AMENDMENT TO H.R. 910, AS REPORTED
OFFERED BY MR. CONNOLLY OF VIRGINIA

Redesignate sections 2 through 4 as sections 3 through 5, respectively, and insert after section 1 the following:

SEC. 2. FINDINGS.

The Congress finds as follows:

(1) Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.

(2) Eleven of the last twelve years (1995–2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The 100-year linear trend (1906–2005) of 0.74 [0.56 to 0.92]°C is larger than the corresponding trend of 0.6 [0.4 to 0.8]°C (1901–2000) given in the Third Assessment Report (TAR). The temperature increase is widespread over the globe and is greater at higher northern latitudes. Land regions have warmed faster than the oceans.

(3) Rising sea level is consistent with warming. Global average sea level has risen since 1961 at an average rate of 1.8 [1.3 to 2.3] mm/yr and since 1993 at 3.1 [2.4 to 3.8] mm/yr, with contributions from thermal expansion, melting glaciers and ice caps, and the polar ice sheets. Whether the faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer-term trend is unclear.

(4) Observed decreases in snow and ice extent are also consistent with warming. Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3] percent per decade, with larger decreases in summer of 7.4 [5.0 to 9.8] percent per decade. Mountain glaciers and snow cover on average have declined in both hemispheres.

(5) From 1900 to 2005, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia but declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Globally, the area affected by drought has likely increased since the 1970s.

(6) It is very likely that over the past 50 years: cold days, cold nights and frosts have become less

frequent over most land areas, and hot days and hot nights have become more frequent. It is likely that: heat waves have become more frequent over most land areas, the frequency of heavy precipitation events has increased over most areas, and since 1975 the incidence of extreme high sea level has increased worldwide.

(7) There is observational evidence of an increase in intense tropical cyclone activity in the North Atlantic since about 1970, with limited evidence of increases elsewhere. There is no clear trend in the annual numbers of tropical cyclones. It is difficult to ascertain longer-term trends in cyclone activity, particularly prior to 1970.

(8) Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years.

(9) Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

(10) Changes in snow, ice and frozen ground have with high confidence increased the number and

size of glacial lakes, increased ground instability in mountain and other permafrost regions and led to changes in some Arctic and Antarctic ecosystems.

(11) There is high confidence that some hydrological systems have also been affected through increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers and through effects on thermal structure and water quality of warming rivers and lakes.

(12) In terrestrial ecosystems, earlier timing of spring events and pole ward and upward shifts in plant and animal ranges are with very high confidence linked to recent warming. In some marine and freshwater systems, shifts in ranges and changes in algal, plankton, and fish abundance are with high confidence associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation.

(13) Of the more than 29,000 observational data series, from 75 studies, that show significant change in many physical and biological systems, more than 89 percent are consistent with the direction of change expected as a response to warming. However, there is a notable lack of geographic bal-

ance in data and literature on observed changes, with marked scarcity in developing countries.

(14) There is medium confidence that other effects of regional climate change on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers. They include effects of temperature increases on agricultural and forestry management at Northern Hemisphere higher latitudes, such as earlier spring planting of crops, and alterations in disturbance regimes of forests due to fires and pests some aspects of human health, such as heat-related mortality in Europe, changes in infectious disease vectors in some areas, and allergenic pollen in Northern Hemisphere high and mid-latitudes some human activities in the Arctic (e.g. hunting and travel over snow and ice) and in lower-elevation alpine areas (such as mountain sports).

(15) Changes in atmospheric concentrations of greenhouse gases (GHGs) and aerosols, land cover and solar radiation alter the energy balance of the climate system.

(16) Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70 percent between 1970 and 2004.

(17) Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its annual emissions grew by about 80 percent between 1970 and 2004. The long-term trend of declining CO_2 emissions per unit of energy supplied reversed after 2000.

(18) Global atmospheric concentrations of CO_2, methane (CH_4) and nitrous oxide (N_2O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years.

(19) Atmospheric concentrations of CO_2 (379ppm) and CH_4 (1774ppb) in 2005 exceed by far the natural range over the last 650,000 years. Global increases in CO_2 concentrations are due primarily to fossil fuel use, with land-use change providing another significant but smaller contribution. It is very likely that the observed increase in CH_4 concentration is predominantly due to agriculture and fossil fuel use. CH_4 growth rates have declined since the early 1990s, consistent with total emissions (sum of anthropogenic and natural sources) being nearly constant during this period. The increase in N_2O concentration is primarily due to agriculture.

