CLIMATE CHANGE MITIGATION and ADAPTATION CONSIDERATIONS for HYDROPOWER PROJECTS in the INDUS BASIN

Dr Michael Clarke
Snowy Mountains Engineering Corporation

Government of Pakistan - Ministry of Water and Power
Project Management and Policy Implementation Unit
Water Sector Capacity Building and Advisory Services Project

The New York Times

ASIA PACIFIC

Starved for Energy, Pakistan Braces for a Water Crisis

By SALMAN MASOOD FEB. 12, 2015

ISLAMABAD, Pakistan — Energy-starved Pakistanis, their economy battered by chronic fuel and electricity shortages, may soon have to contend with a new resource crisis: major water shortages, the Pakistani government warned this week.

A combination of global climate change and local waste and mismanagement have led to an alarmingly rapid depletion of Pakistan's water supply, said the minister for water and energy, Khawaja Muhammad Asif.

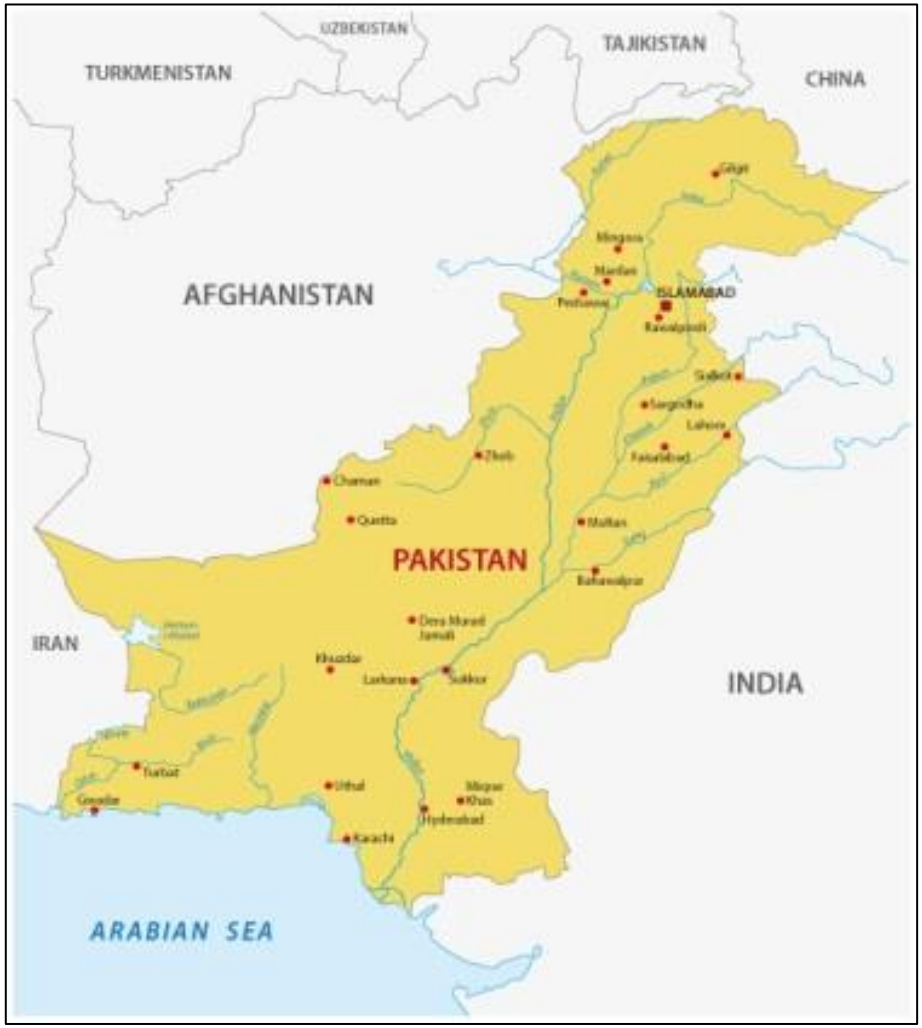
"Under the present situation, in the next six to seven years, Pakistan can be a water-starved country," Mr. Asif said in an interview, echoing a warning that he first issued at a news conference in Lahore this week.

