme climate-related events (Handmer et al., 2012) suggests that the Asian continent could experience changes in the frequency of magnitude of tropical cyclones and heavy precipitation events.

Tropical cyclones. Based on projected population growth alone, it is expected that exposure to tropical cyclones will increase over the next few decades (Handmer et al., 2012). While many of the exposed people are in large megacities of China and Japan, a significant proportion will continue to live in fragile coastal areas of Bangladesh, Myanmar, the Philippines, and South Asia. Of significant concern is the potential for tropical cyclone intensity to increase under climate change: more intense tropical cyclones will affect even wealthier populations. Recent years have seen the devastating impacts of cyclones in Asia: Cyclone Sidr (2007), Cyclone Nargis (2008) and Typhoon Haiyan (2013) have shown the potential destruction of lives and livelihoods that can follow from a cyclone.

A key question in climate science is whether tropical cyclones will become more frequent and more intense as a result of warming sea surface temperatures – and therefore whether or not coastal populations are at high risk. Model results are inconclusive, particularly as long-term historical observational data is limited. Despite model disagreement, three important trends have been identified. First, the frequency of tropical cyclones may decrease or remain unchanged but their intensity will likely increase or show no change (Knutson et al., 2010). Second, typhoons appear to be making landfall in areas where they are typically uncommon (Handmer et al., 2012). Third, sea-level rise will exacerbate typhoon impacts: research in Japan suggests that tropical storms could be 1.3 times stronger with a sea-level rise of 60 cm, causing damage of up to US$40 billion (Suzuki, 2009). Additional observational data may confirm whether these trends are statistically significant.

Highly populated areas (>150 people/km²) and those expeosed to increased storm surge risk (<10m elevation). The approximate envelope of tropical storms is highlighted in orange.

[Source: based on IBTrACS dataset, tracks since 1973, and LandScan, 2013.]



Populated area (>150 people/km2) — Populated area in low elevation zone (<10m elevation) — Tropical storm exposure

Flooding and heavy precipitation. Flood trends are characterized by significant variability: some areas of Asia have experienced an increase in flood events while others have experienced decreases (Hijioka et al., 2014).

Flash floods. Flash floods occur due to sudden, localized heavy rainfall over a short period. This type of event is common near rivers and on plains where large amounts of water can accumulate relatively quickly. Flash floods can have devastating effects on vulnerable populations: at least 73 people were reported to die and thousands were displaced following flash floods in Baghlan Province, Afghanistan in June of 2014 (OCHA, 2014). Flash floods may become more frequent under climate change as seasons are expected to become more variable with more intense rainfall episodes spread over shorter periods (Hijioka et al., 2014).

Floods from heavy precipitation. Heavy precipitation events are responsible for some of the most devastating floods observed in the 20th and 21st centuries, including the Pakistan floods of 2010 and 2011. In a normal year, between 20 and 25 percent of the territory of Bangladesh is inundated during the monsoons. In years experiencing extreme flooding (e.g. 1988, 1998, and 2004, over 60 percent of the country was affected. The impacts of such floods on vulnerable populations are devastating: the 1998 flood resulted in more than 1,000 deaths and left more than 30 million people homeless (Hossain, 2008). Models suggest that such extreme precipitation events could become more frequent, especially in South and Southeast Asia, highlighting the need to better monitor and anticipate flood risk (Hijioka et al., 2014).

Drought. Assessing historical trends in drought climatology is difficult – drought is a complex phenomenon influenced by precipitation, temperature, wind speed and solar radiation (Seneviratne, 2012) as well as non-atmospheric conditions such as soil moisture and land cover. Observational data suggest that drought episodes have become more intense in large parts of South and Southeast Asia, including Cambodia, Thailand, and Indonesia. To some extent, this is attributable to higher sea surface temperatures (Hijioka et al., 2014), although deforestation and land use change have also contributed significantly to the problem (Tosca et al., 2010).

Drought can have a significant impact on the availability of water at the regional level: water availability per capita is decreasing at a rate of 1.6% every year. This trend, combined with population growth, increased water use, and land degradation, would significantly exacerbate drought risk in the region.

Under climate change, models suggest that the intensity of droughts could increase only slightly in the first half of the 21st century, while the second half of the century may experience longer and more intense droughts.

A. **Pakistan** WFP Photo Library

B. **Bangladesh** Kamrul Mithon

C. **Afghanistan** Silke Buhr

Philippines
Blake Audsley

How a changing climate affects urban areas

Urbanization is currently one of the most prominent demographic processes in Asia. There is increasing recognition that cities will face unprecedented challenges as a result of climate change, directly through heat waves, increasing hazard impacts, rising sea-levels, and storm surges, and indirectly through impact on key services. As Asian countries become increasingly urbanized, with some countries expected to reach urbanization rates of over 60% in the coming decades, greater emphasis should be given to the vulnerabilities faced by the urban poor (UNFPA, 2009).

Urban populations are especially vulnerable to disruptions to essential services – for example, electricity is key for refrigeration of certain food items and can affect the availability of public health services for treating malnutrition.

In the context of food security, markets are some of the most critical services. As urban food production is generally quite limited (De Zeeuw et al., 2011), markets play a critical role in food security. Ensuring that markets are resilient to climate change – both from the producer and from the consumer perspective – should therefore be an essential component of urban food security. According to IFPRI, urban populations pay up to 30 percent more for food than rural communities – for the poorest people, fragmented urban markets result in higher food costs (Argenti, 2000). Moreover, as slums are located at the edges of cities and far from central city markets, travel can be highly expensive. Fluctuations in food prices, whether induced by climate variability or not, could have a significant impact on populations who already spend a large proportion of their limited income on food.

