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The impact of extreme events on energy installations and energy supply infrastructure

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ASSESSMENT OF IMPACT OF CLIMATE CHANGE AND EXTREME EVENTS ON ENERGY INSTALLATIONS AND ENERGY SUPPLY INFRASTRUCTURES IN PAKISTAN

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CLIMATE CHANGE

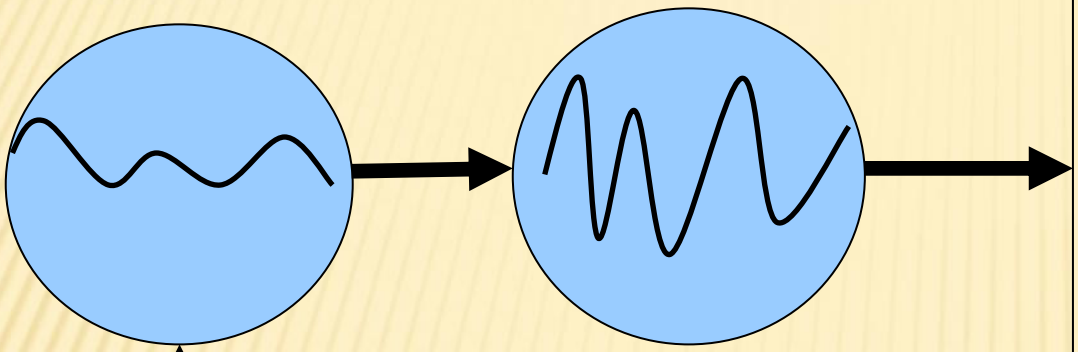
"the greatest challenge facing the world at the beginning of the century"

World Economic Forum

Davos, Switzerland 2000

Natural Climate Variability

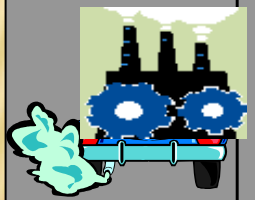
Climate Change
Natural + Anthropogenic



Anthropogenic Influences since the Industrial revolution

Spiraling Population

High pace of Industrialization



Increasing use of Fossil Fuels in Industry & Transport

Deforestation for Agriculture and Urbanization

CLIMATE CHANGE

Global Warming

Increased Precipitation & its Uneven Distribution

Melting of Glaciers & Snow

Sea level Rise

Increase in Frequency & Intensity of Extreme Weather Events

IMPACTS

Uncertainty in Water Availability

Decrease in Crop Yields

Newer perspective for sources of energy

Loss of Biodiversity

Increased Health Risks

SOME MAJOR FINDINGS OF IPCC AR4 (2007)

- 0.6 ^{0}C increase in average global temperature during the last century;
- Global temperature most likely to increase by 1.8 - 4.0 ^{0}C over the 21st Century. This will be accompanied by:
  - Large changes of temperature and precipitation in different world regions, particularly in *Central & South Asia*;
  - *Considerable increase in Frequency and Intensity of Extreme Climatic Events (cyclonic storms, floods, droughts etc.);*
  - Large scale melting of mountain glaciers;
  - Increase in average sea level by up to 0.6 m.
- All these changes will adversely affect various socio-economic sectors worldwide.

PAST AND EXPECTED FUTURE CLIMATIC CHANGES OVER PAKISTAN

(OBSERVED TRENDS)

- During the last century average annual temperature over Pakistan increased by 0.6 C, in agreement with the global trend, with the temperature increase over northern Pakistan being higher than over southern Pakistan (0.8 C versus 0.5 C)

- Precipitation over Pakistan also increased on the average by about 25 %.

PAST AND EXPECTED FUTURE CLIMATIC CHANGES OVER PAKISTAN (CONTD.)

(PROJECTED TRENDS)

- Studies based on the ensembles outputs of several GCMs project that the average temperature over Pakistan will increase in the range 1.3-1.5 C by 2020s, 2.5-2.8 C by 2050s, and 3.9-4.4 C by 2080s, corresponding to an increase in average global surface temperature by 2.8-3.4 C by the turn of 21st century.
- Precipitation is projected to increase slightly in summer and decrease in winter with no significant change in annual precipitation.
- *It is also projected that climate change will increase the variability of monsoon rains and enhance the frequency and severity of extreme events such as floods and droughts.*

MAJOR CC-RELATED CONCERNS OF PAKISTAN

The most important climate change threats to Pakistan are identified as:

- Increased variability of Monsoon;
- Rapid recession of Hindu Kush-Karakoram-Himalayan (HKH) Glaciers threatening water inflows into the Indus River System (IRS);
- *Threats due to Extreme Events i.e. Increased risks of floods droughts and cyclones;*
- *Increased siltation of major dams resulting in greater loss of reservoir capacity;*

MAJOR CC-RELATED CONCERNS OF PAKISTAN (CONTD.)

