

CLIMATE VARIABILITY AND ADAPTATIONS IN DIFFERENT REGIONS OF ASIA WITH REFERENCE TO AGRICULTURE

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• INTRODUCTION

- ★ CLIMATE VARIABILITY IS THE PRINCIPAL SOURCE OF FLUCTUATIONS OF AGRICULTURAL AND ALLIED PRODUCTIONS (AS 40% OF EARTH'S LAND SURFACE IS MANAGED BY CROP LAND, PASTURE, WHILE 30% IS UNDER FOREST LAND COVER).
- ★ AGRICULTURAL PRODUCTION WHICH IS HIGHLY DEPENDENT ON CLIMATE IS DRASTICALLY AFFECTED BY INCREASING CLIMATE VARIABILITY.
- ★ VULNERABILITY OF AGRICULTURAL SECTOR IS A FUNCTION OF CHARACTER, MAGNITUDE AND RATE OF CLIMATE CHANGE AND VARIATION, TO WHICH THE CROPPING SYSTEMS ARE EXPOSED.
- ★ ADAPTATIONS TO INCREASING VARIABILITY PROVIDE TOOLS TO REDUCE THE VULNERABILITY TO AGRICULTURE.
- ★ AGRICULTURAL SECTOR HAS SHOWN HIGH LEVELS OF ADAPTABILITY TO CLIMATE VARIATION, THOUGH ADAPTATION TO CLIMATE CHANGE THROUGH MANAGEMENT OF AGRICULTURE REMAINS A COMPLEX ISSUE .

