Annex: From *the Science of AR5 WG1and the Consequences (2013)*

Future Climate Change and Impacts
South Asia
(Pakistan, India, Nepal, Bhutan, Bangladesh, Burma, portions of China)

Observed Temperature Change

- Increase of 0.4-0.8°C, with most warming in the western portion (Pakistan and western India) (Figure 1)

Projected Climate Change
Temperature:

- Mid-term (2046–2065): increase of 2-3°C, warmest temperature focused in the northern portion (Nepal, Bhutan, southern China, northern India, Pakistan) (Figure 2)
- Long-term (2081–2100): increase of 3-5°C, warmest temperatures focused in the northern portion (Pakistan, northern India, southern China, Nepal, Bhutan) (Figure 2)
- The warmest daily maximum temperature is projected to increase 4-5°C, with highest temperatures in northern India, Pakistan, southern China, Nepal, Bhutan (Figure 3)
- The number of tropical nights (that is the number of 24-hour days above 20°C) is projected to increase from between 0 and 80 days, with most concentrated in the southern portion of the region (India) (Figure 3)

Precipitation:

- Mid-term (2046–2065): 10 to 20% decrease in December - February over most of the region and a 20% increase during September – November over most of the region with a 30% increase in Pakistan (Figure 4)
- Long-term (2081–2100): 10% decrease to a 10% increase in December - February and a 20% to 50% increase in September – November. Most of this precipitation is projected to occur in the western portion of the region (Pakistan, India) (Figure 4)
- Overall, annual precipitation is projected to increase across most of the region (Figure 5)
- Increase in cloudiness and humidity over most of the region, but especially in the western portion (Pakistan, India) with a slight decrease in cloudiness over Nepal (Figure 6)
- Increase in annual mean soil moisture of up to 1 mm across much of the southern and western portion of the region (Pakistan, India, Bangladesh) and a sharp decrease in annual mean soil moisture of -0.8 to -1.6 mm in the northeastern portion of the region (Nepal, China, Bhutan) (Figure 7)
- Large increase in annual runoff (upwards of 40%), mostly in the western region (Pakistan, India) (Figure 7)

Climate Impacts
Water Resources

- Increased inter-annual and intra-seasonal variability of monsoon rainfall with an increase of 10% precipitation with global mean warming approaching 4°C (World Bank 2013)
- Increased risk of groundwater contamination with sea levels in India, China and Bangladesh (Han et al., 1999)
- Increased number of people living under severe water stress and the expansion of areas under severe water stress in South and Southeast Asia. For example, 120 million to 1.2 billion, and 185 to 981 million people will experience increased water stress by the 2020s, and the 2050s, respectively (Arnell, 2004)
- Climate change-related melting of glaciers could seriously affect half a billion people in the Himalaya-Hindu-Kush region and a quarter of a billion people in China who depend on glacial melt for their water supplies (Stern, 2007)
- Continued melting glaciers and increased runoff will lead to more flood risk, substantial reductions in dry season flow, and will negatively impact downstream agriculture, which relies on this water for irrigation (World Bank, 2013)
- Increasing salinity of groundwater and surface water resources, especially along the coast in India, China and Bangladesh, due to sea level rise and droughts (Han et al., 1999)
- Increasing frequency and intensity of droughts will lead to more serious and frequent salt-water intrusion in the estuaries (Xu, 2003; Thanh et al., 2004; Huang et al., 2005)

- Increased water stress during critical seasons (December – February) and more intense rain occurring over fewer days in India (Cruz et al. 2007)

Food Security

- In Bangladesh, production of rice and wheat might drop by 8% and 32%, respectively, by the year 2050 (Faisal and Parveen, 2004)
- Increased loses of rain-fed wheat in South and South-East Asia (Fischer et al., 2002)
- 2 to 5% decrease in yield potential of wheat and maize for a temperature rise of 0.5 to 1.5°C in India (Aggarwal, 2003)
- Decreased yields of non-irrigated wheat and rice will be significant for a temperature increase of beyond 2.5°C incurring a loss in farm-level net revenue of between 9% and 25% (Lal, 2011)
- The net cereal production in South Asian countries is projected to decline at least between 4 to 10% by the end of this century (Lal, 2011)
- Agricultural irrigation demand in arid and semi-arid regions of Asia is estimated to increase by at least 10% for an increase in temperature of 1°C (Fischer et al., 2002; Liu, 2002)
- Increased frequency of El Niño events would likely lead to declines in fish larvae abundance in coastal waters of South and Southeast Asia (Cruz et al. 2007)

Human Health

- Asian megacities with large populations and intensified socio-economic activities are subject to threats of climate change, sea-level rise and extreme climate events (Cruz et al. 2007)
- Increased risk of diarrhea and malnutrition in Southeast Asian countries including Bangladesh, Bhutan, India, Myanmar and Nepal (McMichael et al., 2004)
- Possible reduction in diarrhea and malnutrition in the southern states in India (Mitra et al., 2004)
- Climate-induced reduction in protein content of grains and a reduction of food availability could lead to a 35% increase in childhood stunting by 2050 (World Bank, 2103)
- Warmer sea-surface temperatures along coastlines of South and Southeast Asia would support higher phytoplankton blooms and these habitats could lead to the increased spread of infectious bacterial diseases such as cholera (Pascual et al., 2002)
- Precipitation increase, frequent floods and sea-level rise in the future will degrade the surface water quality and lead to more pollution and more water-borne infectious diseases such as dermatosis, cardiovascular disease and gastrointestinal disease (Cruz et al. 2007)
- Increased flooding and sea-level rise could also contaminate drinking water, which would then lead to more water-borne diseases including cholera and the suite of diarrheal diseases caused by organisms such as *Giardia, Salmonella* and *Cryptosporidium* (Cruz et al. 2007)

Sea-level rise

- Projected sea-level rise could flood the residences of millions of people living in the low lying areas of South, Southeast and East Asia such as in Vietnam, Bangladesh, India and China (Wassmann et al., 2004; Stern, 2007)
- Sea-level rise-induced erosion will increase and thus lead to more shoreline degradation and higher protection costs. For example, a 30 cm rise in sea level can result in 45 m of landward erosion in some coastal areas of Asia (Cruz et al. 2007; Huang and Xie, 2000)
- Sea level rise of 40 cm will increase the annual number of people flooded in coastal populations from 13 million to 94 million and almost 60% of this increase will occur in South Asia (along coasts from Pakistan, through India, Sri Lanka and Bangladesh to Burma) (Wassmann et al., 2004)
- A 1 m rise in sea level could put up to 4.1 million people at risk (Mimura and Yokoki, 2004)
- Increase in the destructive potential of tropical cyclones, and an increasing coastal population mean substantial increase in hurricane-related losses in the 21st century is likely (Emanuel, 2005)

Biodiversity

- Coastal erosion of the major deltas will be caused by sea-level rise, intensifying extreme events (e.g., storm surges) due to climate change and excessive pumping of groundwater for irrigation and reservoir construction upstream (Cruz et al. 2007)

- Mangrove forests, which are breeding grounds for many aquatic species, are under threat due to sea-level rise, storm surges, and coastal development (Tran et al., 2005)
- Increased frequency and intensity of extreme weather events will negatively impact aquatic ecosystems, and existing habitats will be redistributed, affecting species (Short and Neckles, 1999; Simas et al., 2001; Lu, 2003; Paerl et al., 2003)
- Up to 50% of Asia's total biodiversity is at risk due to climate change (Cruz et al. 2007)