(20) There is very high confidence that the net effect of human activities since 1750 has been one of warming.

(21) Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations. It is likely that there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica).

(22) During the past 50 years, the sum of solar and volcanic forcings would likely have produced cooling. Observed patterns of warming and their changes are simulated only by models that include anthropogenic forcings. Difficulties remain in simulating and attributing observed temperature changes at smaller than continental scales.

(23) Advances since the TAR show that discernible human influences extend beyond average temperature to other aspects of climate.

(24) Human influences have very likely contributed to sea level rise during the latter half of the 20th century likely contributed to changes in wind patterns, affecting extra-tropical storm tracks and temperature patterns likely increased temperatures

of extreme hot nights, cold nights and cold days more likely than not increased risk of heat waves, area affected by drought since the 1970s and frequency of heavy precipitation events.

(25) Anthropogenic warming over the last three decades has likely had a discernible influence at the global scale on observed changes in many physical and biological systems.

(26) Spatial agreement between regions of significant warming across the globe and locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability. Several modeling studies have linked some specific responses in physical and biological systems to anthropogenic warming.

(27) More complete attribution of observed natural system responses to anthropogenic warming is currently prevented by the short time scales of many impact studies, greater natural climate variability at regional scales, contributions of non-climate factors, and limited spatial coverage of studies.

(28) There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development prac-

tices, global GHG emissions will continue to grow over the next few decades.

(29) The IPCC Special Report on Emissions Scenarios projects an increase of global GHG emissions by 25 to 90 percent between 2000 and 2030, with fossil fuels maintaining their dominant position in the global energy mix to 2030 and beyond. More recent scenarios without additional emissions mitigation are comparable in range.

(30) Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century

(31) For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emissions scenarios. Even if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Afterwards, temperature projections increasingly depend on specific emissions scenarios.

(32) The range of projections is broadly consistent with the TAR, but uncertainties and upper ranges for temperature are larger mainly because

the broader range of available models suggests stronger climate-carbon cycle feedbacks. Warming reduces terrestrial and ocean uptake of atmospheric CO_2, increasing the fraction of anthropogenic emissions remaining in the atmosphere. The strength of this feedback effect varies markedly among models.

(33) Because understanding of some important effects driving sea level rise is too limited, this report does not assess the likelihood, nor provide a best estimate or an upper bound for sea level rise. The projections do not include uncertainties in climate-carbon cycle feedbacks nor the full effects of changes in ice sheet flow, therefore the upper values of the ranges are not to be considered upper bounds for sea level rise. They include a contribution from increased Greenland and Antarctic ice flow at the rates observed for 1993–2003, but this could increase or decrease in the future.

(34) There is now higher confidence than in the TAR in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation and some aspects of extremes and sea ice.

(35) Warming greatest over land and at most high northern latitudes and least over Southern

Ocean and parts of the North Atlantic Ocean, continuing recent observed trends contraction of snow cover area, increases in thaw depth over most permafrost regions and decrease in sea ice extent; in some projections using SRES scenarios, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century very likely increase in frequency of hot extremes, heat waves and heavy precipitation likely increase in tropical cyclone intensity; less confidence in global decrease of tropical cyclone numbers pole ward shift of extra-tropical storm tracks with consequent changes in wind, precipitation and temperature patterns very likely precipitation increases in high latitudes and likely decreases in most subtropical land regions, continuing observed recent trends.

(36) There is high confidence that by mid-century, annual river runoff and water availability are projected to increase at high latitudes (and in some tropical wet areas) and decrease in some dry regions in the mid-latitudes and tropics. There is also high confidence that many semi-arid areas (e.g. Mediterranean Basin, western United States, southern Africa and north-eastern Brazil) will suffer a decrease in water resources due to climate change.

(37) Studies since the TAR have enabled more systematic understanding of the timing and magnitude of impacts related to differing amounts and rates of climate change.

(38) Africa.—By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50 percent. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10 percent of Gross Domestic Product (GDP). By 2080, an increase of 5 to 8 percent of arid and semi-arid land in Africa is projected under a range of climate.

(39) Asia.—By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. Coastal areas, especially heavily populated megadelta regions in South, East and South-East

Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers. Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development. Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.