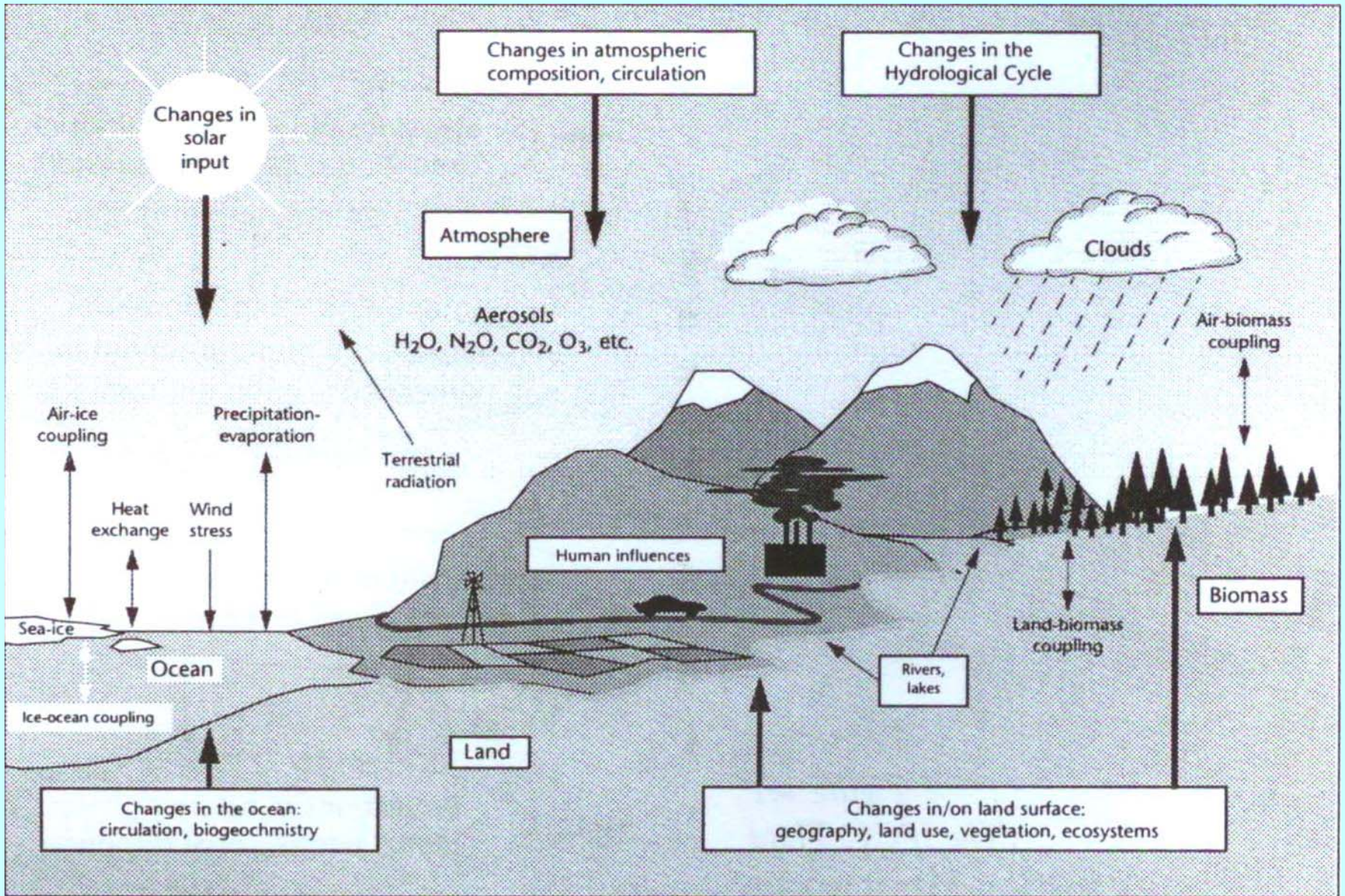


FIG.1. DIAGRAM SHOWING THE COMPONENTS OF THE CLIMATE SYSTEM

• AIM OF THE STUDY

- ✓ TO REVIEW AND SUMMARISE KEY EFFECT OF CLIMATE VARIABILITY IN VARIOUS PARTS OF ASIA.
- ✓ TO SUMMARISE IMPACT OF CLIMATE VARIABILITY ON AGRICULTURE.
- ✓ TO REPORT CURRENT ADAPTIVE MEASURES/OPTIONS AVAILABLE IN AGRICULTURE TO MAINTAIN SUSTAINABLE CROP GROWTH.

• CLIMATE VARIABILITY

❖ COMPONENTS

CLIMATE VARIABLES INCLUDE CHANGE IN TEMPERATURE, PRECIPITATION AND CO₂ GAS CONCENTRATION, THEIR MAGNITUDE AND TIME, WHICH REFLECT FUTURE IMPACTS.

❖ **EFFECT OF CLIMATE VARIABILITY**

- ➔ **INCREASE IN SURFACE TEMPERATURE IS MOST PRONOUNCED IN NORTH ASIA.**
- ➔ **THE OBSERVED TEMPERATURE INCREASE IN PARTS OF ASIA DURING RECENT DECADES IS PROJECTED BETWEEN 1 TO 3°C PER CENTURY .**
- ➔ **AN INCREASING TREND IN TEMPERATURE HAS BEEN NOTICED IN RECENT DECADES IN SOUTHERN AND CENTRAL INDIA IN ALL SEASONS AND ALL THROUGH INDIA DURING POST MONSOON SEASON.**

☐ SUMMARY OF OBSERVED PAST AND PRESENT CLIMATE TRENDS AND VARIABILITY IN ASIA