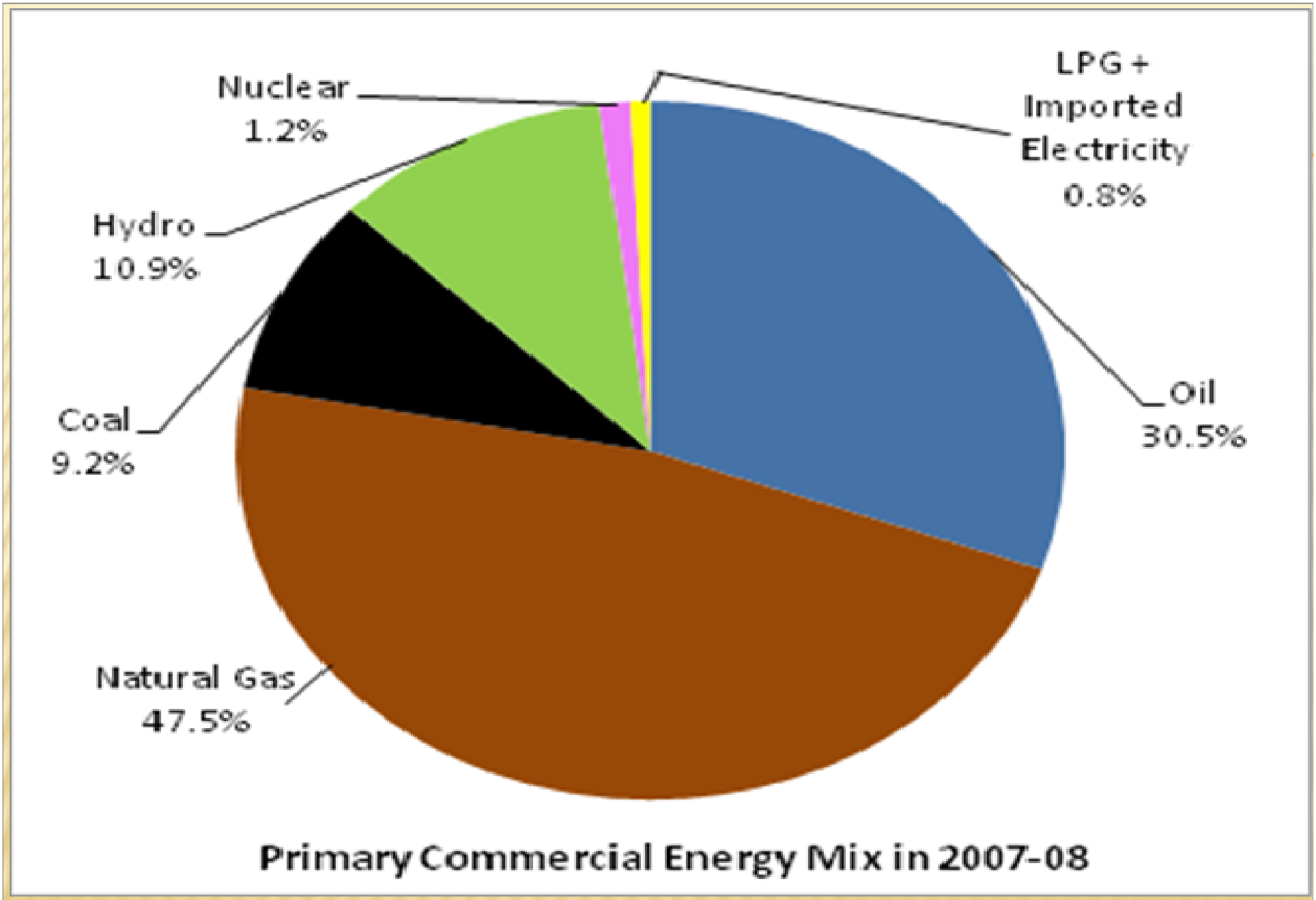
- Severe water-stressed and heat-stressed conditions in arid and semi-arid regions leading to reduced agriculture productivity and *power generation*;
- *Threats to coastal areas including the city of Karachi due to sea level rise and increased cyclonic activity due to higher surface temperature in the Arabian Sea;*

The above threats lead to major concerns for Pakistan in terms of its Water Security, Food Security, and Energy Security (risk to energy supply facilities).