(40) AUSTRALIA AND NEW ZEALAND.—By 2020, significant loss of biodiversity is projected to occur in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics.

(41) By 2030, water security problems are projected to intensify in southern and eastern Australia and, in New Zealand, in Northland and some eastern regions.

(42) By 2030, production from agriculture and forestry is projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire. However, in New Zealand, initial benefits are projected in some other regions.

(43) By 2050, ongoing coastal development and population growth in some areas of Australia and New Zealand are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding.

(44) EUROPE.—Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods and more frequent coastal flooding and increased erosion (due to storminess and sea level rise). Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60 percent under high emissions scenarios by 2080). In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. Climate change is also projected to increase the health risks due to heat waves and the frequency of wildfires.

(45) LATIN AMERICA.—By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replace-

ment of tropical forest by savanna in eastern Amazonia. Semi-arid vegetation will tend to be replaced by arid-land vegetation. There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America. Productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones, soybean yields are projected to increase. Overall, the number of people at risk of hunger is projected to increase (TS; medium confidence). Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation.

(46) NORTH AMERICA.—Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources. In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20 percent, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which

depend on highly utilized water resources. Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts. Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.

(47) POLAR REGIONS.—The main projected biophysical effects are reductions in thickness and extent of glaciers, ice sheets and sea ice, and changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and higher predators. For human communities in the Arctic, impacts, particularly those resulting from changing snow and ice conditions, are projected to be mixed. Detrimental impacts would include those on infrastructure and traditional indigenous ways of life. In both Polar Regions, specific ecosystems and habitats are projected to be vulnerable, as climatic barriers to species invasions are lowered.

(48) SMALL ISLANDS.—Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening

vital infrastructure, settlements and facilities that support the livelihood of island communities. Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources. By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods. With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands.

(49) Some systems, sectors and regions are likely to be especially affected by climate change.

(50) SYSTEMS AND SECTORS/PARTICULAR ECOSYSTEMS; TERRESTRIAL.—Tundra, boreal forest and mountain regions because of sensitivity to warming; Mediterranean-type ecosystems because of reduction in rainfall; and tropical rainforests where precipitation declines coastal: mangroves and salt marshes, due to multiple stresses marine: coral reefs due to multiple stresses; the sea ice biome because of sensitivity to warming water resources in some dry regions at mid-latitudes and in the dry tropics, due to changes in rainfall and evapotranspiration, and in

areas dependent on snow and ice melt agriculture in low latitudes, due to reduced water availability low-lying coastal systems, due to threat of sea level rise and increased risk from extreme weather events human health in populations with low adaptive capacity.

(51) REGIONS.—The Arctic, because of the impacts of high rates of projected warming on natural systems and human communities Africa, because of low adaptive capacity and projected climate change impacts small islands, where there is high exposure of population and infrastructure to projected climate change impacts Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges and river flooding.

(52) Within other areas, even those with high incomes, some people (such as the poor, young children and the elderly) can be particularly at risk, and also some areas and some activities.

(53) OCEAN ACIDIFICATION.—The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic with an average decrease in pH of 0.1 units. Increasing atmospheric CO_2 concentrations lead to further acidification. Projections based on SRES scenarios give a reduc-

tion in average global surface ocean pH of between 0.14 and 0.35 units over the 21st century. While the effects of observed ocean acidification on the marine biosphere are as yet undocumented, the progressive acidification of oceans is expected to have negative impacts on marine shell-forming organisms (e.g. corals) and their dependent species.

(54) Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems.

(55) Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights; Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks; effects on water resources relying on snowmelt; effects on some water supplies; reduced human mortality from decreased cold exposure; reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; and effects on winter tourism.

(56) WARM SPELLS/HEAT WAVES.—Frequency increases over most land areas; Very likely Reduced yields in warmer regions due to heat stress; in-

creased danger of wildfire; Increased water demand; water quality problems, e.g. algal blooms; Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated; Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor.

(57) Frequency of heavy precipitation events will increase over most areas. Very likely damage to crops; soil erosion, inability to cultivate land due to water logging of soils.

(58) Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved. Increased risk of deaths, injuries and infectious, respiratory and skin diseases. Disruption of settlements, commerce, transport and societies due to flooding: pressures on urban and rural infrastructures; loss of property.

(59) Area affected by drought increases the likelihood of land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire; more widespread water stress; increased risk of food and water shortage; increased risk of malnutrition; increased risk of water- and food- borne diseases; water shortage for settle-

ments, industry and societies; reduced hydropower generation potentials; potential for population migration.

