### Climate Change and Agriculture

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### Abstract

As our climate continues to heat up and the impacts of that warming grow more frequent and severe, farmers and farm communities around the world will be increasingly challenged. And US farmers won't be spared the damage that climate change is already beginning to inflict. The combination of advancing climate change and an already-vulnerable industrial system is a "perfect storm" that threatens farmers' livelihoods and our food supply. The good news is that there are tools—in the form of science-based farming practices that can buffer farmers from climate damage and help make their operations more resilient and sustainable for the long term. But farmers face many obstacles to changing practices, so it's critical that policymakers shift federal agriculture investments to support and accelerate this transition.

#### I. Introduction

In the long list of potential problems from global warming, the risks to world agriculture stand out as among the most important. Yet there has been a tendency in the climate economics literature in recent years to downplay this risk, and even to argue that a couple of degrees Celsius warming might benefit world agriculture. But such studies typically have too short a time horizon (generally out to about 2050). They also focus on overall temperature change (which includes oceans), rather than on the changes that will occur over land (which warms more easily and quickly than water)—and specifically agricultural land.It has been widely recognized that developing countries in general stand to lose more from the effects of global warming on agriculture than do industrial countries. Most developing countries have less capacity to adapt than do their wealthier neighbours. Most are in warmer parts of the globe, where temperatures are already close to or beyond thresholds at which further warming will reduce rather than increase agricultural output. And agriculture is a larger share of developing economies than of industrial If steps are not taken to curb carbon emissions, agricultural productivity could fall dramatically, especially in developing countries.

If carbon emissions continue unabated, by the 2080s, land and farm area temperatures will rise sharply . . . Land area Farm area Base levels Temperature1 13.15 16.20 Precipitation2 2.20 2.44 By 2080s Temperature 18.10 20.63 Precipitation 2.33 2.51 . . . and agricultural productivity will tail off across the globe, but most sharply in developing countries. (percent change in agricultural output potential) Without CF3 With CF4 World Output-weighted -16 -3 Population-weighted -18 -6 Median by country -24 -12 Industrial countries -6 8 Developing countries5 -21 -9 Median -26 -15 Africa -28 -17 Asia -19 -7 Middle East and North Africa -21 -9 Latin America -24 -13 Source: Cline (2007).

1) Temperature is average daily in °C.

2) Precipitation is measured in millimeters per day.

3) Assumes no benefit to crop yields from increased carbon dioxide in atmosphere (carbon fertilization, CF).

4) Assumes a positive impact on yields from carbon fertilization.

5) Excludes Europe economies.

But it has been difficult to estimate just how much individual countries are likely to be affected.For that reason, this study (Cline, 2007) was undertaken both to get a better long-term fix on overall world effects under current policies (the so-called baseline or businessas-usual scenario) and to understand the likely impact on individual countries and regions. The time frame stretched out to the average for 2070–99, what is called the "2080s." Climate model projections are available on a comparable basis for this period, which is far enough in the future

to allow sizable warming and potential damage to materialize but close enough to the present to elicit public concern.

### How climate affects agriculture

Climate change can affect agriculture in a variety of ways. Beyond a certain range of temperatures, warming tends to reduce yields because crops speed through their development, producing less grain in the process. And higher temperatures also interfere with the ability of plants to get and use moisture. Evaporation from the soil accelerates when temperatures rise and plants increase transpiration—that is, lose more moisture from their leaves. The combined effect is called "evapotranspiration." Because global warming is likely to increase rainfall, the net impact of higher temperatures on water availability is a race between higher evapotranspiration and higher precipitation. Typically, that race is won by higher evapotranspiration.But a key culprit in climate change—carbon emissions— can also help agriculture by enhancing photosynthesis in many important, so-called  $C_3$ , crops (such as wheat, rice, and soybeans). The science, however, is far from certain on the benefits of carbon fertilization. But we do know that this phenomenon does not much help  $C_4$  crops (such as sugarcane and maize), which account for about one-fourth of all crops by value.

To estimate the country-specific impact of global warming on agriculture if carbon emissions continue to grow unabated, the study combined two sets of existing models—one from climate science and the other from agronomy and economics. Six leading climate models provided estimates of future changes in temperature and precipitation at a typical detail of about 2,000 land-based areas, or grid cells. These changes were added to information on present climate (about 22,000 land cells) and then averaged to obtain a consensus climate projection at a detail of about 4,000 land cells. These estimates were fed into crop impact models from agronomy and economics to produce the yield-impact estimates, which were then averaged up to the level of countries and regions. The consensus of the six models shows that a doubling of atmospheric carbon concentration will produce an eventual overall warming of 3.3°C. This is close to the UN Intergovernmental Panel on Climate Change (IPCC) estimate of what is called "climate sensitivity," or the amount of long-term global warming to be expected from a doubling of carbon dioxide in the atmosphere above preindustrial levels —an indication that the models are producing mainstream forecasts. To develop these estimates, the baseline emissions projections

from the most widely used scenario in the IPCC's Third Assessment Review in 2001 were fed into the climate models. Currently, annual fossil-fuel emissions amount to about 7 billion tons of carbon. Under the IPCC's business-as-usual estimate, they would rise to about 16 billion by 2050 and 29 billion by 2100, partly because of a greater use of coal. The corresponding atmospheric concentrations of carbon dioxide would reach 735 parts per million (ppm) by 2085, in contrast to the preindustrial level of 280 ppm and today's level of 380 ppm. The study divides the world into 116 countries and regions. By the 2080s, the six climate models predict an average surface temperature increase of nearly 5°C weighting by land area and about 4.4°C weighting by farm area .This is higher than a global mean warming of 3°C, because land areas warm more than the oceans. Precipitation also rises, but only by about 3 percent. The climate change projections are then applied to the agricultural impact models to develop two sets of assessments of the effect of climate change on agricultural productivity. One set, the "crop models," relates farm output 24 Finance & Development March 2008 to land quality, climate, fertilizer inputs, and so forth (Rosenzweig and Iglesias, 2006). The other, "Ricardian models," statistically infers the contribution of temperature and precipitation to agricultural productivity by examining the relationship of land price to climate-agricultural productivity improves as temperatures go from cold to warm, then deteriorates going from warm to hot (Mendelsohn and Schlesinger, 1999). Models relating county- or farm-level data on land values or net revenue to such influences as soil quality as well as temperature and rainfall are now available for Canada, the United States, India, and many countries in Africa and Latin America. Both sets of models tend to produce similar results. The study combined them to create a consensus estimate of crop yields both under conditions in which there is no benefit from increased carbon dioxide on crop yields and under assumptions that result in positive effects from carbon fertilization.