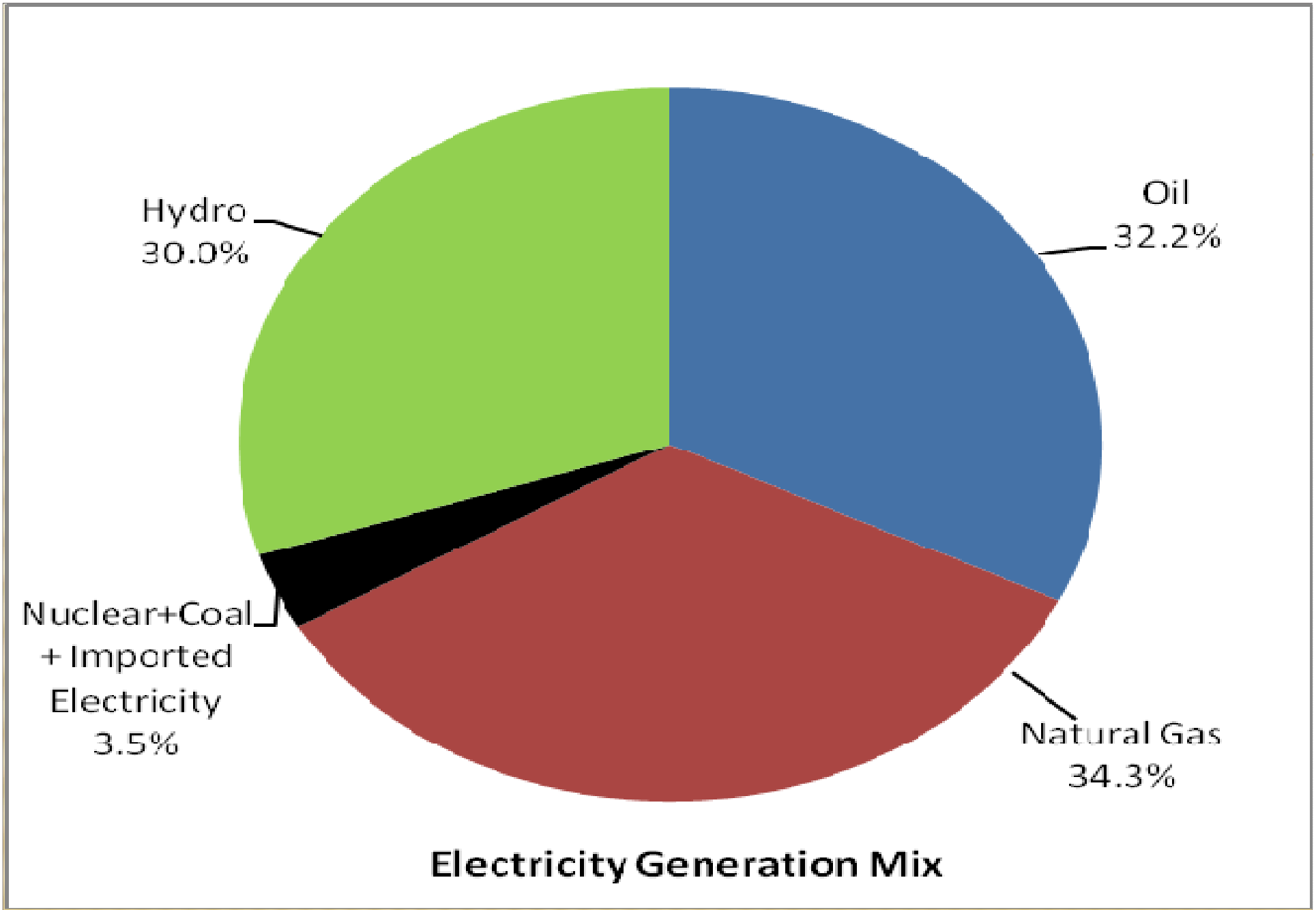
“ENERGY SECURITY of PAKISTAN”

