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MEDITERRANEAN ACTION PLAN

First Meeting of the Task Team on the
Implications of Climatic Changes
on the Kastela Bay Coastal Area

Split, 25-26 April 1991

REPORT OF THE FIRST MEETING OF THE TASK TEAM ON THE IMPLICATIONS OF CLIMATIC CHANGES ON THE KASTELA BAY COASTAL AREA

UNEP
Athens, 1991

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BACKGROUND

The greenhouse effect is Man's most pressing environmental problem, one which presents major scientific challenges that span a wide range of disciplines. Changes in global climate between now and the middle of the 21st century are likely to be dominated by the influence of global warming due to increasing concentrations of carbon dioxide and other gases in the atmosphere. These greenhouse gases individually and collectively change the radiative balance of the atmosphere, trapping more heat near the Earth's surface and causing a rise in global-mean surface air temperature and as a consequence substantial global warming is virtually certain.

The question of the probable climate warming in the next few decades is a question concerning both the world in general and the Mediterranean in particular.

In spite of uncertainties surrounding predicted climatic changes, greenhouse gases seem to have accumulated in the atmosphere to such a level that the changes may have started already and their continuation now may be inevitable.

There is a consensus in the scientific community that if allowed to continue to build up, a doubling of the greenhouse gases concentration (relative to the pre-industrial era) will occur sometime in the 21st century, possibly as early as 2030 AD. A corresponding global increase of temperature of between 1.5-4^{o}C is predicted, to become effective 2-3 decades later, reflecting the time lags due to inertia of the earth system.

Cyclogenesis and rainfall are often promoted by land-sea temperature contrasts. Because land and sea have different effective thermal inertias, a large-scale warming could affect this contrast, possibly reducing it in winter months. This could in turn lead to reductions in rainfall and in storminess, particularly in the Eastern Mediterranean Basin. On the other hand, warmer sea surface temperatures both in the Mediterranean and in the North Atlantic could lead to increases in atmospheric moisture and thus precipitation.

Another major consequence of a warmer atmosphere is an acceleration of the current rate of sea level rise, due to the melting of alpine and polar glaciers and thermal expansion of ocean waters. Sea-level has been rising since the last glacial maximum (120m rise in last 16,000 years at rates as rapid as 8 to 12 mm/year). In recent historical times, the rate has been 0.5 to 1.5 mm/yr. Analysis of tide gauge data, the principal source of evidence for detecting relatively short-term sea level trends, suggests the world-wide rise has been about 10-15 cm in the past 100 years.

Depending on the extent of oceanic thermal expansion and on (especially) the behaviour of the polar ice caps (Greenland and the western Antarctic ice sheet), conservative to moderate estimates of sea level rise range from 13-39 cm, by 2025; 24-52 cm, by 2050; and 38-91 cm, by 2075. The Villach Conference in 1985 concluded that a global warming of 1.5^{o}-4.5^{o}C would lead to a sea-level rise between 20 and 140 cm. Future sea level rises have been estimated at the meeting of experts in Norwich, September 1987. The best estimate of change between 1985 and 2030 is 14-22 cm, the approximate rise of sea level over the past 100 years.

The recent Second World Climate Conference (Geneva, 29 October-7 November 1990), on the basis of the work of the Intergovernmental Panel on Climate Change (IPCC) concluded that without actions to reduce emissions, global warming is predicted to reach 2^{o} to 5^{o} C over the next century, a rate of change unprecedented in the past 10,000 years. The warming is expected to be accompanied by a sea level rise of 65 cm +/- 35 cm by the end of the next century. There remain uncertainties in predictions, particularly in regard to the timing, magnitude and regional patterns of climate change, as well as in the numerous secondary effects of this warming and sea level rise.

The Second World Climate Conference adopted the Conference Statement and Ministerial Declaration which were prepared on the basis of presentations made at the Conference; the deliberations of task groups of participants organized to address various specific issues; and plenary discussions. Due to the importance and relevance of these two documents to the work of the Task Team on the implications of climatic changes on the Kastela Bay area, the Conference Statement and the Ministerial Declaration are reproduced as Appendix to this report.