The prospect of a major water crisis in Pakistan, even if several years distant, offers a stark reminder of a growing challenge in other poor and densely populated countries that are vulnerable to global climate change.

PROPOSED HYDROPOWER DEVELOPMENT

- In 2008, the Water and Power Development Authority (WADPA) announces "Vision 2025"
- Develop 80 billion cubic metres of water storage and add 37,770 megawatts of hydropower generation capacity by 2025
- Cost of implementation US$ 32.15 billion*

*(*up to $90 billion including privately funded projects)*



CLIMATE RISK INDEX 2012 for 10 MOST AFFECTED COUNTRIES

Ranking 2012 (2011)	Country	CRI score	Death toll	Deaths per 100,000 inhabitants	Absolute losses (in million US$ PPP)	Losses per unit GDP in %	Human Development Index[8]
1 (37)	Haiti	6.83	128	1.23	1220.66	9.53	161
2 (4)	Philippines	10.33	1408	1.47	1205.48	0.29	114
3 (3)	Pakistan	12.67	662	0.37	6087.82	1.11	146
4 (22)	Madagascar	15.67	113	0.50	356.98	1.69	151
5 (131)	Fiji	17.00	17	1.89	135.55	3.18	96
6 (36[9])	Serbia	17.67	28	0.39	1325.06	1.70	64
7 (131)	Samoa	18.33	6	3.28	220.91	19.57	96
8 (49)	Bosnia and Herzegovina	21.67	13	0.33	920.21	2.92	81

Source: Global Climate Risk Index – German Watch (2014)

VULNERABILITY of PAKISTAN to CLIMATE CHANGE

Physical Factors

- Dependence on a single major river system – The Indus River
- Source of Indus River is mainly glacier melt, susceptible to temperature changes
- Northern Pakistan's climate is influenced by three major weather systems:
    - Sub-Mediterranean regime of winter, westerly storms;
    - Indian summer monsoon;
    - Tibetan anticyclone (Huntington, 2006).