ENERGY SECTOR OF PAKISTAN: CURRENT STATUS AND FUTURE NEEDS

- The primary commercial energy consumption in Pakistan in 2008 amounted to 62.9 Million tonnes of oil equivalent (mtoe)
- A total of 95.7 TWh of electricity were generated during the year 2008
- Figures show the Primary Energy supplies and Electricity Generation By-Source in 2008



Source: HDIP, Pakistan Energy Year Book 2008

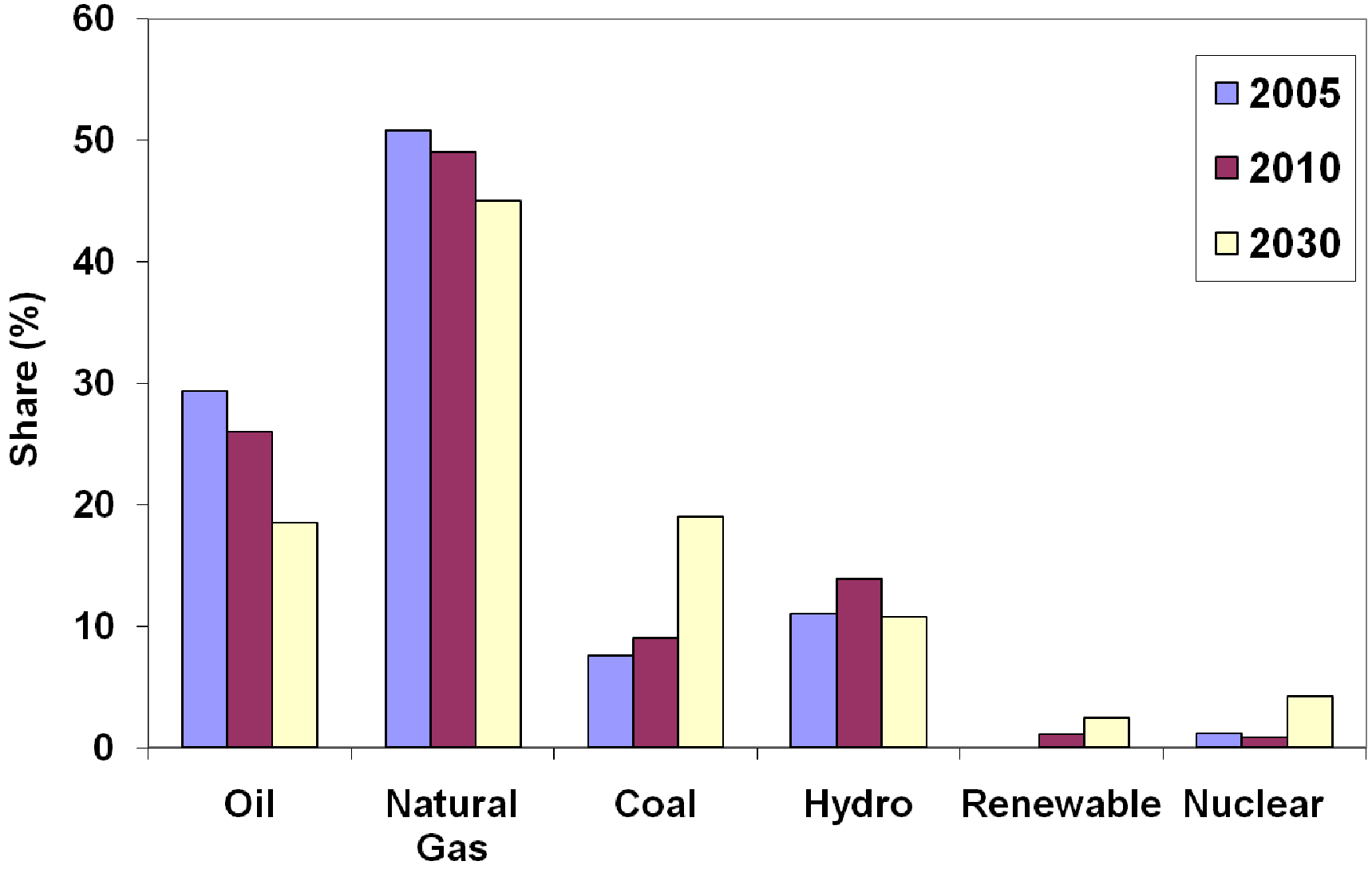


Source: HDIP, Pakistan Energy Year Book 2008

ENERGY SECTOR OF PAKISTAN: CURRENT STATUS AND FUTURE NEEDS (CONTD.)