REGION	COUNTRY	CHANGE IN TEMPERATURE	CHANGE IN PRECIPITATION
NORTH ASIA	RUSSIA	2 TO 3 °C RISE IN PAST 90 YEARS, MORE PRONOUNCED IN SPRING AND WINTER.	HIGHLY VARIABLE, DECREASED DURING 1951 TO 1995, INCREASED IN LAST DECADE.
CENTRAL ASIA	NORTH-WEST CHINA	0.7°C INCREASE IN MEAN ANNUAL TEMP. FROM 1961 TO 2000.	BETWEEN 22% AND 33% INCREASE IN R/F.
WEST ASIA (MIDDLE-EAST)	IRAN	DURING 1951 TO 2003 SIGNIFICANT DECREASE IN FROST DAYS DUE TO RISE IN SURFACE TEMP.	DECREASING TREND IN PRECIPITATION (ANZALI, TABRIZ, ZAHEDAN), WHILE OTHERS (MASHAD, SHIRAZ) REPORTED INCREASING TREND.
EAST ASIA	CHINA	WARMING DURING LAST 50 YEARS, PRONOUNCED DURING WINTER, RATE OF INCREASE PRONOUNCED IN MIN. THAN IN MAX. TEMP.	ANNUAL RAIN DECLINED IN NORTH –EAST AND NORTH CHINA, INCREASED IN WESTERN CHINA, CHANGJIANG RIVER AND ALONG SOUTH AND EAST COAST.
	JAPAN	ABOUT 1.0 °C RISE IN 20 TH CENTURY, 2 TO 3 °C RISE IN LARGE CITIES.	NO SIGNIFICANT TREND IN THE 20 TH CENTURY ALTHOUGH FLUCTUATIONS INCREASED.