(60) Intense tropical cyclone activity increases the likelihood of damage to crops; windthrow (uprooting) of trees; damage to coral reefs.

(61) Power outages causing disruption of public water supply; increased risk of deaths, injuries, water- and food- borne diseases; post-traumatic stress disorders Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers; potential for population migrations; loss of property.

(62) Increased incidence of extreme high sea level (excludes tsunamis).

(63) Salinisation of irrigation water, estuaries and fresh- water systems; decreased freshwater availability due to saltwater intrusion; increased risk of deaths and injuries by drowning in floods; migration-related health effects; Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure.

(64) Contraction of the Greenland ice sheet is projected to continue to contribute to sea level rise after 2100. Current models suggest virtually com-

plete elimination of the Greenland ice sheet and a resulting contribution to sea level rise of about 7m if global average warming were sustained for millennia in excess of 1.9 to 4.6°C relative to pre-industrial values. The corresponding future temperatures in Greenland are comparable to those inferred for the last interglacial period 125,000 years ago, when palaeoclimatic information suggests reductions of polar land ice extent and 4 to 6m of sea level rise.

(65) Current global model studies project that the Antarctic ice sheet will remain too cold for widespread surface melting and gain mass due to increased snowfall. However, net loss of ice mass could occur if dynamical ice discharge dominates the ice sheet mass balance.

(66) Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change.

(67) Partial loss of ice sheets on polar land could imply meters of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands. Such changes are projected to occur over millennial time scales, but more rapid sea level rise on century time scales cannot be excluded.

(68) Climate change is likely to lead to some irreversible impacts. There is medium confidence that approximately 20 to 30 percent of species assessed so far are likely to be at increased risk of extinction if increases in global average warming exceed 1.5 to 2.5°C (relative to 1980–1999). As global average temperature increase exceeds about 3.5°C, model projections suggest significant extinctions (40 to 70 percent of species assessed) around the globe.

(69) Based on current model simulations, the meridional overturning circulation (MOC) of the Atlantic Ocean will very likely slow down during the 21st century; nevertheless temperatures over the Atlantic and Europe are projected to increase. The MOC is very unlikely to undergo a large abrupt transition during the 21st century. Longer-term MOC changes cannot be assessed with confidence. Impacts of large-scale and persistent changes in the MOC are likely to include changes in marine ecosystem productivity, fisheries, ocean CO_2 uptake, oceanic oxygen concentrations and terrestrial vegetation. Changes in terrestrial and ocean CO_2 uptake may feedback on the climate system.

(70) A wide array of adaptation options is available, but more extensive adaptation than is cur-

rently occurring is required to reduce vulnerability to climate change. There are barriers, limits and costs, which are not fully understood.

(71) Societies have a long record of managing the impacts of weather- and climate-related events. Nevertheless, additional adaptation measures will be required to reduce the adverse impacts of projected climate change and variability, regardless of the scale of mitigation undertaken over the next two to three decades. Moreover, vulnerability to climate change can be exacerbated by other stresses. These arise from, for example, current climate hazards, poverty and unequal access to resources, food insecurity, trends in economic globalization, conflict and incidence of diseases such as HIV/AIDS.

(72) Some planned adaptation to climate change is already occurring on a limited basis. Adaptation can reduce vulnerability, especially when it is embedded within broader sectoral initiatives. There is high confidence that there are viable adaptation options that can be implemented in some sectors at low cost, and/or with high benefit-cost ratios. However, comprehensive estimates of global costs and benefits of adaptation are limited.

(73) Selected examples of planned adaptation by sector. Sector Adaptation option/strategy; underlying policy framework; key constraints and opportunities to implementation; water expanded rainwater harvesting; water storage and conservation techniques; water re-use; desalination; water-use and irrigation efficiency; National water policies and integrated water resources management; water-related hazards management; financial, human resources and physical barriers; integrated water resources management; synergies with other sectors.