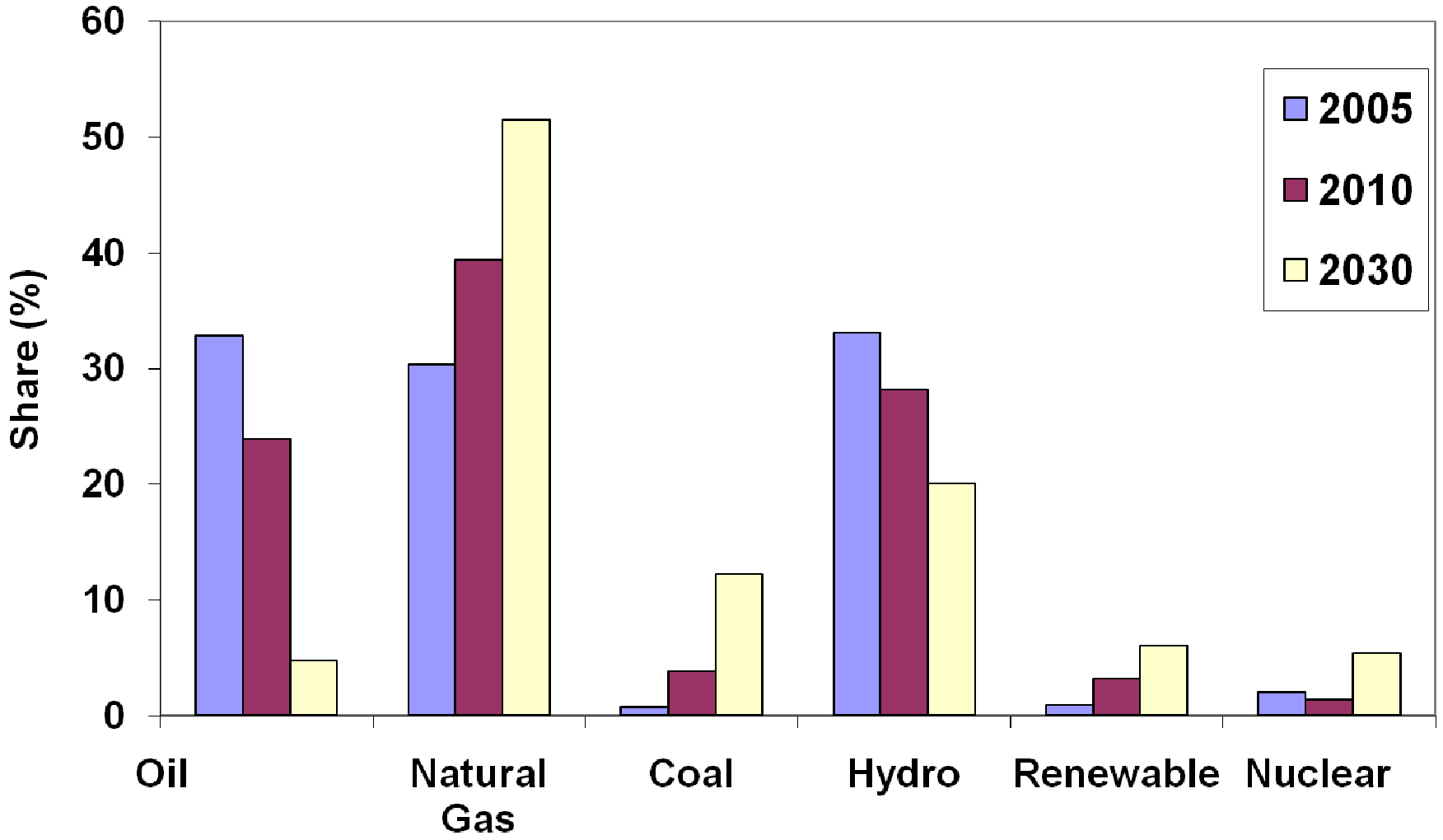
- Based on historical and current trends in economic and energy growth in Pakistan, the Planning Commission envisages in its Energy Security Action Plan (ESAP) for 2005-2030 that;
- The demand for energy will rise 6.5 fold from about 55 mtoe in 2005 to 360 mtoe by 2030;
- The corresponding requirements of power generation capacity have been projected to increase more than eight fold from about 19,500 MW in 2005 to 162,500 MW in 2030;