Agriculture is an important sector of the U.S. economy. The crops, livestock, and seafood produced in the United States contribute more than \$300 billion to the economy each year .When food-service and other agriculture-related industries are included, the agricultural and food sectors contribute more than \$750 billion to the gross domestic product.<sup>[2]</sup>

Agriculture and fisheries are highly dependent on the climate. Increases in temperature and carbon dioxide  $(CO_2)$  can increase some crop yields in some places. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. Changes

in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers and threaten food safety.<sup>[3]</sup> Meanwhile, warmer water temperatures are likely to cause the habitat ranges of many fish and shellfish species to shift, which could disrupt ecosystems. Overall, climate change could make it more difficult to grow crops, raise animals, and catch fish in the same ways and same places as we have done in the past. The effects of climate change also need to be considered along with other evolving factors that affect agricultural production, such as changes in farming practices and technology.

Higher CO<sub>2</sub> levels can affect crop yields. Some laboratory experiments suggest that elevated CO<sub>2</sub> levels can increase plant growth. However, other factors, such as changing temperatures, ozone, and water and nutrient constraints, may counteract these potential increases in yield. For example, if temperature exceeds a crop's optimal level, if sufficient water and nutrients are not available, yield increases may be reduced or reversed. Elevated CO<sub>2</sub> has been associated with reduced protein and nitrogen content in alfalfa and soyabean plants, resulting in a loss of quality. Reduced grain and forage quality can reduce the ability of pasture and rangeland to support grazing livestock.<sup>[6]</sup>

More extreme temperature and precipitation can prevent crops from growing. Extreme events, especially floods and droughts, can harm crops and reduce yields. For example, in 2010 and 2012, high nighttime temperatures affected corn yields across the U.S. Corn Belt, and premature budding due to a warm winter caused \$220 million in losses of Michigan cherries in 2012.<sup>[6]</sup>

Dealing with drought could become a challenge in areas where rising summer temperatures cause soils to become drier. Although increased irrigation might be possible in some places, in other places water supplies may also be reduced, leaving less water available for irrigation when more is needed.

Many weeds, pests, and fungi thrive under warmer temperatures, wetter climates, and increased  $CO_2$  levels. Currently, U.S. farmers spend more than \$11 billion per year to fight weeds, which compete with crops for light, water, and nutrients.<sup>[6]</sup> The ranges and distribution of weeds and pests are likely to increase with climate change. This could cause new problems for farmers' crops previously unexposed to these species.

Though rising  $CO_2$  can stimulate plant growth, it also reduces the nutritional value of most food crops. Rising levels of atmospheric carbon dioxide reduce the concentrations of protein and essential minerals in most plant species, including wheat, soybeans, and rice. This direct effect of rising  $CO_2$  on the nutritional value of crops represents a potential threat to human health. Human health is also threatened by increased pesticide use due to increased pest pressures and reductions in the efficacy of pesticides.<sup>[4]</sup>

The consensus of the Intergovernmental Panel for Climate Change (IPCC) is that substantial climate change has already occurred since the 1950s, and that it's likely the global mean surface air temperature will increase by 0.4 to  $2.6^{\circ}$ C in the second half of this century (depending on future greenhouse gas emissions). Agriculture, and the wider food production system, is already a major source of greenhouse gas emissions. Future intensification of agriculture to compensate for reduced production (partly caused by climate change) alongside an increasing demand for animal products, could further increase these emissions. It's estimated that the demand for livestock products will grow by +70% between 2005 and 2050.

### **International Impacts**

Climate change is very likely to affect food security at the global, regional, and local level. Climate change can disrupt food availability, reduce access to food, and affect food quality.<sup>[5]</sup> For example, projected increases in temperatures, changes in precipitation patterns, changes in extreme weather events, and reductions in water availability may all result in reduced agricultural productivity. Increases in the frequency and severity extreme weather events can also interrupt food delivery, and resulting spikes in food prices after extreme events are expected to be more frequent in the future. Increasing temperatures can contribute to spoilage and contamination.

Internationally, these effects of climate change on agriculture and food supply are likely to be similar to those seen in the United States. However, other stressors such as population growth may magnify the effects of climate change on food security. In developing countries, adaptation options like changes in crop-management or ranching practices, or improvements to irrigation are more limited than in the United States and other industrialized nations.

Any climate-related disturbance to food distribution and transport, internationally or domestically, may have significant impacts not only on safety and quality but also on food access. For example, the food transportation system in the United States frequently moves large volumes of grain by water. In the case of an extreme weather event affecting a waterway, there are few, if any, alternate pathways for transport. High temperatures and a shortage of rain in the summer of 2012 led to one of the most severe summer droughts the nation has seen and posed serious impacts to the Mississippi River watershed, a major transcontinental shipping route for Midwestern agriculture. This drought resulted in significant food and economic losses due to reductions in barge traffic, the volume of goods carried, and the number of Americans employed by the tugboat industry. The 2012 drought was immediately followed by flooding throughout the Mississippi in the spring of 2013, which also resulted in disruptions of barge traffic and food transport.<sup>[4]</sup> Transportation changes such as these reduce the ability of farmers to export their grains to international markets, and can affect global food prices.

Impacts to the global food supply concern the United States because food shortages can cause humanitarian crises and national security concerns. They also can increase domestic food prices.