(74) Agriculture adjustment of planting dates and crop variety; crop relocation; improved land management, e.g. erosion control and soil protection through tree planting; R&D policies; institutional reform; land tenure and land reform; training; capacity building; crop insurance; financial incentives, e.g. subsidies and tax credits; technological and financial constraints; access to new varieties; markets; longer growing season in higher latitudes; revenues from ‘‘new’’ products;

(75) Infrastructure/settlement (including coastal zones); relocation; seawalls and storm surge barriers; dune reinforcement; land acquisition and creation of marshlands/wetlands as buffer against sea

level rise and flooding; protection of existing natural barriers; standards and regulations that integrate climate change considerations into design; land-use policies; building codes; insurance.

(76) Financial and technological barriers; availability of relocation space; integrated policies and management; synergies with sustainable development goals; human health; heat-health action plans; emergency medical services; improved climate-sensitive disease surveillance and control; safe water and improved sanitation Public health policies that recognize climate risk; strengthened health services; regional and international cooperation Limits to human tolerance (vulnerable groups); knowledge limitations; financial capacity; upgraded health services; improved quality of life.

(77) TOURISM.—Diversification of tourism attractions and revenues; shifting ski slopes to higher altitudes and glaciers; artificial snow-making.

(78) Integrated planning (e.g. carrying capacity; linkages with other sectors); financial incentives, e.g. subsidies and tax credits; appeal/marketing of new attractions; financial and logistical challenges; potential adverse impact on other sectors (e.g. artificial snow-making may increase energy use); revenues

from ''new'' attractions; involvement of wider group of stakeholders.

(79) TRANSPORTATION.—Realignment/relocation; design standards and planning for roads, rail and other infrastructure to cope with warming and drainage; integrating climate change considerations into national transport policy; investment in R&D for special situations; financial and technological barriers; availability of less vulnerable routes; improved technologies and integration with key sectors (e.g. energy).

(80) ENERGY.—Strengthening of overhead transmission and distribution infrastructure; underground cabling for utilities; energy efficiency; use of renewable sources; reduced dependence on single sources of energy National energy policies, regulations, and fiscal and financial incentives to encourage use of alternative sources; incorporating climate change in design standards; access to viable alternatives; financial and technological barriers; acceptance of new technologies; stimulation of new technologies; use of local resources. (Note: Other examples from many sectors would include early warning systems. Adaptive capacity is intimately connected to

social and economic development but is unevenly distributed across and within societies.).

(81) A range of barriers limits both the implementation and effectiveness of adaptation measures. The capacity to adapt is dynamic and is influenced by a society's productive base, including natural and man-made capital assets, social networks and entitlements, human capital and institutions, governance, national income, health and technology. Even societies with high adaptive capacity remain vulnerable to climate change, variability and extremes.

(82) Both bottom-up and top-down studies indicate that there is high agreement and much evidence of substantial economic potential for the mitigation of global GHG emissions over the coming decades that could offset the projected growth of global emissions or reduce emissions below current levels. While top-down and bottom-up studies are in line at the global level there are considerable differences at the sectoral level.

(83) No single technology can provide all of the mitigation potential in any sector. The economic mitigation potential, which is generally greater than the market mitigation potential, can only be

achieved when adequate policies are in place and barriers removed.

(84) Bottom-up studies suggest that mitigation opportunities with net negative costs have the potential to reduce emissions by around 6 $GtCO_2$-eq/yr in 2030, realizing which requires dealing with implementation barriers.

(85) Future energy infrastructure investment decisions, expected to exceed $20,000,000,000,000 between 2005 and 2030, will have long-term impacts on GHG emissions, because of the long lifetimes of energy plants and other infrastructure capital stock. The widespread diffusion of low-carbon technologies may take many decades, even if early investments in these technologies are made attractive. Initial estimates show that returning global energy-related CO_2 emissions to 2005 levels by 2030 would require a large shift in investment patterns, although the net additional investment required ranges from negligible to 5 to 10 percent.

(86) A wide variety of policies and instruments are available to governments to create the incentives for mitigation action. Their applicability depends on national circumstances and sectoral context.

(87) They include integrating climate policies in wider development policies, regulations and standards, taxes and charges, tradable permits, financial incentives, voluntary agreements, information instruments, and research, development and demonstration (RD&D).

(88) An effective carbon-price signal could realize significant mitigation potential in all sectors. Modeling studies show that global carbon prices rising to \$20-80/tCO_2-eq by 2030 are consistent with stabilization at around 550ppm CO_2-eq by 2100. For the same stabilization level, induced technological change may lower these price ranges to \$5-65/tCO_2-eq in 2030.