Urban areas are not homogeneous. Social inequalities influenced by income differences, gender, ethnicity, age, and health all affect the ability of individuals to manage climate risk. It is often the poorest people with limited livelihood options who are most vulnerable to climate change – this applies to urban contexts as well. The poorest people often live in informal settlements, in the areas most at-risk that are easily damaged or destroyed during a flood or storm. Reconstruction of houses is often unaffordable and some households are forced to take out loans becoming highly indebted.

Of increasing concern are low elevation coastal zones – those less than 10 metres above sea level. Many major Asian metropolises are located on or near the coast and are more exposed to certain climate hazards such as coastal flooding and sea-level rise. Of the more than 600 million people living in these areas, over 360 million live in urban settlements (McGranahan et al., 2007). As these settlements continue to expand, many of the poorest residents could live in more marginal lands that are highly vulnerable to climate-related risks. In addition, the poor quality housing offers little protection from storm surges, sea-level rise, and flood risk.

In Asia, several cities are located along coastal areas and are therefore especially vulnerable to sea-level rise, coastal flooding, and storms. In the absence of adaptation, up to 168 million people may be exposed to risks associated with sea-level rise by 2100 (Hinkel et al., 2012; Schellnhuber et al., 2013).

Climate and socioeconomic trends

Climate does not affect food security in isolation – it interacts with other factors.

A

A.
Indonesia
Krishna Krishnamurthy

As countries in Asia continue to develop, so will their capacity to adapt to climatic changes. At the community scale, vulnerable populations have already adapted to some changes: in Himachal Pradesh, India, apple growers have been experiencing extremely low yields due to increasing temperatures and have responded by shifting to cultivation of vegeta-bles and pomegranates (Sharma, 2013).

At a larger scale, technological developments and improvements in agricultural practices are helping increase yields and incomes. Introduction of irrigation and small ponds in vulnerable regions helps reduce some of the effects of variable weather (Howden et al., 2007). At the same time, techniques such as the system of rice intensification (SRI) are enhancing the capacity of farmers and countries to manage climate risks (Uphoff, 2003). This type of adaptation will likely enhance as the region develops further.

While these forms of adaptation are important, there is a limit to how much adaptation can occur – either because adaptation becomes too expensive or impossible.

In addition, other socioeconomic trends such as land use change, demographic change and urbanization will also affect the relationships between food security and climate change.

Deforestation-induced reduction in rainfall

Tropical forests influence key processes in the water cycle, so changes in forest cover influence regional and global hydrological cycling (Avissar and Werth, 2005). Therefore, it would be expected that large-scale deforestation would influence rainfall distribution. An analysis of changes in rainfall over Borneo reveals that there has been a constant decline in total annual rainfall between 1951 and 2007. The most abrupt decreases occurred in the 1980s, which corresponds with intensive deforestation activities (primarily logging) (Kumagai et al., 2013). This trend can also exacerbate the risk of extreme drought and forest fires, leading to even more deforestation.

Similarly, in the Indochina peninsula, a modeling experiment reveals that deforestation is linked to changes in hydrological process – both locally and regionally. At the local level, the effects include higher temperatures and lower rainfall. At the regional level, impacts include weakening of the monsoonal flow over east China, near the Tibetan Plateau, and a strengthening over the neighbouring South China Sea (Sen et al., 2003). This trend suggests that deforestation may be one of the key drivers of climatic change in the region.

Key messages

- One of the most significant impacts of climate change is the potential increase in food insecurity due to changes in the productivity of agricultural land, seasonal variability, and higher magnitude of disasters.
- Livelihoods in Asia are highly diverse as the result of rapid development and urbanization in recent years. However, rural livelihoods remain highly climate-sensitive with several households depending on rain-fed and subsistence agriculture.
- Climate change is a hunger risk multiplier: it interacts with the different drivers of food insecurity to create new risks (but it can also create opportunities).
- Climate can affect all aspects of food security.

Availability: Increases in temperature have already had impacts on crop production, and in the absence of sufficient adaptation efforts, this trend is expected to continue under a climate change scenario.

Access: Variable weather patterns and extreme climate-related events could affect households' ability to access food through increases in food prices and impact on livelihood activities.

Utilization: Climatic changes can affect nutrition through impacts on food security, care practices, and health. Recent evidence suggests that climate-induced crop and livestock failure, and climate extremes are associated with negative outcomes on nutrition.

- There is evidence of climate change over Asia, with temperatures increasing across most of the continent and rainfall events becoming more intense. These trends are projected to continue as a result of human-induced climate change.
- Changes in the seasonal rainfall patterns have also resulted in more frequent but less intense dry spells, and more intense wet spells. The timing and duration of rainfall is critical for certain agricultural activities.
- The magnitude of climate extremes can also have devastating effects on food se-curity and livelihoods. Typhoons, floods, and droughts are expected to become more intense in some areas as a result of changing climatic conditions. Anticipating these changes, and adapting to them, is essential to ensure food security.
- Climate trends do not affect food security on their own. Socioeconomic development and the adaptive capacity of populations ultimately determine the impact of climate change. As societies develop and change, so will their capacities to adapt to climate-related risks.

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