Various authoritative reports, most notably the multiagency 2018 Fourth National Climate Assessment, have reviewed what science is telling US farmers to expect in coming decades—and it's not pretty. Climate change trendschanging precipitation patterns. Rainfall patterns have already begun shifting across the country, and such changes are expected to intensify over the coming years. This is likely to mean more intense periods of heavy rain and longer dry periods, even within the same regions.



Projected increase in maximum daily precipitation between now and 2090 according to the RCP 8.5 and RCP 4.5 climate change scenarios. Intense rainfall events, and the flooding that often follows them, will become more common in most of the contiguous US. Map source: EPA report.

**Changing temperature patterns.** Rising average temperatures, more extreme heat throughout the year, fewer sufficiently cool days during the winter, and more frequent cold-season thaws will likely affect farmers in all regions.



Projected increases in number of days over 90°F between now and 2090 according to two climate change scenarios. Even in the less severe RCP 4.5 scenario, there will be many more 90-degree days in important farm states such as Iowa, Missouri and Kansas. Map source: EPA report.

### **Climate change impacts**

**Floods.** We've already seen an increase in flooding in many agricultural regions of the country, including the Midwest, the Southern Plains, and California. Sea level rise is also ratcheting up the frequency and intensity of flooding on farms in coastal regions. These costly floods devastate crops and livestock, accelerate soil erosion, pollute water, and damage roads, bridges, schools, and other infrastructure.

**Droughts.** Too little water can be just as damaging as too much. Severe droughts have taken a heavy toll on crops, livestock, and farmers in many parts of the country, most notably California, the Great Plains, and the Midwest, over the past decade—and science tells us that rising temperatures will likely make such droughts even worse, depleting water supplies and, in some cases, spurring destructive wildfires.

**Changes in crop and livestock viability**. Farmers choose crop varieties and animal breeds that are well suited to local conditions. As those conditions shift rapidly over the coming decades, many farmers will be forced to rethink some of their choices—which can mean making new capital investments, finding new markets, and learning new practices.

New pests, pathogens, and weed problems. Just as farmers will need to find new crops, livestock, and practices, they will have to cope with new threats. An insect or weed that couldn't

thrive north of Texas in decades past may find Iowa a perfect fit going forward—and farmers will have to adapt.

### **Industrial amplifiers**

**Degraded soils.** Typical monoculture cropping systems leave soil bare for much of the year, rely on synthetic fertilizer, and plow fields regularly. These practices leave soils low in organic matter and prevent formation of deep, complex root systems. Among the results: reduced waterholding capacity (which worsens drought impacts), and increased vulnerability to erosion and water pollution (which worsens flood impacts).

**Simplified landscapes.** Industrial agriculture treats the farm as a crop factory rather than a managed ecosystem, with minimal biodiversity over wide areas of land. This lack of diversity in farming operations exposes farmers to greater risk and amplifies climate impacts such as changes in crop viability and encroaching pests.

**Intensive inputs.** The industrial farm's heavy climate impacts accelerate soil erosion and increase pest problems problems reliance on fertilizers and pesticides may become even more costly to struggling farmers as. Heavy use of such chemicals will also increase the pollution burden faced by downstream communities as flooding increases. Farmers may also increase irrigation in response to rising temperature extremes and drought, further depleting precious water supplies.

### What it will mean

How will these industrially amplified climate change impacts affect people—farmers, residents of rural communities, and all of us who rely on the food farmers produce? In a variety of ways:

- As summer heat intensifies, farmers and farm workers will face increasingly grueling and potentially unsafe working conditions.
- Accelerating crop failures and livestock losses will make farmers with access to insurance or disaster relief programs more reliant on those taxpayer-funded supports, while those without sufficient safety nets will face additional challenges. Failing farms and stagnating farm profits will also increase suffering in many rural communities.
- Farming communities will be among the first to feel the ways extreme weather exacerbates agriculture's impacts on water resources—with nearby water supplies

polluted or depleted before the damage extends to drinking water and fisheries far downstream.

Nationwide, reductions to agricultural productivity or sudden losses of crops or livestock will likely have ripple effects, including increased food prices and greater food insecurity.



Projected impact of climate change on yields of corn, wheat, soybeans and cotton by the years 2080-2099. Areas where yields are projected to decline (warmer colors) include some of our most important agricultural regions, such as the Corn Belt and California's Central Valley. Map: Fourth National Climate Assessment, Figure 7.6 (Source data: Hsiang et al 2017).



Figure 2: Figure SPM.9 | Summary of projected changes in crop yields, due to climate change over the 21st century. The figure includes projections for different emission scenarios, for tropical and temperate regions, and for adaptation and no-adaptation cases combined. Relatively few studies have considered impacts on cropping systems for scenarios where global mean temperatures increase by 4°C or more. For five timeframes in the near term and long term, data (n=1090) are plotted in the 20-year period on the horizontal axis that includes the midpoint of each future projection period. Changes in crop yields are relative to late-20th-century levels. Data for each timeframe sum to 100%. © IPCC, 2014, 5th assessment

### **II.** Meeting the challenge

Business as usual won't protect the future of our food supply—or the well-being of the farmers and communities that produce it. We need to take concrete steps to prepare for climate impacts on agriculture and to reduce both their severity and our vulnerability to them.

We also need to remember that climate change risks aren't distributed equally—and neither are the pathways to climate adaptation. Public policies and institutional practices have long denied communities of color, low-income groups, and tribal communities' access to critical resources and decision-making processes, leaving them with feweroptions and more risk in the face of climate impacts. So it's crucial to ensure that these communities have a voice in shaping our adaptation strategies.

## Helping farm communities manage severe impacts

When climate impacts strike, support systems need to be in place to help communities cope and recover:

**Shelters and other facilities** to provide housing, food, first aid, and other immediate needs for people whose lives have been disrupted or displaced by floods, droughts, fires, or storms.