In the framework of the Mediterranean Action Plan of UNEP, four Comprehensive Coastal Area Management Programmes are being developed (Island of Rhodos, Kastela Bay, Bay of Ismir, Syrian coast) which include a number of studies of which one concerns the implications of climatic changes. For this study in the Kastela Bay area, the Task Team was established in February 1991 and consists of seven members of the core Task Team (Mr A. Baric, Co-ordinator, and Mr M. Gacic, Ms. B. Grbec, Mr J. Margeta, Mr B. Milos, Mr I. Onofri, Mr V. Veldic) and three external Task Team members (Mr L. Jeftic, Mr. S. Keckes, Mr. J. Pernetta). The present meeting is the first meeting of the Task Team.

REPORT OF THE MEETING

Opening of the Meeting - Agenda Item 1

The meeting was opened in the premises of the Priority Actions Programme Regional Activity Centre (PAP/RAC) of the Mediterranean Action Plan (MAP) by Mr L. Jeftic, Senior Marine Scientist in the Co-ordinating Unit for MAP, on behalf of Dr M. K. Tolba, Executive Director of UNEP. Mr A. Pavasovic, Director of the Centre welcomed the participants on behalf of the host institution.

After welcoming the participants and thanking Mr Pavasovic for hosting the meeting, Mr Jeftic outlined the background and scope of the meeting. He expressed the hope that both the meeting and the work of the Task Team on the study of implications of climatic changes on the Kastela Bay coastal area would be successful.

The list of participants appears as Annex I to this report.

Election of Officers - Agenda Item 2

The meeting unanimously elected Mr A. Baric, Director of the Institute for Oceanography and Fisheries, Split and Co-ordinator of the Task Team as Chairman, Mr J. Margeta, Faculty of Civil Engineering, Split as Vice-Chairman and Mr J. Pernetta as Rapporteur. Mr L. Jeftic acted as Technical Secretary of the Meeting.

Adoption of the Agenda - Agenda Item 3

The provisional agenda as proposed by the secretariat and adopted by the meeting appears as Annex II to this report.

Overview of the Greenhouse Effect and its Implications - Agenda Item 4

Mr L. Jeftic presented an overview of the implications of climatic changes (Annex III to this report). In doing so he presented 43 transparencies in which he reviewed:

- the basics of Greenhouse effect;
- past and predicted changes in temperatures and sea level;
- work of the Climatic Research Unit (CRU) of the East Anglia University, UK, on the development of Mediterranean scenarios (with sub-regional specifics) of future changes in temperature and precipitation;
- possible implications of climatic changes;
- activities organised by the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) of UNEP and MAP concerned with studying the implications of climatic changes in coastal areas;
- work carried out by the Mediterranean Task Team on climatic changes and its results;
- the work of the sub-regional task teams for Rhodos, Syrian coast, and Ismir Bay.

Participants expressed appreciation for the presentation and requested that copies of all transparencies presented by Mr Jeftic be annex to the report (Annex III). Since these transparencies were prepared for oral presentations only, by using various sources of open and grey publications, in a number of transparencies the source of information was not properly cited.

During the discussion which followed the presentation, a number of specific areas relating to the implications of climatic changes were clarified. In particular:

The IPCC concluded that without actions to reduce emissions, global warming is predicted to reach 2° to 5° C over the next century, a rate of change unprecedented in the past 10,000 years. The warming is expected to be accompanied by a sea level rise of 65 cm +/- 35 cm by the end of the next century;

The IPCC statement concerning potential changes to the climate of Southern Europe (35° - 50°N 10°W - 45°E) that: " warming would be about 2° C in winter and would vary from 2° to 3° C in summer. There is some indication of increased precipitation in winter but summer precipitation decreases by 5 to 15%, and summer soil moisture by 15 to 25%.";

It was noted that confidence in this regional estimate is low; that the University of East Anglia (UEA) would be producing a final report on climate scenarios for the Mediterranean region in the near future; and that the UEA group be asked to produce specific scenarios for the Kastela Bay area on the basis of data supplied by members of the Task Team.

Kastela Bay Coastal Area Management Programme - Agenda Item 5

Mr L. Jeftic presented the basic structure of the Kastela Bay Coastal Area Management Programme (Annex IV to this report) and outlined the place of the present study within the framework of the 14 current activities envisaged as components of this programme.