Energy Demand Projections by Fuel in Pakistan's Energy Security Action Plan (2005 – 2030)



Source: GoP-PC (2005, 2007)

Power Generation Capacity Mix in Pakistan's Energy Security Action Plan (2005 – 2030)



Source: GoP-PC (2005, 2007)

MAJOR CONCERNS

Climate change will affect the energy sector directly as well indirectly through the ripple effect from its impacts on other sectors. The main potential impacts of both the types are identified below:

LOCATION AND DESCRIPTION

- Pakistan is located within the latitudinal and longitudinal extensions 24°N to 37°N and 61°E to 76°E respectively
- The country is located in sub-tropics as well as in temperate region
- Mountainous North of the country comprises parallel mountain ranges intervened by narrow and deep river valleys
- Northern mountains comprise parts of the Himalayan and Karakoram ranges with a small part of the Hindukush range
- Separated by Kabul River, are the Western Highlands consisting of series of dry and lower hills
- Vast expanses of Arabian Sea lie to the south of Pakistan

DIFFERENT PHYSIOGRAPHIC AND CLIMATIC REGIONS OF PAKISTAN

Regions

I (a):
Greater Himalayas

I (b):
Sub-montane

II:
Western Highlands

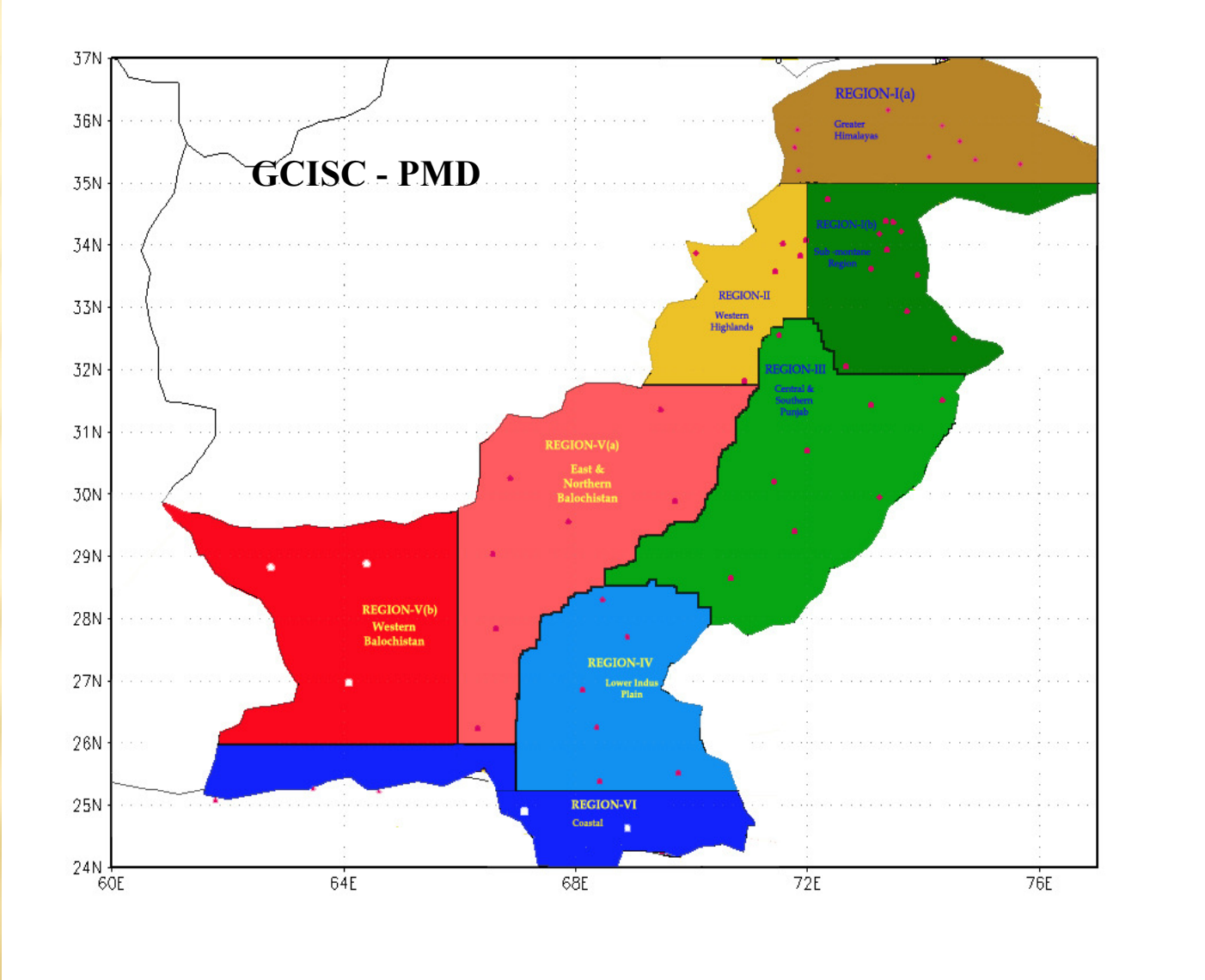
III
Central & Southern Punjab

IV
Lower Indus Plains

V (a)
Balochistan Plateau (East)

V (b)
Balochistan Plateau (West)

VI
Coastal Areas



The Indus River System, Pakistan

DIRECT IMPACTS

1) *On HYDROPOWER*

a) Changes in water availability and the timing of water availability for hydropower generation;
b) Increased rate of sedimentation / siltation of major reservoirs resulting in reduced hydropower generation capacity;

- Pakistan's water storage capacity comprises three large reservoirs *Mangla* (on Jhelum river mainly fed by snow melt and rains from summer monsoon), *Chashma* and *Tarbela* (on Indus river mainly fed by snow and glacier melt) built in the years 1967,1971 and 1974 with total original capacity of 18.37 maf.

DIRECT IMPACTS

On HYDROPOWER (contd.)

- Due to siltation process *the capacities of all the three reservoirs have been decreasing* with time.