**Investment in local capacity and infrastructure** to support people harmed by climate impacts as they rethink or rebuild their lives and businesses. This includes not only infrastructure for communication, transportation, water and sanitation, but also training in new practices and opportunities that build adaptive capacity.

# Reducing damage by making farms more resilient

Our farms and farm communities don't have to be sitting ducks for climate impacts. Forward-looking farmers and scientists are finding new, climate-resilient ways to produce our food:

**Build healthier, "spongier" soils** through practices—such as planting cover crops and deeprooted perennials—that increase soil's capacity to soak up heavy rainfall and hold water for dry periods;

Make farms stronger by **redesigning them as diverse agro ecosystems**—incorporating trees and native perennials, reducing dependence on fertilizers and pesticides, and reintegrating crops and livestock;

**Develop new crop varieties, livestock breeds, and farm practices** specifically designed to help farmers adapt to evolving climate realities.

# Addressing the root of the problem

Finally, whatever we do to help farmers adapt to climate change, we still face the urgent need and obligation to reduce the source of the problem as far and as fast as we can. This means bringing net emissions of heat-trapping gases down to zero, and doing it soon. Fortunately, our farm and food system can be an important part of the solution, both by reducing emissions at every stage of the food production and distribution process, and by building agroecosystems that can sequester (store) more carbon.

### **III.** Policy recommendations

What policy levers can we pull to help get these solutions off the ground?

**Invest in public research.** Publicly funded research provides farmers with the tools and information they need to maximize efficiency and productivity. With climate change, farmers need science more than ever, yet public funding for research that can help them cope has been in short supply. Agroecology research—which produces the kind of long-term, literally root-deep solutions that can help farms stay viable for generations—has been particularly underfunded.

**Expand conservation programs** in the federal farm bill that make it easier for farmers to adopt sustainable practices that will make their farms more climate-resilient. We need to boost their funding and their impact.

**Strengthen safety nets (and make them drivers of resilience)**. Regardless of what science and forward-looking policy can do, farms across the country will be challenged—and some more than others. It's essential that we provide farm families and communities with the support they need to survive the climate crisis and become more resilient. This includes better crop insurance programs, health care access for farmers and farm workers, and effective, responsive disaster relief programs.

Achieve net zero emissions. We need to prioritize policies to drastically reduce our climate emissions and give us a chance of getting to net zero ASAP. Reversing the Trump administration's withdrawal from the Paris Agreement would be a good start, but there is much more we can do.

### International efforts control green house gases and climate change

What is the United Nations Framework Convention on Climate Change? The UNFCCC entered into force on 21 March 1994. Today, it has near-universal membership. The 198 countries that

have ratified the Convention are called Parties to the Convention. Preventing "dangerous" human interference with the climate system is the ultimate aim of the UNFCCC. Definition: The United Nations Framework Convention on Climate Change (UNFCCC or FCCC) is an international environmental treaty negotiated at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. It entered into force on 21 March 1994 and today it has near-universal membership. The 195 countries that have ratified the Convention are called Parties to the Convention. The UNFCCC's main aim is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interferences with the climate system.

UNFCCC and the Rio Convention The UNFCCC is a "Rio Convention", one of two opened for signature at the "Rio Earth Summit" in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification. The three are intrinsically linked. It is in this context that the Joint Liaison Group was set up to boost cooperation among the three Conventions, with the ultimate aim of developing synergies in their activities on issues of mutual concern.

The Kyoto Protocol was adopted on 11 December 1997. Owing to a complex ratification process, it entered into force on 16 February 2005. Currently, there are 192 Parties to the Kyoto Protocol. In short, the Kyoto Protocol operationalizes the United Nations Framework Convention on Climate Change by committing industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets. The Convention itself only asks those countries to adopt policies and measures on mitigation and to report periodically. The Kyoto Protocol is based on the principles and provisions of the Convention and follows its annex-based structure. It only binds developed countries, and places a heavier burden on them under the principle of "common but differentiated responsibility and respectively capabilities", because it recognizes that they are largely responsible for the current high levels of GHG emissions in the atmosphere. In its Annex B, the Kyoto Protocol sets binding emission reduction targets for 37 industrialized countries and economies in transition and the European Union. Overall, these targets add up to an average 5 per cent emission reduction compared to 1990 levels over the five year period 2008–2012 (the first commitment period).

Doha Amendment In Doha, Qatar, on 8 December 2012, the Doha Amendment to the Kyoto Protocol was adopted for a second commitment period, starting in 2013 and lasting until 2020. As of 28 October 2020, 147 Parties deposited their instrument of acceptance, therefore the threshold of 144 instruments of acceptance for entry into force of the Doha Amendment was achieved. The amendment entered into force on 31 December 2020. The amendment includes: New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on• commitments in a second commitment period from 1 January 2013 to 31 December 2020; A revised list of GHG to be reported on by Parties in the second commitment period;• and Amendments to several articles of the Kyoto Protocol which specifically referenced• issues pertaining to the first commitment period and which needed to be updated for the second commitment period. On 21 December 2012, the amendment was circulated by the Secretary-General of the United Nations, acting in his capacity as Depositary, to all Parties to the Kyoto Protocol in accordance with Articles 20 and 21 of the Protocol. During the first commitment period, 37 industrialized countries and economies in transition and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

One important element of the Kyoto Protocol was the establishment of flexible market mechanisms, which are based on the trade of emissions permits. Under the Protocol, countries must meet their targets primarily through national measures. However, the Protocol also offers them an additional means to meet their targets by way of three market-based mechanisms: International Emissions Trading•

**Clean Development Mechanism (CDM)**• Joint implementation (JI)• These mechanisms ideally encourage GHG abatement to start where it is most cost-effective, for example, in the developing world. It does not matter where emissions are reduced, as long as they are removed from the atmosphere. This has the parallel benefits of stimulating green investment in developing countries and including the private sector in this endeavour to cut and hold steady GHG emissions at a safe level. It also makes leap-frogging—that is, the possibility of skipping the use

of older, dirtier technology for newer, cleaner infrastructure and systems, with obvious longerterm benefits—more economical. Monitoring emission targets