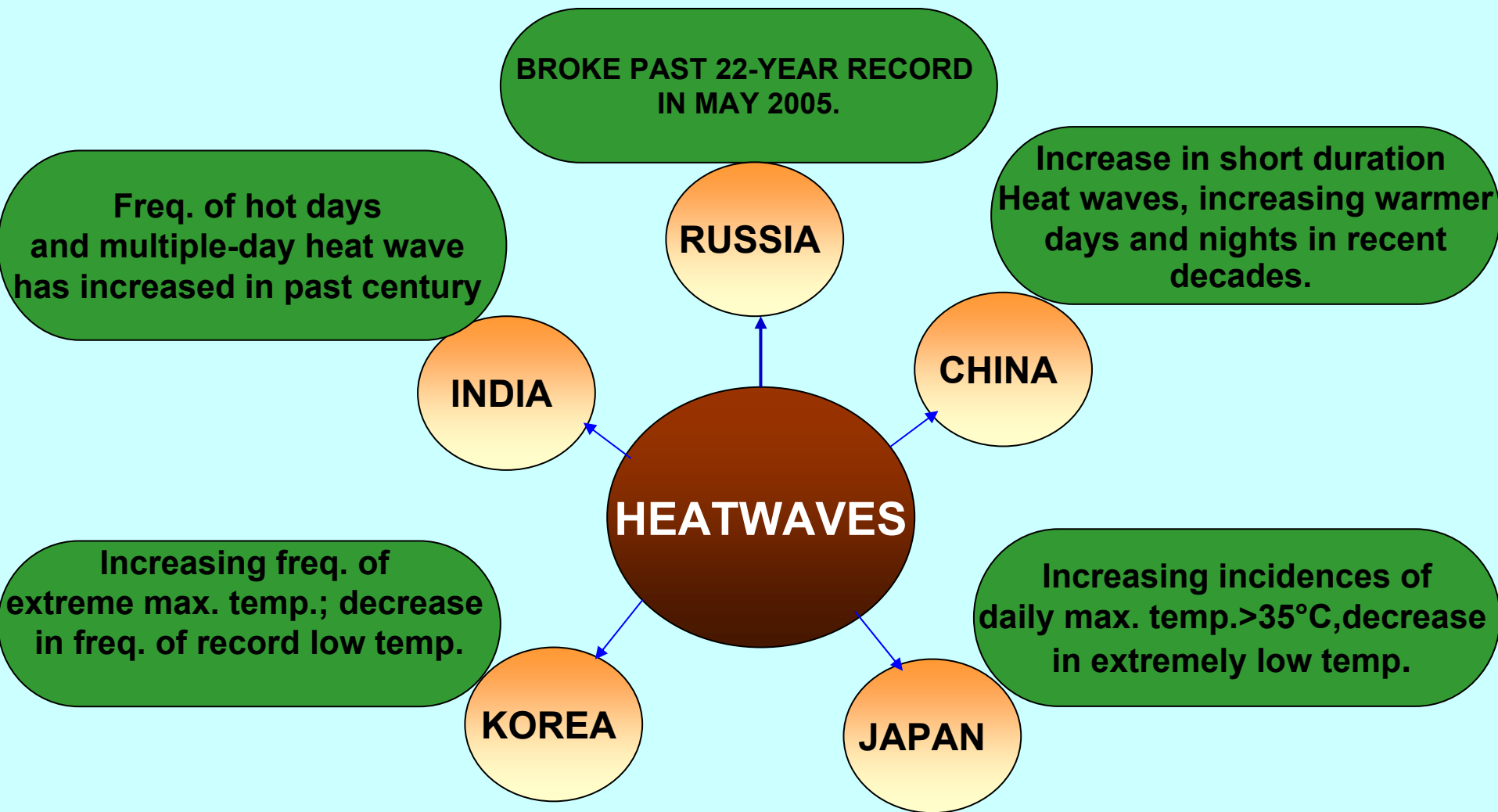
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REGION	COUNTRY	CHANGE IN TEMPERATURE	CHANGE IN PRECIPITATION
SOUTH ASIA	INDIA	0.68 °C INCREASE PER CENTURY, INCREASING TRENDS IN ANNUAL MEAN TEMP., WARMING PRONOUNCED DURING POST MONSOON AND WINTER.	INCREASED RAINS IN NORTH-WEST DURING SUMMER MONSOON IN RECENT DECADES, LOWER NO. OF RAINY DAYS ALONG EAST COAST.
	PAKISTAN	0.6 TO 1.0 °C RISE IN MEAN TEMP. IN COSTAL AREAS SINCE EARLY 1900S.	10 TO 15% DECREASE IN COSTAL BELT & HYPER ARID PLAINS, INCREASE IN SUMMER AND WINTER PRECIPITATION OVER LAST 40 YEARS IN NORTHERN PAKISTAN.
	BANGLADESH	AN INCREASING TREND OF ABOUT 1 °C IN MAY AND 0.5 °C IN NOVEMBER DURING THE 14 YEARS PERIOD (1985 TO 1998).	DECADAL RAIN ANOMALIES ABOVE LONG TERM AVERAGES SINCE 1960S.
S-E ASIA	PHILIPPINES	INCREASE IN MEAN ANNUAL, MAX. AND MIN. TEMP. BY 0.14 °C BETWEEN 1971 TO 2000.	INCREASE IN ANNUAL MEAN R/F SINCE 1980S AND NUMBER OF RAINY DAYS SINCE 1990S, INCREASE IN INTER - ANNUAL VARIABILITY OF ONSET OF R/F.