(89) There is high agreement and much evidence that mitigation actions can result in near-term co-benefits (e.g. improved health due to reduced air pollution) that may offset a substantial fraction of mitigation costs.

(90) There is high agreement and medium evidence that Annex I countries' actions may affect the global economy and global emissions, although the scale of carbon leakage remains uncertain.

(91) Fossil fuel exporting nations (in both Annex I and non-Annex I countries) may expect, as

indicated in the TAR, lower demand and prices and lower GDP growth due to mitigation policies. The extent of this spillover depends strongly on assumptions related to policy decisions and oil market conditions.

(92) There is also high agreement and medium evidence that changes in lifestyle, behavior patterns and management practices can contribute to climate change mitigation across all sectors.

(93) Many options for reducing global GHG emissions through international cooperation exist. There is high agreement and much evidence that notable achievements of the UNFCCC and its Kyoto Protocol are the establishment of a global response to climate change, stimulation of an array of national policies, and the creation of an international carbon market and new institutional mechanisms that may provide the foundation for future mitigation efforts. Progress has also been made in addressing adaptation within the UNFCCC and additional international initiatives have been suggested.

(94) Greater cooperative efforts and expansion of market mechanisms will help to reduce global costs for achieving a given level of mitigation, or will improve environmental effectiveness. Efforts can in-

clude diverse elements such as emissions targets; sectoral, local, sub-national and regional actions; RD&D programs; adopting common policies; implementing development-oriented actions; or expanding financing instruments.

(95) In several sectors, climate response options can be implemented to realize synergies and avoid conflicts with other dimensions of sustainable development. Decisions about macroeconomic and other non-climate policies can significantly affect emissions, adaptive capacity and vulnerability.

(96) Making development more sustainable can enhance mitigative and adaptive capacities, reduce emissions and reduce vulnerability, but there may be barriers to implementation. On the other hand, it is very likely that climate change can slow the pace of progress towards sustainable development. Over the next half-century, climate change could impede achievement of the Millennium Development Goals.

(97) Determining what constitutes ''dangerous anthropogenic interference with the climate system'' in relation to Article 2 of the UNFCCC involves value judgments. Science can support informed decisions on this issue, including by providing criteria

for judging which vulnerabilities might be labeled ‘‘key’’.

(98) Key vulnerabilities may be associated with many climate-sensitive systems, including food supply, infrastructure, health, water resources, coastal systems, ecosystems, global biogeochemical cycles, ice sheets and modes of oceanic and atmospheric circulation.

(99) The five ‘‘reasons for concern’’ identified in the TAR remain a viable framework to consider key vulnerabilities. These ‘‘reasons’’ are assessed here to be stronger than in the TAR. Many risks are identified with higher confidence. Some risks are projected to be larger or to occur at lower increases in temperature. Understanding about the relationship between impacts (the basis for ‘‘reasons for concern’’ in the TAR) and vulnerability (that includes the ability to adapt to impacts) has improved. This is due to more precise identification of the circumstances that make systems, sectors and regions especially vulnerable and growing evidence of the risks of very large impacts on multiple-century time scales.

(100) RISKS TO UNIQUE AND THREATENED SYSTEMS.—There is new and stronger evidence of

observed impacts of climate change on unique and vulnerable systems (such as polar and high mountain communities and ecosystems), with increasing levels of adverse impacts as temperatures increase further. An increasing risk of species extinction and coral reef damage is projected with higher confidence than in the TAR as warming proceeds. There is medium confidence that approximately 20 to 30 percent of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C over 1980–1999 levels. Confidence has increased that a 1 to 2°C increase in global mean temperature above 1990 levels (about 1.5 to 2.5°C above pre-industrial) poses significant risks to many unique and threatened systems including many biodiversity hotspots. Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1 to 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals. Increasing vulnerability of indigenous communities in the Arctic and small island communities to warming is projected.

(101) RISKS OF EXTREME WEATHER EVENTS.—Responses to some recent extreme events reveal higher levels of vulnerability than the TAR. There is now higher confidence in the projected increases in droughts, heat waves and floods, as well as their adverse impacts.

(102) DISTRIBUTION OF IMPACTS AND VULNERABILITIES.—There are sharp differences across regions and those in the weakest economic position are often the most vulnerable to climate change. There is increasing evidence of greater vulnerability of specific groups such as the poor and elderly not only in developing but also in developed countries. Moreover, there is increased evidence that low-latitude and less developed areas generally face greater risk, for example in dry areas and megadeltas.