The Kyoto Protocol also established a rigorous monitoring, review and verification system, as well as a compliance system to ensure transparency and hold Parties to account. Under the Protocol, countries' actual emissions have to be monitored and precise records have to be kept of the trades carried out. Registry systems track and record transactions by Parties under the mechanism .The UN Climate Change Secretariat, based in Bonn, Germany, keeps an international transaction log to verify that transactions are consistent with the rules of the Protocol. Reporting is done by Parties by submitting annual emission inventories and national reports under the Protocol at regular intervals. A compliance system ensures that Parties are meeting their commitments and helps them to meet their commitments if they have problems doing so. Adaptation The Kyoto Protocol, like the Convention, is also designed to assist countries in adapting to the adverse effects of climate change. It facilitates the development and deployment of technologies that can help increase resilience to the impacts of climate change. The Adaptation Fund was established to finance adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol. In the first commitment period, the Fund was financed mainly with a share of proceeds from CDM project activities. In Doha, in 2012, it was decided that for the second commitment period, international emissions trading and joint implementation would also provide the Adaptation Fund with a 2 percent share of proceeds.

**The Paris Agreement**-The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by midcentury.

The Paris Agreement is a landmark in the multilateral climate change process because, for the first time, a binding agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects. How does the Paris Agreement work? Implementation of the Paris Agreement requires economic and social transformation, based on the best available science. The Paris Agreement works on a 5- year cycle of increasingly

ambitious climate action carried out by countries. By 2020, countries submit their plans for climate action known as nationally determined contributions (NDCs).NDCs In their NDCs, countries communicate actions they will take to reduce their Greenhouse Gas emissions in order to reach the goals of the Paris Agreement. Countries also communicate in the NDCs actions they will take to build resilience to adapt to the impacts of rising temperatures. Long-Term Strategies To better frame the efforts towards the long-term goal, the Paris Agreement invites countries to formulate and submit by 2020 long-term low greenhouse gas emission development strategies (LT-LEDS). LT-LEDS provide the long-term horizon to the NDCs. Unlike NDCs, they are not mandatory. Nevertheless, they place the NDCs into the context of countries' long-term planning and development priorities, providing a vision and direction for future development. How are countries supporting one another? The Paris Agreement provides a framework for financial, technical and capacity building support to those countries who need it. Finance The Paris Agreement reaffirms that developed countries should take the lead in providing financial assistance to countries that are less endowed and more vulnerable, while for the first time also encouraging voluntary contributions by other Parties. Climate finance is needed for mitigation, because large-scale investments are required to significantly reduce emissions. Climate finance is equally important for adaptation, as significant financial resources are needed to adapt to the adverse effects and reduce the impacts of a changing climate. Technology The Paris Agreement speaks of the vision of fully realizing technology development and transfer for both improving resilience to climate change and reducing GHG emissions. It establishes a technology framework to provide overarching guidance to the well-functioning Technology Mechanism. The mechanism is accelerating technology development and transfer through it's policy and implementation arms. Capacity-Building Not all developing countries have sufficient capacities to deal with many of the challenges brought by climate change. As a result, the Paris Agreement places great emphasis on climate-related capacity-building for developing countries and requests all developed countries to enhance support for capacity-building actions in developing countries. How are we tracking progress? With the Paris Agreement, countries established an enhanced transparency framework (ETF). Under ETF, starting in 2024, countries will report transparently on actions taken and progress in climate change mitigation, adaptation measures and support provided or received. It also provides for international procedures for the review of the submitted reports. The information gathered through the ETF will feed into the Global stocktake which will

assess the collective progress towards the long-term climate goals. This will lead to recommendations for countries to set more ambitious plans in the next round. What have we achieved so far? Although climate change action needs to be massively increased to achieve the goals of the Paris Agreement, the years since its entry into force have already sparked lowcarbon solutions and new markets. More and more countries, regions, cities and companies are establishing carbon neutrality targets. Zero-carbon solutions are becoming competitive across economic sectors representing 25% of emissions. This trend is most noticeable in the power and transport sectors and has created many new business opportunities for early movers. By 2030, zero-carbon solutions could be competitive in sectors representing over 70% of global emissions. What are governing, process management, subsidiary, constituted and concluded Bodies? The Convention, the Kyoto Protocol, and the Paris Agreement establish the institutional arrangements for the climate change intergovernmental process: A supreme governing body: the COP for the Convention, the CMP for the Kyoto• Protocol and the CMA for the Paris Agreement; A process management body: the Bureau of the COP, the CMP and the CMA;• Subsidiary bodies: two permanent subsidiary bodies - the SBSTA and the SBI - as• well as other ad hoc subsidiary bodies established by the COP, the CMP, or the CMA as deemed necessary to address specific issues; Technical subsidiary bodies with limited membership (referred to in practice as the constituted bodies) established under the Convention, the Kyoto Protocol and the Paris Agreement; A secretariat; and • Entities entrusted with the operations of the Financial Mechanism (i.e. the Global• Environment Facility -GEF- and the Green Climate Fund -GCF-). Collectively, these institutions participate in the process of developing policies and guidance to support Parties in the implementation of the Convention, the Kyoto Protocol and the Paris Agreement. Governing bodies & process management body Conference of the Parties (COP) The COP is the supreme decision-making body of the Convention. All States that are Parties to the Convention are represented at the COP, at which they review the implementation of the Convention and any other legal instruments that the COP adopts and take decisions necessary to promote the effective implementation of the Convention, including institutional and administrative arrangements. Conference of the Parties (COP) What is the COP? The COP is the supreme decision-making body of the Convention. All States that are Parties to the Convention are represented at the COP, at which they review the implementation of the Convention and any other legal instruments that the COP adopts and take decisions necessary to promote the effective implementation of the Convention, including institutional and administrative arrangements. More Background on the COP A key task for the COP is to review the national communications and emission inventories submitted by Parties. Based on this information, the COP assesses the effects of the measures taken by Parties and the progress made in achieving the ultimate objective of the Convention. The COP meets every year, unless the Parties decide otherwise. The first COP meeting was held in Berlin, Germany in March, 1995. The COP meets in Bonn, the seat of the secretariat, unless a Party offers to host the session. Just as the COP Presidency rotates among the five recognized UN regions - that is, Africa, Asia, Latin America and the Caribbean, Central and Eastern Europe and Western Europe and Others – there is a tendency for the venue of the COP to also shift among these groups.