- The total capacity decreased to *13.68 maf* in 2003 and is projected to decrease to *12.34 maf* by 2010.
- At present on the average 35 maf of water flows to the sea annually during flood season, while there is need to conserve every drop.
- With the frequency and intensity of floods and droughts increasing as a result of climate change, *there will be even greater need to store the surplus water* during high river flow periods (the summer months Apr-Sep) which will in turn benefit our hydro power system to produce electricity.

DIRECT IMPACTS

2) On NUCLEAR POWER

- Impact of sea level rise and increased cyclonic activity on existing energy infrastructure located along the coast;

- Pakistan's Nuclear Power capacity comprises of two plants KANNUP (of capacity 300 MW built on 1972) &
  CHASNUPP (of capacity 140 MW built on 2000)
- KANNUP is located It is located at Paradise Point on the arid Arabian Sea coast, about 15 miles to the west of Karachi as reactors usually require a large amount of water for cooling.
- This reason makes *KANNUP increasingly vulnerable to sea level rise, extreme weather and storm surges*.

DIRECT IMPACTS

On NUCLEAR POWER (contd.)

- CHASNUPP is located near Chashma Barrage on the left bank of River Indus, in Mianwali City.
- Thus it is dependent on increasingly valuable, and variable, freshwater supplies for cooling purposes.
- But Pakistan is extremely short of fresh water resources and under the pressure of increasing population, it became a water stressed country.
- Given the high cost, long life span and potential for damage of nuclear power plants, it is essential that substantially more research be done on how they will interact with an increasingly volatile global environmental system.

DIRECT IMPACTS

3) <u>On Thermal Power Plants</u>

a) Changes in water availability and the timing of water availability for thermal power plant cooling;
b) Reduced thermal power plant efficiency at elevated temperatures;

- Power plant operations can be affected by extreme heat waves. For example, intake water that is normally used to cool power plants become warm enough during extreme heat events that it compromises power plant operations.

DIRECT IMPACTS (CONTD.)