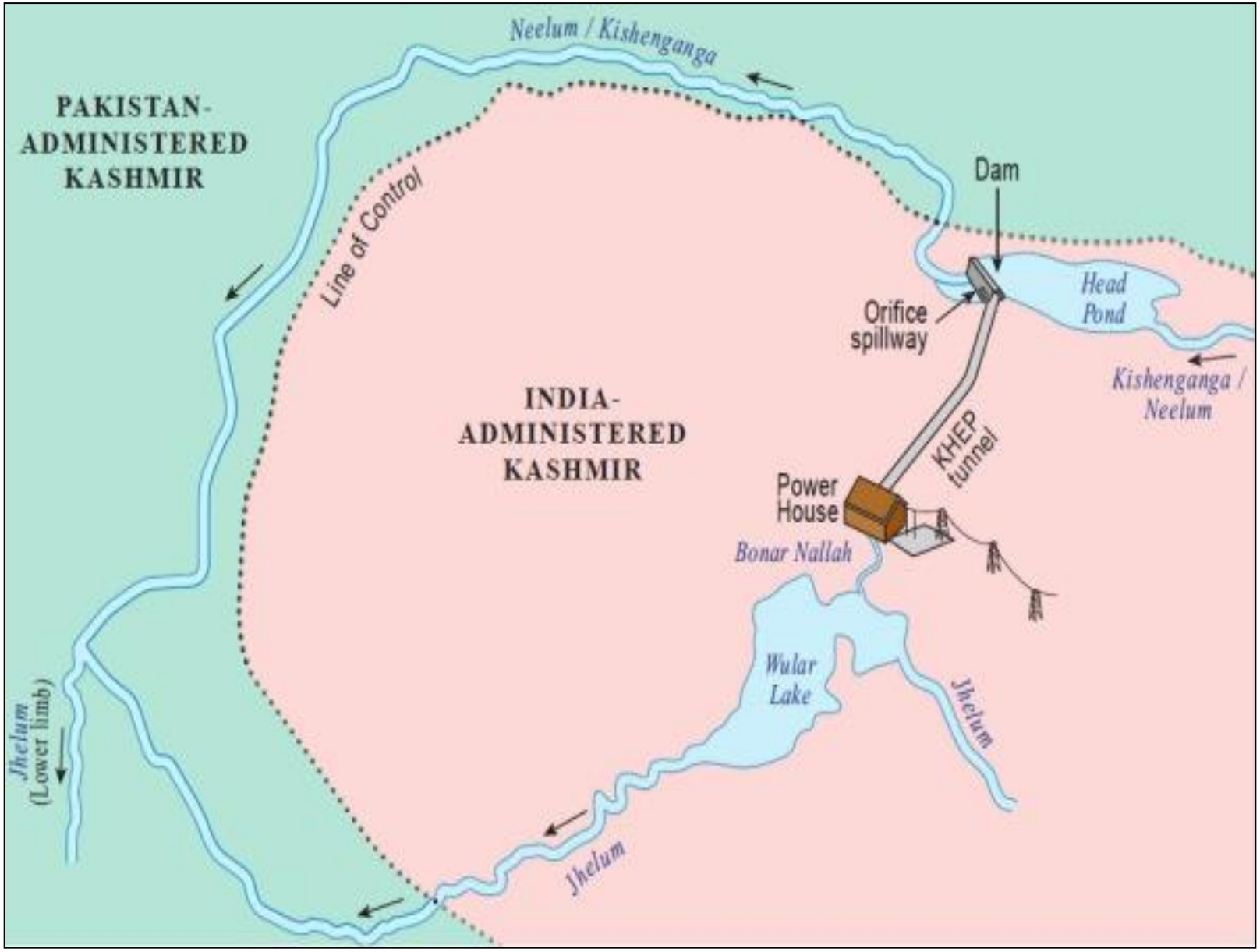
Geo-Political Factors

- Source of the Indus River is in an neighbouring country
- Ongoing hostilities between India and Pakistan over Kashmir Region
- India developing upstream hydropower projects

"Many of the wars of this century were about oil, but the wars of the next century will be about water"

Ismail Serageldin
Former Vice President of the World Bank


Himalayan
Mountains
China
Pakistan
Harappa
Tibet
Mohenjodaro
Karachi
India
Arabian
Sea
Bay of
Bengal
Indian Ocean


Neelum / Kishenganga
PAKISTAN-
ADMINISTERED
KASHMIR
Line of Control
Dam
Orifice
spillway
Head
Pond
Kishenganga /
Neelum
INDIA-
ADMINISTERED
KASHMIR
KHEP
tunnel
Power
House
Bonar Nallah
Wular
Lake
Jhelum
Jhelum
(Lower limb)
Jhelum