The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to the Kyoto Protocol. All States that are Parties to the Kyoto Protocol are represented at the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP), while States that are not Parties participate as observers. The CMP oversees the implementation of the Kyoto Protocol and takes decisions to promote its effective implementation. What is the CMP? The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to the Kyoto Protocol. All States that are Parties to the Kyoto Protocol are represented at the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP), while States that are not Parties participate as observers. The CMP oversees the implementation of the Kyoto Protocol and takes decisions to promote its effective implementation. More Background on the CMP The CMP meets annually during the same period as the COP. Parties to the Convention that are not Parties to the Protocol are able to participate in the CMP as observers, but without the right to take decisions. The functions of the CMP relating to the Protocol are similar to those carried out by the COP for the Convention. The first meeting of the Parties to the Kyoto Protocol was held in Montreal, Canada in December 2005, in conjunction with the eleventh session of the Conference of the Parties (COP 11). The Parties to the Kyoto Protocol also formally adopted the "rulebook" of the 1997 Kyoto Protocol, the so-called 'Marrakesh accords', which sets the framework for implementation of the Protocol. The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to the Paris Agreement. All States that are Parties to the Paris Agreement are represented at the Conference of the Parties serving as the meeting of the Parties

to the Paris Agreement (CMA), while States that are not Parties participate as observers. The CMA oversees the implementation of the Paris Agreement and takes decisions to promote its effective implementation. The CMA meets annually during the same period as the COP. Parties to the Convention that are not Parties to the Paris Agreement are able to participate in the CMA as observers, but without the right to take decisions. The functions of the CMA relating to the Paris Agreement are similar to those carried out by the COP for the Convention. The Bureau supports the COP, CMP and CMA through the provision of advice and guidance regarding the ongoing work under the Convention, the Kyoto Protocol, and the Paris Agreement, the organization of their sessions and the operation of the secretariat, especially at times when the COP, CMP, and CMA are not in session. The Bureau is elected from representatives of Parties nominated by each of the five United Nations regional groups and Small Island Developing States. The Bureau is mainly responsible for questions of process management. It assists the President in the performance of his or her duties by providing advice and by helping with various tasks (e.g. members undertake consultations on behalf of the President). The Bureau is responsible for examining the credentials of Parties, reviewing the list of IGOs and NGOs seeking accreditation, and submitting a report thereon to the Conference. Secretariat The UNFCCC secretariat provides organizational support and technical expertise to the UNFCCC negotiations and institutions and facilitates the flow of authoritative information on the implementation of the Convention, the Kyoto Protocol and the Paris Agreement. This includes the development and effective implementation of innovative approaches to mitigate climate change and drive sustainable development. What is the purpose of the Secretariat? The UNFCCC secretariat (UN Climate Change) is the United Nations entity tasked with supporting the global response to the threat of climate change. UNFCCC stands for United Nations Framework Convention on Climate Change. The Convention has near universal membership (198 Parties) and is the parent treaty of the 2015 Paris Agreement. The main aim of the Paris Agreement is to keep the global average temperature rise this century as close as possible to 1.5 degrees Celsius above pre-industrial levels. The UNFCCC is also the parent treaty of the 1997 Kyoto Protocol. The ultimate objective of all three agreements under the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system, in a time frame which allows ecosystems to adapt naturally and enables sustainable development. When was the secretariat created? The secretariat was established in 1992 when countries adopted the UNFCCC. The original secretariat was in Geneva. Since 1996, the secretariat has been located in Bonn, Germany. Who works at the secretariat? Around 450 staff are employed at UN Climate Change. Secretariat staff come from over 100 countries and represent a blend of diverse cultures, gender and professional backgrounds. At the head of the secretariat is the Executive Secretary, a position held by Mr. Simon Stiell of Grenada since August 2022. What does the secretariat do? Focusing in its early years largely on facilitating the intergovernmental climate change negotiations, the secretariat today supports a complex architecture of bodies that serve to advance the implementation of the Convention, the Kyoto Protocol and the Paris Agreement. The secretariat provides technical expertise and assists in the analysis and review of climate change information reported by Parties and in the implementation of the Kyoto mechanisms. It also maintains the registry for Nationally Determined Contributions (NDC) established under the Paris Agreement, a key aspect of implementation of the Paris Agreement. The secretariat organizes and supports between two and four negotiating sessions each year. The largest and most important is the Conference of the Parties, held annually and hosted in different locations around the globe. It is the largest annual United Nations conference, attended on average by around 25,000 participants. In addition to these major conferences, the secretariat organizes annual sessions of the so-called subsidiary bodies as well as a large number of meetings and workshops throughout the year. In recent years, the secretariat also supports the Marrakech Partnership for Global Climate Action, agreed by governments to signal that successful climate action requires strong support from a wide range of actors, including regions, cities, business, investors and all parts of civil society. At UN Climate Change Conferences, a large number of events demonstrate how non-Party stakeholders are working with governments and the UN system to implement the Paris Agreement. In addition, the secretariat co-organizes regional Climate Weeks. The important events aim to drive forward Paris Agreement implementation at the regional level and to build new climate action partnerships. United Nations institutional linkage The United Nations serves as Depository for the Convention, the Kyoto Protocol (including its amendments) and the Paris Agreement.