- INCREASING CLIMATE VARIABILITY AND ANTHROPOGENIC CLIMATE CHANGES LEAD TO FLOODS, DROUGHTS, CYCLONES, TROPICAL STORMS, HEAT AND COLD WAVES, DUST AND SAND STORMS, FOREST FIRES.

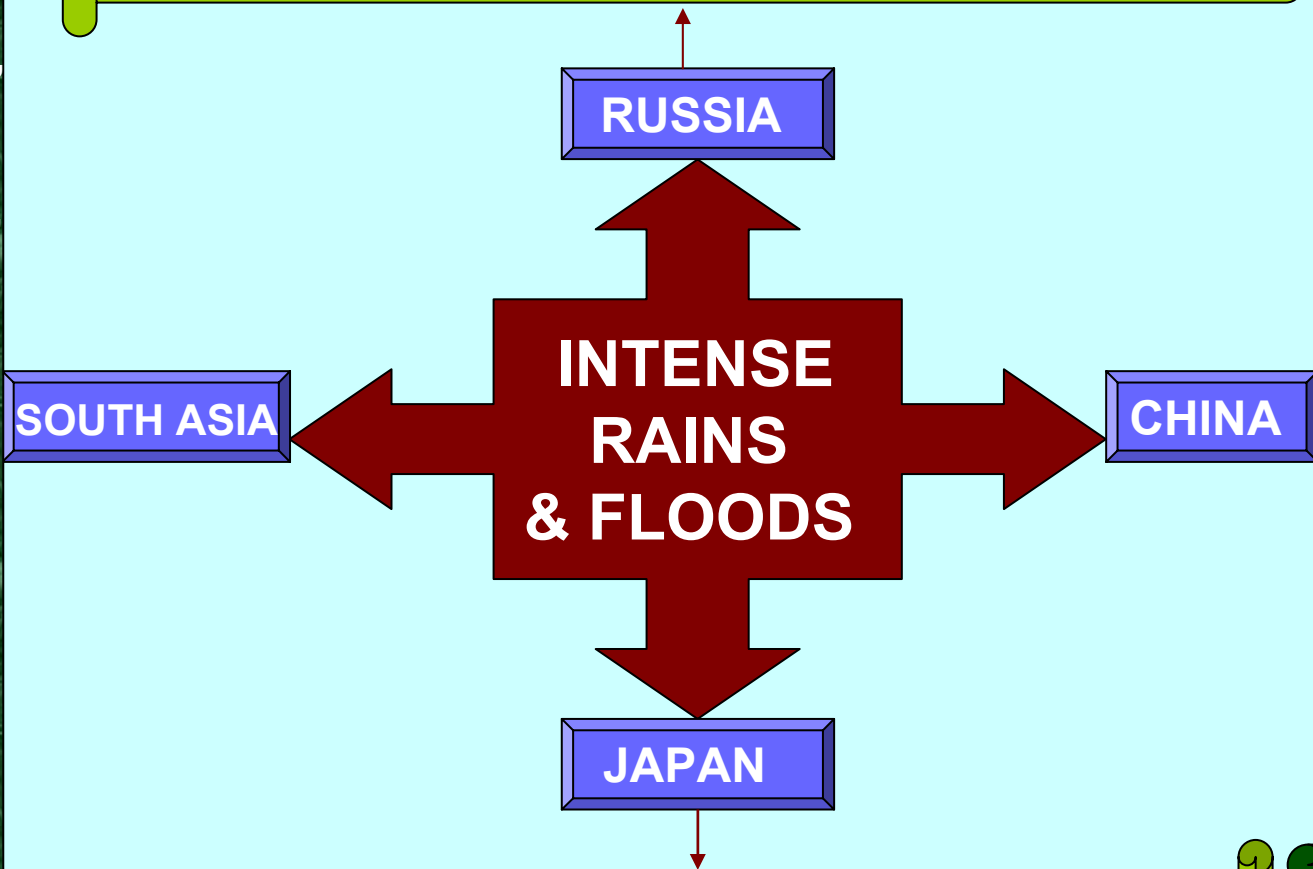


OBSERVED CHANGES



Increase in heavy rains in W - Russia; increase in no. of days with more than 10 mm rain; 50 to 70% Increase in surface runoff in Siberia.

More freq. floods in N-E China since 1990s more intense summer rains in E-China; severe flood in 1999; 7-fold increase in freq. Of floods since 1950s



Serious & recurrent floods in Bangladesh, Nepal and N-E India during 2002, 03 & 04; a record 944 mm of R/F in Mumbai on 26 to 27 July 05, Floods in Surat, Barmer & in Srinagar during 2006

Increasing freq. of extreme rains in past 100 years; Serious Flood in 2004; increase in max. R/F during 1961 to 2000.

Increase in area affected by drought has exceeded 6.7 Mha since 2000 in Beijing, Hebei Province, Shanxi Province, Inner Mongolia and North China; increase in dust storm affected area.

China

Droughts in 1999 & 2000 in Pakistan & N-W India reduces water tables; droughts between 2000 and 2002 caused crop failures; droughts in N-E India during 2006.

South Asia

DROUGHTS

**CYCLONES
&
TYPHOONS**

Frequency of monsoon depressions and cyclones formation in Bay of Bengal & Arabian Sea on decline since 1970 but intensity increased causing severe floods.

South Asia

Number of tropical storms has two peaks, one in mid 1960s and another in early 1990s, often lower than historical average

Japan

❖ IMPACTS ON AGRICULTURE

- 🌐 **INCREASING INTENSITY AND FREQUENCY OF DROUGHTS IN VARIOUS PARTS OF ASIA ARE DUE TO RISE IN TEMPERATURE AND ENSO EVENTS.**
- 🌐 **DAMAGE CAUSED BY INTENSE CYCLONES HAS INCREASED PARTICULARLY IN INDIA, JAPAN, CHINA, PHILIPPINES ETC. IN INDIA 28% OF LAND IS VULNERABLE TO DROUGHTS, 12% TO FLOODS AND 8% TO CYCLONES.**
- 🌐 **ABOUT 2.5 TO 10% CROP YIELD DECREASE IS PROJECTED IN PARTS OF ASIA BY 2020S AND 5 TO 30% DECREASE BY 2050s.**

- PRODUCTION OF RICE, MAIZE AND WHEAT HAS DECLINED IN MANY PARTS OF ASIA, IN PAST DECADES DUE TO INCREASING WATER STRESS AS A RESULT OF RISE IN TEMPERATURE, INCREASING FREQUENCY OF EL NIÑO AND DECLINE IN NUMBER OF RAINY DAYS.**
- LOW RAINFALL IN ARID AND SEMI-ARID REGIONS RESULTS IN SHALLOW SOIL PROFILE WITH POOR INHERENT QUALITIES.**
- AGRICULTURAL IRRIGATION DEMAND IN ARID AND SEMI-ARID REGIONS OF ASIA IS EXPECTED TO RISE BY AT LEAST 10% FOR AN INCREASE IN 1⁰C TEMPERATURE.**