VULNERABILITY of PAKISTAN to CLIMATE CHANGE

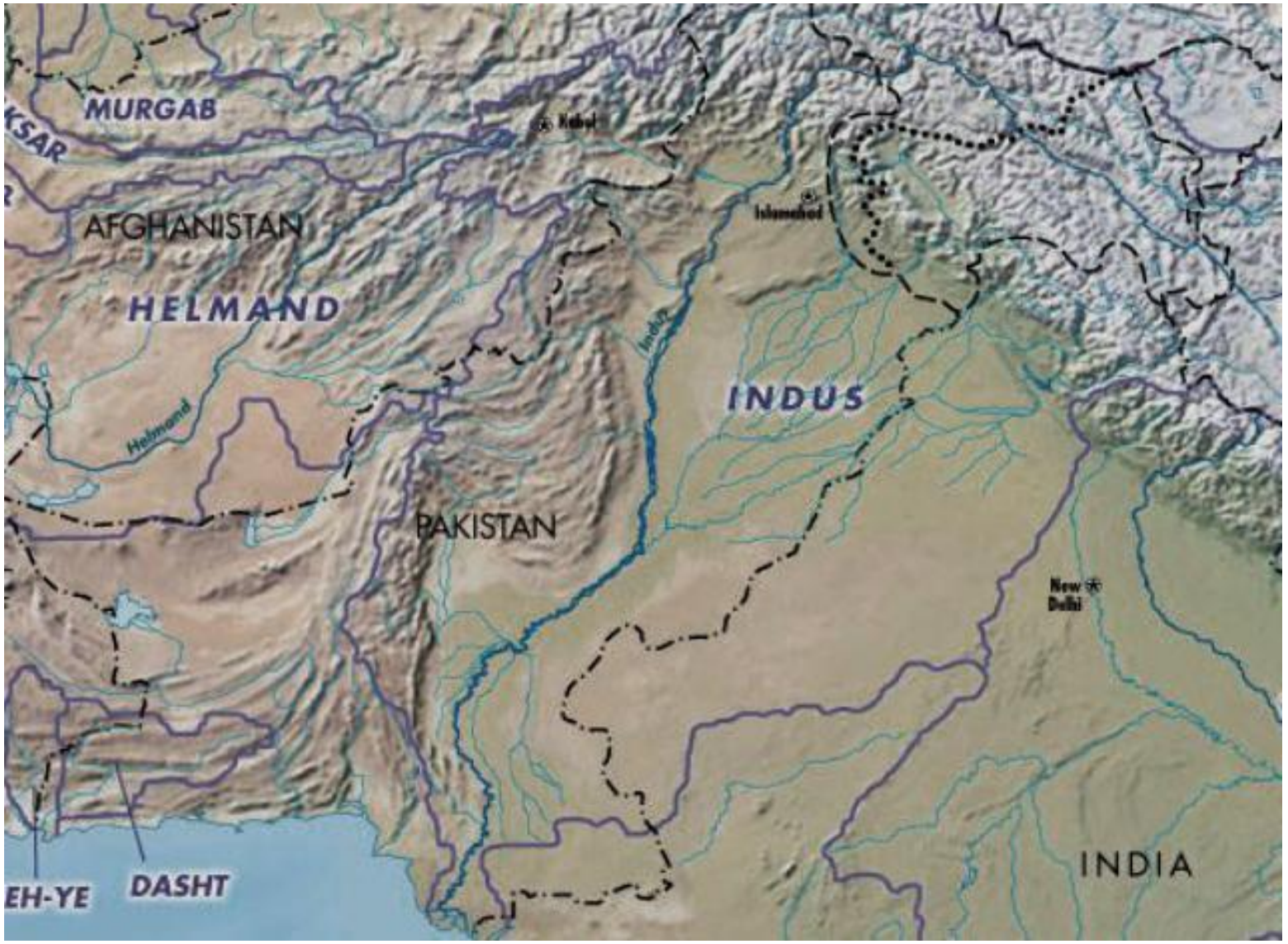
Socio-economic Factors

- Socioeconomic fragility
- Poor infrastructure
- Indus Basin food basket is dependent on irrigation
- Population growth
- Rapid urbanisation and industrialisation
- Environmental degradation
- Unregulated utilisation of the resources
- Inefficient water use
- Poverty
- Reliance on hydropower for electricity

VULNERABILITY of HYDROPOWER to CLIMATE CHANGE

Projected changes in rainfall intensity/variability and temperature can result in:

- Increased run-off variability
  - glacier retreat
  - intensified monsoon precipitation
  - decreased precipitation in the dry season
- Competing uses for water (e.g. agriculture)
- Increased evaporation losses from reservoirs as a result of rising temperatures
- Increased risk of Glacial Lake Outburst Flooding (i.e. failure of a glacial dam)
- Increased sediment loading
  - Reduced turbine longevity
  - Reservoir sedimentation


MURGAB
KSAR
Kabul
Islamabad
AFGHANISTAN
HELMAND
Helmand
Indus
INDUS
PAKISTAN
New Delhi
INDIA
EH-YE
DASHT

PROJECTED IMPACTS OF CLIMATE CHANGE

- ***Increased Temperature Variation***

Significant increases in winter mean and maximum temperatures, while mean and minimum summer temperatures show a consistent decline *(Fowler and Archer, 2006)*.

- ***Increased Precipitation***

In the upper Indus there has been a statistically significant increase in precipitation since 1961 *(Archer and Fowler, 2004)*.

- ***Increased Frequency and Intensity of Extreme Events***

Floods – Flooding from abnormally high monsoon rainfalls in 2010 and 2014 killed approximately 2000 and 360 respectively (Singapore Red Cross, 2010; Pakistan Red Crescent Society, 2014).