3) On RENEWABLE ENERGY RESOURCES

- Impact of changes in cloud cover, wind resources and agricultural productivity on renewable energy resources;

4) On ELECTRIC GRID

- Increased Transmission and Distribution (T&D) line losses due to elevated temperatures, and increased occurrence of blackouts resulting from line sagging;

INDIRECT IMPACTS

- Reductions in river flow rates with consequent reduction of hydropower generation will necessitate an increase in fossil fuel capacity and a commensurate increase in water cooling needs.
- Higher temperature will result in increased demand of energy for pumping ground water to meet higher irrigation requirements due to increased evapotranspiration, and to compensate for water losses due to evaporation.
- Higher temperatures will increase electricity demand for space cooling, thereby increasing the peak demand and hence requiring additional generation capacity.

THREATS DUE TO EXTREME EVENTS

- *Pakistan is extremely vulnerable to climate extremes as has been experienced over the last two decades.*

Some Salient Climate Extreme Events in Pakistan Since 1990

SOME SALIENT CLIMATE EXTREME EVENTS IN PAKISTAN SINCE 1990

- 2009

  Karachi received 205 mm of rain at Masroor Airbase and 143 mm at Airport on 18 & 19 July. Heaviest rainfall earlier recorded at Karachi Airport was 207 mm on 1st July, 1977. The normal rainfall at Karachi Airport for the periods 1961-1990 and 1971-2000 are respectively 85.5 mm and 66.2 mm.

- 2007

  Record heat wave gripped Pakistan during June, 2007. 48°C temperature was recorded on 9th June at Lahore, a record repeated after 78 years. Earlier it was recorded on 8th June 1929.

SOME SALIENT CLIMATE EXTREME EVENTS IN PAKISTAN SINCE 1990 (CONTD.)

- 2007

Two super cyclones namely Gonu (02A) of Cat-5 and Yemyin (03B) of Cat-1 developed in the Arabian Sea during June, 2007 and hit Makran coast and adjoining countries. The history of the Arabian Sea at least during the previous century shows no such events occurring twice in a month.

- 2006

In Pakistan, monsoon-related flooding resulted in more than 185 deaths from late July through mid-August 2006. In neighbouring eastern Afghanistan, heavy rainfall generated flooding that claimed at least 35 lives

SOME SALIENT CLIMATE EXTREME EVENTS IN PAKISTAN SINCE 1990 (CONTD.)

- 2005

  Heavy rain caused flooding in parts of Baluchistan / NWFP and Afghanistan during March. The flooding hit Baluchistan province very adversely. There were more than 30 fatalities in south-western Pakistan.

- 2005

  During June, unusually warm temperatures in the mountainous areas of northern Pakistan accelerated snowmelt and brought extensive flooding along the Kabul, Swat, Kunar and Chitral rivers.

SOME SALIENT CLIMATE EXTREME EVENTS IN PAKISTAN SINCE 1990 (CONTD.)

- 2003

  Heavy rain and snow produced flooding during February (around 17th of February) and was responsible for more than 60 deaths in Baluchistan province. Flash flooding washed away parts of roads and highways.

- 2003

  At least one million people were affected by seasonal monsoon rains in southern Pakistan. Heavy rains caused 162 deaths with 153 fatalities in the Sind province.

SOME SALIENT CLIMATE EXTREME EVENTS IN PAKISTAN SINCE 1990 (CONTD.)

- 2003

  During early June, a heat wave caused maximum temperature to reach 52°C at Jacobabad on the 5th of June; normal highs in early June are around 44°C.

- 2001

  620 mm rainfall in Islamabad during 10 hours in the month of July (on 23rd of July); it caused flooding in Lai nullah.

SOME SALIENT CLIMATE EXTREME EVENTS IN PAKISTAN SINCE 1990 (CONTD.)

- 1998-2001

  History's worst drought gripped southern parts of Pakistan and parts of surrounding countries.

- 1999

  A severe cyclonic storm hit the coastal areas of Pakistan and India and caused catastrophic damages.

SOME SALIENT CLIMATE EXTREME EVENTS IN PAKISTAN SINCE 1990 (CONTD.)

- 1996

  640 mm of rain was received by Lahore in August 1996, making it the wettest month for Lahore during the period 1961-2000. Previously the city received 511.7 mm rainfall during August 1976.

- 1996

  437.4 mm rainfall occurred in Lahore during a 3-day period (23-25 August) causing heaviest urban flooding of the city.

SOME SALIENT CLIMATE EXTREME EVENTS IN PAKISTAN SINCE 1990 (CONTD.)

- 1992

  Last century's worst flood in Jhelum river in Pakistan.

THANK YOU