● **ADAPTATIONS**

- **ADAPTATION IS CONCERNED WITH RESPONSES TO BOTH ADVERSE AND POSITIVE EFFECTS OF CLIMATE CHANGE. ANY ADJUSTMENT - WHETHER PASSIVE, REACTIVE OR ANTICIPATORY, WHICH CAN RESPOND TO ANTICIPATED OR ACTUAL CONSEQUENCES ASSOCIATED WITH CLIMATE CHANGE IS REFERRED AS ADAPTATION.**
- **ADAPTATION OPTIONS HAVE TWO PURPOSES VIZ. I) TO REDUCE DAMAGE FROM CLIMATE CHANGE AND II) TO INCREASE RESILIENCE OF ECOSYSTEMS TO ASPECTS OF CLIMATE CHANGE.**
- **PRACTICALLY, ADAPTATION MEASURES ARE INTER – LINKED WITH MITIGATION MEASURES.**
- **ADAPTATION IN VARIOUS DEGREES AND IN SOME FORM OR OTHER MAY BE NECESSARY TO COPE WITH ECOSYSTEM CHANGES.**
- **ADAPTATION TO CLIMATE CHANGE THROUGH MANAGEMENT OF AGRICULTURE REMAINS A COMPLEX ISSUE. USE AND MANAGEMENT OF SOILS ULTIMATELY INFLUENCE ABILITY OF AGRICULTURE TO ADAPT TO CLIMATE CHANGE.**

❖ ADAPTATION OPTIONS AT THREE SPATIAL SCALES:

- ✓ **THE FIELD SCALE, BY CHANGING MACHINERY, TIMING OF OPERATIONS, USE OF DIFFERENT CROPS, INTRODUCING IRRIGATION.**
- ✓ **THE FARM SCALE THROUGH SOCIO-ECONOMIC CHANGES AFFECTING FARM SIZES OR DIVERSIFICATION TO NON – AGRICULTURAL LAND USES.**
- ✓ **THE REGIONAL AND / OR NATIONAL SCALE, THROUGH POLICY RESPONSES AIMED AT MARKET SUPPORT OR ENVIRONMENTAL REGULATION.**

GENERALLY, ADAPTIVE MEASURES ARE INTENDED TO INCREASE ADAPTIVE CAPABILITIES OF CROPS BY MODIFYING FARMING PRACTICES, IMPROVING CULTIVARS THROUGH NEW TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT.

❖ VARIOUS ADAPTIVE MEASURES IN AGRICULTURE

SECTORS	ADAPTATION MEASURES
1°C TEMPERATURE INCREASE DURING JUNE TO AUGUST	<p>A) CHOICE OF CROP AND CULTIVAR:</p> <ul style="list-style-type: none">I) MORE HEAT/DROUGHT-TOLERANT CROP VARIETIES IN AREAS UNDER WATER STRESS.II) MORE DISEASE AND PEST TOLERANT CROP VARIETIES.III) SALT-TOLERANT CROP VARIETIES.IV) INTRODUCE HIGH YIELDING, EARLY MATURING CROP VARIETIES IN COLD REGIONS. <p>B) FARM MANAGEMENT:</p> <ul style="list-style-type: none">I) ALTER APPLICATION OF NUTRIENTS/FERTILISERS.II) ALTER APPLICATION OF INSECTICIDES/PESTICIDES.III) CHANGE PLANTING DATE TO EFFECTIVELY USE PROLONGED GROWING SEASON AND IRRIGATION.IV) DEVELOP ADAPTIVE MANAGEMENT STRATEGY AT FARM LEVEL.