Earth Quakes - A correlation exists between temperature increase and earthquakes as glacier melt releases pressure on earth below triggering quakes (Usman et.al. 2009).

TOP NATURAL DISASTERS IN PAKISTAN FOR THE PERIOD 1900 TO 2014

NUMBERS OF TOTAL AFFECTED PEOPLE

DISASTER	DATE	TOTAL AFFECTED
Flood	**2014**	**2,530,000**
Flood	**2013**	**1,489,063**
Flood	**2012**	**4,849,841**
Flood	**2011**	**9,275,568**
Flood	**2010**	**20,202,327**
Flood	2005	7,000,450
Flood	1992	6,655,450
Flood	1992	6,184,418
Flood	1976	5,566,000
Earthquake	2013	185,150
Earthquake	2005	5,128,000
Flood	1973	4,800,000
Flood	1978	2,246,000
Drought	1999	2,200,000
Storm	2007	1,650,000

Source Pakistan Disaster Network (2015)

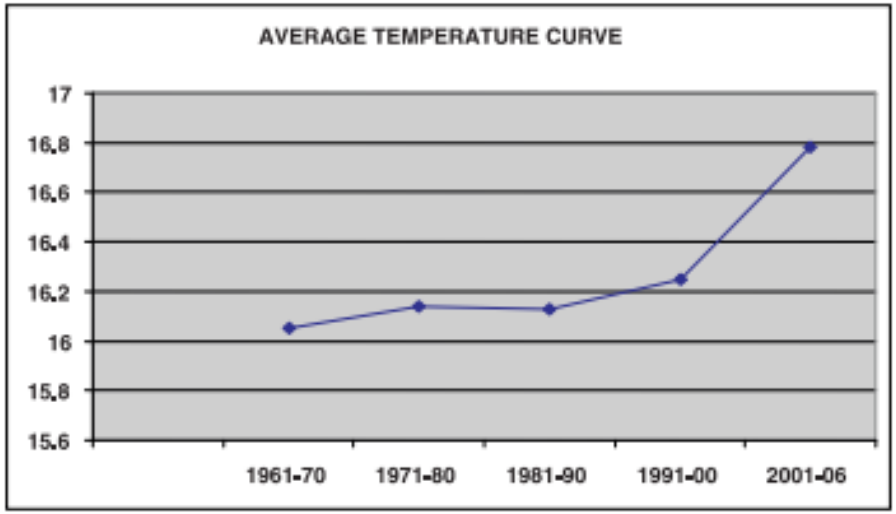


Figure-19: This figure shows average surface temperature of study area in duration 1961-06