(103) AGGREGATE IMPACTS.—Compared to the TAR, initial net market-based benefits from climate change are projected to peak at a lower magnitude of warming, while damages would be higher for larger magnitudes of warming. The net costs of impacts of increased warming are projected to increase over time.

(104) RISKS OF LARGE-SCALE SINGULARITIES.—There is high confidence that global warming over many centuries would lead to a sea level rise contribution from thermal expansion alone that is projected to be much larger than observed over the 20th century, with loss of coastal area and associated impacts. There is better understanding than in the TAR that the risk of additional contributions to sea level rise from both the Greenland and possibly Antarctic ice sheets may be larger than projected by ice sheet models and could occur on century time scales. This is because ice dynamical processes seen in recent observations but not fully included in ice sheet models assessed in the AR4 could increase the rate of ice loss.

(105) There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change.

(106) Adaptation is necessary in the short and longer term to address impacts resulting from the warming that would occur even for the lowest stabilization scenarios assessed. There are barriers, limits and costs, but these are not fully understood.

Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed and human systems to adapt. The time at which such limits could be reached will vary between sectors and regions. Early mitigation actions would avoid further locking in carbon intensive infrastructure and reduce climate change and associated adaptation needs.

(107) Many impacts can be reduced, delayed or avoided by mitigation. Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilization levels and increase the risk of more severe climate change impacts.

(108) In order to stabilize the concentration of GHGs in the atmosphere, emissions would need to peak and decline thereafter. The lower the stabilization level, the more quickly this peak and decline would need to occur.

(109) Sea level rise under warming is inevitable. Thermal expansion would continue for many centuries after GHG concentrations have stabilized, for any of the stabilization levels assessed, causing

an eventual sea level rise much larger than projected for the 21st century. The eventual contributions from Greenland ice sheet loss could be several meters, and larger than from thermal expansion, should warming in excess of 1.9 to 4.6°C above pre-industrial be sustained over many centuries. The long time scales of thermal expansion and ice sheet response to warming imply that stabilization of GHG concentrations at or above present levels would not stabilize sea level for many centuries.

(110) There is high agreement and much evidence that all stabilization levels assessed can be achieved by deployment of a portfolio of technologies that are either currently available or expected to be commercialized in coming decades, assuming appropriate and effective incentives are in place for their development, acquisition, deployment and diffusion and addressing related barriers.

(111) All assessed stabilization scenarios indicate that 60 to 80 percent of the reductions would come from energy supply and use and industrial processes, with energy efficiency playing a key role in many scenarios. Including non-CO_2 and CO_2 land-use and forestry mitigation options provides greater flexibility and cost-effectiveness. Low sta-

bilization levels require early investments and substantially more rapid diffusion and commercialization of advanced low-emissions technologies.

(112) Without substantial investment flows and effective technology transfer, it may be difficult to achieve emission reduction at a significant scale. Mobilizing financing of incremental costs of low-carbon technologies is important.

(113) The macro-economic costs of mitigation generally rise with the stringency of the stabilization target. For specific countries and sectors, costs vary considerably from the global average.

(114) In 2050, global average macro-economic costs for mitigation towards stabilization between 710 and 445ppm CO_2-eq are between a 1 percent gain and 5.5 percent decrease of global GDP. This corresponds to slowing average annual global GDP growth by less than 0.12 percentage points.

(115) Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity and attitudes to risk.

(116) Impacts of climate change are very likely to impose net annual costs, which will increase over

time as global temperatures increase. Peer-reviewed estimates of the social cost of carbon in 2005 average \$12 per ton of CO_2, but the range from 100 estimates is large (-\$3 to \$95/tCO_2). This is due in large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses and discount rates. Aggregate estimates of costs mask significant differences in impacts across sectors, regions and populations and very likely underestimate damage costs because they cannot include many non-quantifiable impacts.

(117) Limited and early analytical results from integrated analyses of the costs and benefits of mitigation indicate that they are broadly comparable in magnitude, but do not as yet permit an unambiguous determination of an emissions pathway or stabilization level where benefits exceed costs.

(118) Climate sensitivity is a key uncertainty for mitigation scenarios for specific temperature levels.

(119) Choices about the scale and timing of GHG mitigation involve balancing the economic costs of more rapid emission reductions now against

the corresponding medium-term and long-term climate risks of delay.

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