The secretariat is institutionally linked to the United Nations without being integrated into any programme and is administered under United Nations rules and regulations. The Conference of the Parties Recalling its decisions 14/CP.1, 22/CP.5 and 6/CP.6 Recalling also General Assembly resolution 50/115 of 20 December 1995, resolution 54/222 of 22 December 1999, and resolution

56/199 of 21 December 2001, Having considered the report of the Executive Secretary on the implementation of the arrangements on the institutional linkage of the secretariat to the United Nations,1 Noting that the Executive Secretary consulted with the Under-Secretary-General for Management and the Under-SecretaryGeneral for Economic and Social Affairs at United Nations Headquarters on this matter, Noting with satisfaction that the linkage continues to provide a sound basis for the functioning and administration of the secretariat,

1. Expresses its appreciation to the Secretary-General of the United Nations for the support provided to the secretariat through the Department of Economic and Social Affairs and the Department of Management.

2. Approves the continuation of the current institutional linkage of the secretariat to the United Nations and related administrative arrangements until such time as a review is deemed necessary by either the Conference of the Parties or the General Assembly.

3. Invites the Secretary-Generndorsement of the General Assembly at its sixty-first session for the continuation of the institutional linkage. Subsidiary bodies Subsidiary Body for Scientific and Technological Advice (SBSTA) The SBSTA assists the governing bodies through the provision of timely information and advice on scientific and technological matters as they relate to the Convention, the Kyoto Protocol and the Paris Agreement. In addition, the SBSTA cooperates with relevant international organizations on scientific, technological and methodological questions. The SBSTA is one of two permanent subsidiary bodies to the Convention established by the COP/CMP. It supports the work of the COP, the CMP and the CMA through the provision of timely information and advice on scientific and technological matters as they relate to the Convention, its Kyoto Protocol and the Paris Agreement. Key areas of work for the SBSTA include the impacts, vulnerability and adaptation to climate change, promoting the development and transfer of environmentally-sound technologies and conducting technical work to improve the guidelines for preparing and reviewing greenhouse gas emission inventories from Annex I Parties. The SBSTA carries out methodological work under the Convention, the Kyoto Protocol and the Paris Agreement, and promotes collaboration in the field of research and systematic observation of the climate system. In addition, the SBSTA plays an important role as the link between the scientific information provided by expert sources such as the IPCC on the one hand, and the policy-oriented needs of the COP on the other hand. It works

closely with the IPCC, sometimes requesting specific information or reports from it, and also collaborates with other relevant international organizations that share the common objective of sustainable development. The SBSTA and SBI work together on cross-cutting issues that touch on both their areas of expertise. These include the vulnerability of developing countries to climate change and response measures, discussions under the Technology Mechanism, the Adaptation Committee and the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts. The SBSTA and the SBI have traditionally met in parallel, twice a year. When they are not meeting in conjunction with the COP, the subsidiary bodies. More recently, the Paris Committee on Capacity-building (PCCB), created in 2015, meets annually in conjunction with the spring sessions of the SBI and addresses current and emerging gaps and needs in implementing and further enhancing capacity-building in developing countries. The PCCB and the Durban Forum report on their work to the COP through the SBI at the sessions of the SBI held in conjunction with sessions of the COP.

# Cooperation with UN bodies/agencies and intergovernmental organizations Intergovernmental Panel on Climate Change (IPCC)

The IPCC is a scientific body. It reviews and assesses, at regular intervals, the most recent scientific, technical and socioeconomic information produced worldwide, relevant to the understanding of climate change. It does not conduct any research, nor does it monitor climate-related data or parameters. The UN Climate change process receives the outputs of the IPCC and uses IPCC data and information as a baseline on the state of knowledge on climate change in making science-based decisions. End of 2018, the IPCC Special Report on global warming of 1.5 C sent strong messages on the need to be more ambitious in taking action if the objective of staying well below 2 degrees is to be achieved. The IPCC is currently in its Sixth Assessment cycle. During this cycle, the Panel will produce three Special Reports, a Methodology Report on national greenhouse gas inventories and the Sixth Assessment Report (AR6).

These conferences are the foremost global forums for multilateral discussion of climate change matters, and have an incredibly busy schedule. The conferences, which rotate annually among the five United Nations regional groups, serve as the formal meetings of the Conference of the Parties (COP), the Conference of the Parties serving as the meeting of the Parties to the Kyoto

Protocol(CMP) and the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (the CMA).

The UNFCCC secretariat supports all institutions involved in the negotiations, as well as the Bureau of the COP/CMP/CMA, which is the executive body that advises the President of the conference. Meetings of the Conference of the Parties (COP/CMP/CMA): The Conference of the Parties – meeting as COP, CMP and CMA – serves two main purposes:

1. To review the implementation of the Convention, the Kyoto Protocol and the Paris Agreement, respectively; and

2. To adopt decisions to further develop and implement these three instruments.

The latter can include establishment of any subsidiary bodies that are deemed necessary. Parties may also negotiate and adopt new legal instruments, like the Paris Agreement adopted by the COP in 2015 or the Doha Amendment to the Kyoto Protocol adopted by the CMP in 2012. The conduct of the meetings follows certain rules (the so-called UNFCCC draft rules of procedure that are being applied by the COP, CMP, CMA and their subsidiary bodies). The brokering of agreed outcomes within the collective decision-making framework of the COP/CMP/CMA, however, is often a highly complex exercise which involves negotiation and compromise.

The conduct of the meetings and brokering of agreements within the collective decisionmaking framework of the COP therefore involves negotiation and compromise.

The five principles of UNFCCC responsibility; (b) Principle 2: Reduce overall climate impact; (c) Principle 3: Educate for climate action; (d) Principle 4: Promote sustainable and responsible consumption; (e) Principle 5: Advocate for climate action through communication. UNFCCC a law The UNFCCC is the principal international legal instrument adopted by countries to address climate change.

### UN conference on climate change: COP27 in Egypt

The 27th Conference of the Parties (COP27) to the United Nations Framework Convention on Climate Change (UNFCCC) was held in Sharm el-Sheikh, Egypt from **November 6-18, 2022**. The Conference of the Parties (COP) is an annual meeting that brings together the 197 Parties to

the UNFCCC. More information about COP27 can be found on the Egyptian presidency's official website.