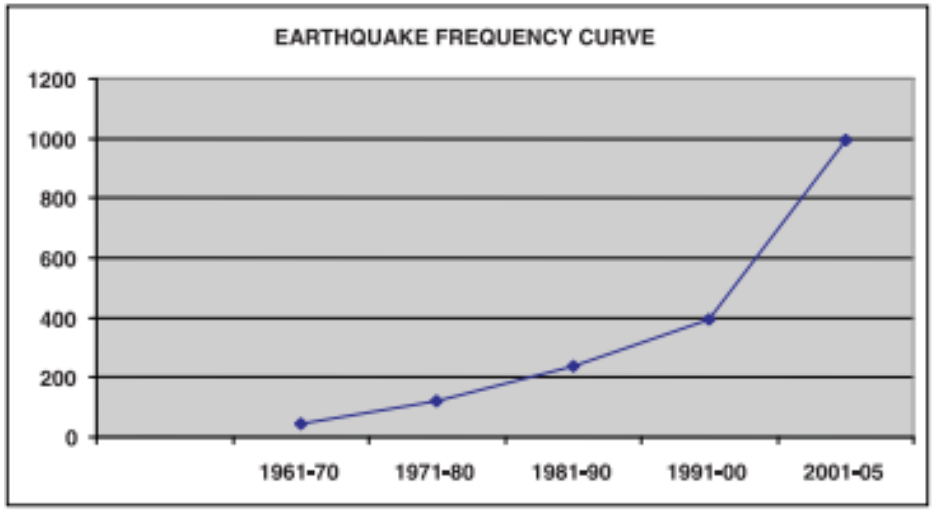


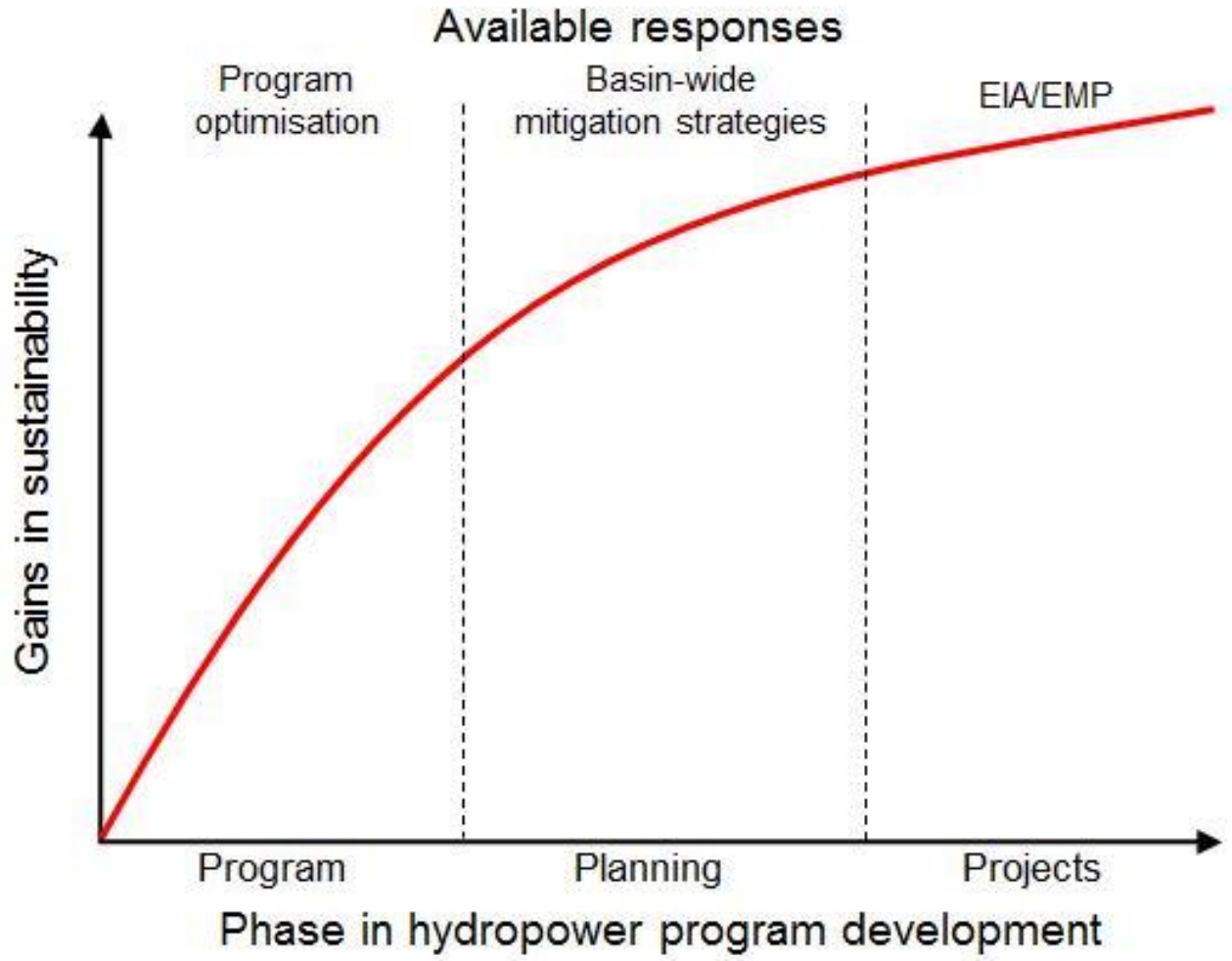
Figure-20: This figure shows earthquake frequency in study area in duration 1961-05

Source: *Usman et.al 2009.* Effects of Global Warming on the Frequency of Earthquakes in the Northern Areas of Pakistan. SCIENCE VISION Vol.15 No.1 (January to June 2009)

INTEGRATION OF CLIMATE RESILIENCE IN TO "VISION 2025"

- Two strategies for integrating climate change resilience: **mitigation and adaptation**
- Hydropower development is an effective mitigation measure as it reduces reliance on carbon based fuels
- Adaptation measures will require a system-scale approach, incorporating measures at the program, planning and project levels.