❖ **SOME MORE ADAPTIVE MEASURES INCLUDE:**

- ✓ **RAIN WATER HARVESTING,**
- ✓ **DEVELOPMENT AND MANAGEMENT OF ARID / SEMI-ARID FARMING SYSTEMS,**
- ✓ **GROWING TOLERANT CROP VARIETIES,**
- ✓ **ALTERNATE LAND USE SYSTEMS AND**
- ✓ **IMPROVEMENT IN AGRICULTURAL INFRASTRUCTURE AT FARM LEVEL.**

★ **IN CHINA, ADAPTIVE MEASURES ARE SUGGESTED TO MINIMIZE DETRIMENTAL EFFECT OF CLIMATE VARIABILITY.**

★ **IN BANGLADESH, AGRICULTURAL ADAPTATION STRATEGIES INCLUDE RICE GENOTYPE DEVELOPMENT FOR SUSTAINING YIELD.**

❖ **ROLE OF IAAS IN INDIA**

- ★ **IN INDIA, INTEGRATED AGROMETEOROLOGICAL ADVISORY SERVICES (AAS) AT DISTRICT LEVEL PROVIDES SUITABLE CROP SPECIFIC ADVISORIES DEPENDING UPON FORECAST AND ONGOING AGRICULTURAL OPERATIONS.**
- ★ **ADAPTIVE MEASURES ARE SUGGESTED THROUGH ADVISORY BULLETINS DEPENDING UPON TYPE, MAGNITUDE OF EXTREME EVENTS.**

CONCLUSIONS

- ✓ **OBSERVATIONAL EVIDENCES SHOW THAT MANY CROPPING SYSTEMS ARE BEING AFFECTED BY REGIONAL CLIMATE VARIABILITY IN DIFFERENT PARTS OF ASIA.**
- ✓ **MORE SCIENTIFIC INFORMATION REGARDING FUTURE CLIMATE VARIABILITY IS NOW AVAILABLE EVEN FOR ASIATIC REGIONS.**
- ✓ **AT THE SAME TIME, WIDER RANGES OF ADAPTATION OPTIONS ARE AVAILABLE.**
- ✓ **THEREFORE, AN EFFECTIVE STRATEGY FOR SUSTAINABLE AGRICULTURAL GROWTH IS REQUIRED THROUGH STRENGTHENING OF RESEARCH RELATED TO MORE FEASIBLE, ADAPTIVE MEASURES.**

● EXTENDED LEARNING

Aggarwal, P.K., 2003: Impact of climate change on Indian agriculture. *Journal of Plant Biology*, 30, 189-198.

Gruza, G. and E. Rankova, 2004: Detection of changes in climate state, Climate variability and climate extremity. *Proc. World Climate Change Conference*, Moscow, Izrael, Y., G.Gruza, S. Semenov and I. Nazarov, Eds., Institute of Global Climate and Ecology, Moscow, 90-93.

IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Working Group II Contribution to Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.Parry, O.Canziani, J.Palutikof, P.V.D.Linden and C.Hanson, Eds., Cambridge University Press, Cambridge, 976 pp.

Kalra, N., P.K.Aggarwal, S.Chander, H.Pathak, R. Choudhary, A.Choudhary, S. Mukesh, H.K.Rai, U.A.Soni, S.Anil, M.Jolly, U.K.Singh, A.Owrs and M.Z.Hussain, 2003: Impacts of climate change on agriculture. *Climate Change and India: Vulnerability Assessment and Adaptation*, Shukla, P.R., S.K.Sharma, N.H.Ravindranath, A.Garg and S.Bhattacharya, Eds., Orient Longman Private, Hyderabad, 193-226.

Kashyapi, A.,2008: 'Overview of the impacts, vulnerability and adaptation of climate change for agriculture in different regions based on IPCC fourth assessment report' presented at WMO+SECC workshop held at Orlando, Florida, USA during 18 – 21 Nov.,2008 (to be published as a chapter by USDA).

Lal, M., 2007: Implications of climate change on agricultural productivity and food security in south Asia. *Key vulnerable regions and climate change identifying thresholds for impacts and adaptation in relation to Article 2 of UNFCCC*, Springer, Dordrecht (in press).

Stigter, C.J., T. Ying, H.P. Das, Z. Dawei, R.E. Rivero Vega, N.V. Viet, N.I.Bakheit and Y.M. Abdullahi, 2007: Complying with farmers conditions and needs using new weather and climate information approaches and technologies, In: Sivakumar, M.V.K., R. Motha, Eds. *Managing Weather and Climate Risks in Agriculture*, Springer, Berlin, Heidelberg, 171-190.

Salinger, J.,M.V.K.Sivakumar and P.Motha, 2005: Increasing climate variability and change (reducing the vulnerability of agriculture and forestry), Springer, Netherlands,1-362.

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