Canada participated in COP27 to support successful and ambitious outcomes that are in line with the Paris Agreement's long-term goals. Parties were expected to continue and increase their mitigation efforts in order to keep the goal of limiting global temperature increase to 1.5°C within reach, build adaptive capacity and resilience, and deliver on climate finance commitments.

COP27 was also an opportunity to showcase Canadian climate action. Months ahead of COP26 in Glasgow, Canada announced its new ambitious Nationally Determined Contribution to cut emissions by 40-45% below 2005 levels by 2030. The Government of Canada established the 2030 Emissions Reduction Plan on March 29, 2022 to provide a credible roadmap to achieve Canada's 2030 target and put us on a path towards net-zero emissions by 2050. Canada is also finalizing our first National Adaptation Strategy in 2022 and delivering on our five-year (2021-2026) \$5.3 billion international climate finance commitment.

The latest science, including the 2022 Sixth Assessment Reports of the Intergovernmental Panel on Climate Change, points to climate change intensifying across the planet, at a time when the other global crises of biodiversity loss and pollution are also coming into sharp focus. That's why Canada is taking strong action at home and demonstrating leadership overseas.

### Canada's delegation

The Government of Canada is committed to taking a whole-of-government, whole-of-society approach to climate change action. Full participation from Canadians in all parts of the country and all sectors of the economy is essential to building an effective path forward that both achieves Canada's climate goals for 2030 and 2050 and builds a prosperous economy. Canada recognizes the need to mobilize as many resources as possible in the fight against climate change, and the key is to take into account diverse perspectives.

Minister Steven Guilbeault led Canada's delegation to COP27, supported by Canada's Ambassador for Climate Change, Catherine Stewart. Steven Kuhn, Canada's Chief Negotiator for Climate Change led Canada's participation in the negotiations.Canada's COP27 delegation

included representatives from various groups, including parliamentarians representing both the House of Commons and the Senate, representatives from civil society organizations, business, labour, most provinces and territories as well as Indigenous representatives and youth. This year a member of the new Environment and Climate Change Youth Council joined Canada's delegation to COP27. Canada's strong presence in this important climate conference demonstrated our leadership and commitment to inclusive and effective climate action at home and abroad.

#### **<u>COP27 climate summit: What India can expect at UNFCCC meet in Egypt?</u>**

Against a backdrop of weather extremes and geopolitical crises, two upcoming UN summits, the climate change conference in Egypt and the biodiversity summit in Canada to which India is a crucial Party to both -- are considered to be pivotal moments in global efforts to address the interlinked global warming and extinction crises.Unlike other "gap" reports, including last week's UNEP Emissions Gap report, which describe a divide between mitigation ambition and the emissions reductions needed to achieve the climate goals to be discussed at the UN Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP27) in Sharm El-Sheikh, Egypt, from November 6-20.

The biodiversity meeting named COP15, the biggest conference in a decade, in Montreal, Canada, is expected to deliver a biodiversity agreement on par with the Paris Agreement, a legally binding international treaty on climate change that was adopted by 196 Parties at COP21 in Paris in December 2015 with the goal to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels.

### What India can expect at COP27?

The main focus this year will be on climate financing where India will push for better financing for G20 countries.Power and New and Renewable Energy Minister R.K. Singh said the International Solar Alliance would "take up the cause" of demanding delivery of the Paris Agreement's \$100 billion per year climate financing pledge, which was supposed to run from 2020 to 2025 before increasing thereafter.According to the latest OECD analysis, the climate

finance provided and mobilised by developed countries for climate action in developing countries reached \$83.3 billion in 2020.

This is a further four per cent increase from 2019 and followed a one per cent increase from 2018 to 2019. However, it still falls short of the goal for developed countries to provide and mobilise \$100 billion a year for developing countries by 2020. The increase in 2020 climate finance was primarily driven by a rise in public flows.India's updated climate plan comprises 45 per cent reduction in emissions intensity by 2030 and to reach 500 GW of non-fossil installed capacity by 2030.Future technologies including green hydrogen, offshore wind, off grid and decentralized renewable energy applications need to be adapted.

A new report by BloombergNEF (BNEF) states that India will require \$223 billion investment in order to meet its goal of wind and solar capacity installations by 2030 as in its updated Nationally Determined Contribution (NDC), India has committed to 50 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. This will necessitate the need to attract private finance.

Climate negotiators say the recent slew of policies show India is serious about meeting its 2030 decadal targets, which can set the pathway for its 2070 net-zero decarbonisation, pledged by Prime Minister Narendra Modi in November at the COP26 climate summit in Glasgow, Scotland.

UNFCCC defines climate finance as "local, national or transnational financing, drawn from public, private and alternative sources of financing,that seeks to support mitigation and adaptation actions that will address climate change".Climate finance is necessary for mitigation because large-scale investments are required to significantly reduce emissions. It is also equally important for adaptation, as significant financial resources are needed to adapt to the adverse effects and reduce the impacts of a changing climate.

The Green Climate Fund (GCF) will play a major role in supporting India to make this transition. But central banks and other financial institutions will have to step up their game.What's needed is a multi-sovereign de-risking mechanism.R.R. Rashmi, Distinguished Fellow at The Energy and Resources Institute, said India hasn't benefited much from the \$100 billion climate finance. As UN Secretary-General, Antonio Guterres says: "COP27 must provide a clear and time-bound roadmap on closing the finance gap for addressing loss and damage. This will be a central litmus test for success at COP27."

The UN estimates that the current cost of meeting adaptation needs is \$70 billion. By 2050, it could reach \$500 billion. According to the Carbon Disclosure Project, just for water risks alone, the costs of doing nothing is five times that of acting today.

As recent extreme weather events across the developing and developed world showed adaptation is not just for the most vulnerable, host Egypt in a message sums up acethe world needs to come together to act now to save lives and livelihoods.

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