INTEGRATION OF CLIMATE RESILIENCE IN TO "VISION 2025"



ADAPTATION OPTIONS

Programmatic

- Multipurpose Projects
- Run-of-River Projects
- Program Optimisation (e.g. Cascade Arrangements)
- Siting of projects

System-scale

- Hydrological Forecasting Systems
- Integrated Water Resource Management Program
- System wide Management Plans (e.g. Catchment Management Plans; Basin-wide Land Use Planning).

ADAPTATION OPTIONS

Operations

An integrated and coordinated operations strategy throughout the hydropower system will provide additional benefits to minimise the impacts of climate change, including:

- Water Storage
- Cascades
- Flood Attenuation
- Irrigation
- Environmental Flows

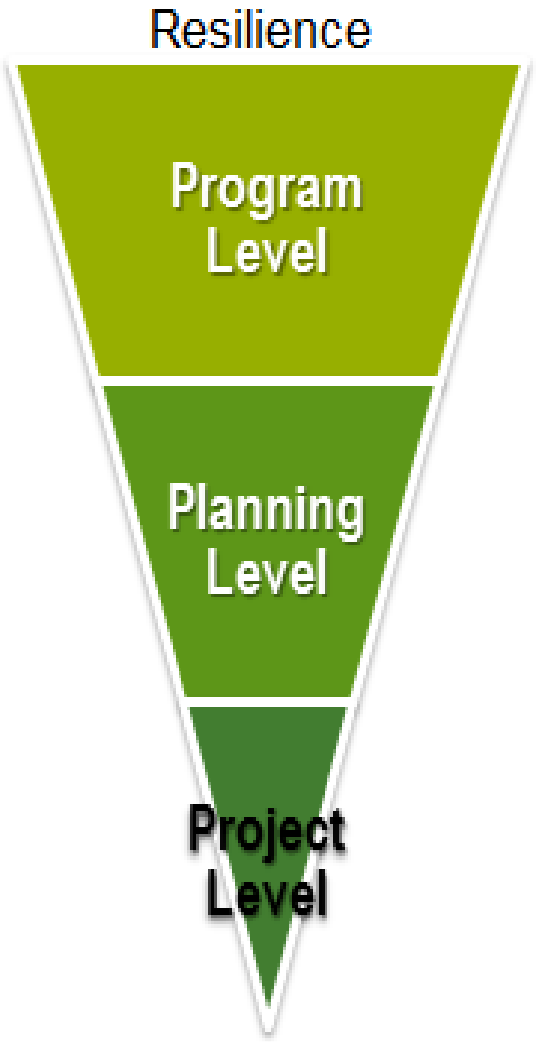
Project Design

- Increasing of dam height
- Controllable spillway gates (flush silted reservoirs, regulate flow, flood attenuation)
- Multiple turbine sizes (e.g. low flow and high flow turbines)
- Over design of canals and tunnels to accommodate projected extremes of water flow.

RECOMMENDATIONS

Climate change adaptation measures should take the form of:

- **PROGRAM OPTIMISATION**
  - Siting of hydropower plants
  - Multipurpose / Run-of-river mix
  - Cascades
- **BASIN-WIDE MANAGEMENT SYSTEMS**
  - Land Use Management Plans
  - Catchment Management Plans
- **OPERATIONAL EFFICIENCIES**
  - Water storage
  - Flood attenuation
  - Environmental flows
  - Agricultural irrigation flows
- **PROJECT DESIGN**
  - Overdesign of infrastructure



Mitigate we Might,

Adapt we Must !

Climate Change, Water and Food Security in Pakistan