In the discussion which followed the presentation a number of points were clarified and additional information was provided.

Implications of Expected Climatic Changes on Kastela Bay Coastal Area - Agenda Item 6

Project outline - Agenda Item 6.1.

Mr A. Baric presented basic information on the Kastela Bay (Annex V to this report).

The objectives and assumptions for the study which were presented by Mr L. Jeftic were discussed at length and some clarification made. The objectives, assumptions and outputs as adopted are contained in Annex VI to this report.

The need to define the geographic area of coverage of the study was stressed. It was further recognised that the surrounding areas within which impacts would not be studied but where changes would influence processes and activities within the core area covered by the study would also need to be examined. The core area for this study is defined essentially as the area contained within the boundaries of the four municipalities of Split, Solin, Kastela, Trogir (see map in Annex VII).

Mr A. Baric gave a detailed presentation of the proposed outline of the project which included responsibilities of each Task Team member.

The discussion which followed this presentation stressed the need for an integrated approach in the work of the Task Team and that this integration needed to be adequately reflected in the final report of the Task Team. After discussion the outline of the report was adopted as appearing in Annex VIII to this report.

General Workplan and timetable - Agenda Item 6.2.

Mr A. Baric presented the proposed general workplan and timetable of the project. Following discussion and amendment the workplan and timetable as attached in Annex IX of this report were adopted by the meeting.

The need to involve planners and decision makers in the development of the work of the Task Team was considered essential if the results were to be appropriately formulated and implemented by decision makers.

Detailed workplan for each Task Team member - Agenda Item 6.3.

Specific tasks and the workplan for each Task Team member were then discussed and details of the various approaches were agreed upon. These are outlined in the detail provided under each section of the report outline (Annex VIII).

Adoption of the Report - Agenda Item 7

The report of the meeting together with the nine annexes was then considered and adopted by the meeting on 26 April 1991.

Closure of the Meeting - Agenda Item 8

Dr Ivo Lozic, member of the Executive Council of the Split Commune, who came to the closing of the meeting, expressed regrets that he was not able, due to other urgent commitments to participate more fully in the meeting. He greeted the participants on behalf of the President of the Executive Council of the Split Commune, Mr Puljic and expressed interest and support for this programme.

The representative of the Ministry of the Environment of Croatia expressed the interest in and support of the Ministry to this programme and the readiness of the Ministry to ensure continued participation and support to the future work of the Task Team. Participants expressed satisfaction and hope that such support and participation would continue throughout the work of the Task Team.

In his closing remarks, Mr L. Jeftic expressed satisfaction with the results of the meeting and the constructive manner in which it had been conducted. He also thanked the participants, Chairmen and Rapporteur for their work during the meeting and the Director of the host institution for providing technical and logistic help and for his hospitality.

An exchange of courtesies followed after which the Chairman closed the meeting.

ANNEX I

LIST OF PARTICIPANTS

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ANNEX II

AGENDA

1. Opening of the Meeting

2. Election of Officers

3. Adoption of the Agenda

4. Overview of Greenhouse effect and its implications

5. Kastela Bay Coastal Area Management Programme

6. Implications of expected climatic changes on Kastela Bay Coastal Area

   6.1. Project outline
   6.2. General workplan and timetable
   6.3. Detailed workplan for each Task Team member

7. Adoption of the report

8. Closure of the Meeting

ANNEX III

OVERVIEW OF THE GREENHOUSE EFFECT AND ITS IMPLICATIONS

This Annex contains copies of transparencies reviewing:

- the basics of Greenhouse effect;
- past and predicted changes in temperatures and sea level;
- work of the Climatic Research Unit (CRU) of the East Anglia University, UK, on the development of Mediterranean scenarios (with sub-regional specifics) of future changes in temperature and precipitation;
- possible implications of climatic changes;
- activities organised by the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) of UNEP and MAP concerned with studying the implications of climatic changes in coastal areas;
- work carried out by the Mediterranean Task Team on climatic changes and its results;
- the work of the sub-regional task teams for Rhodos, Syrian coast, and Ismir Bay.

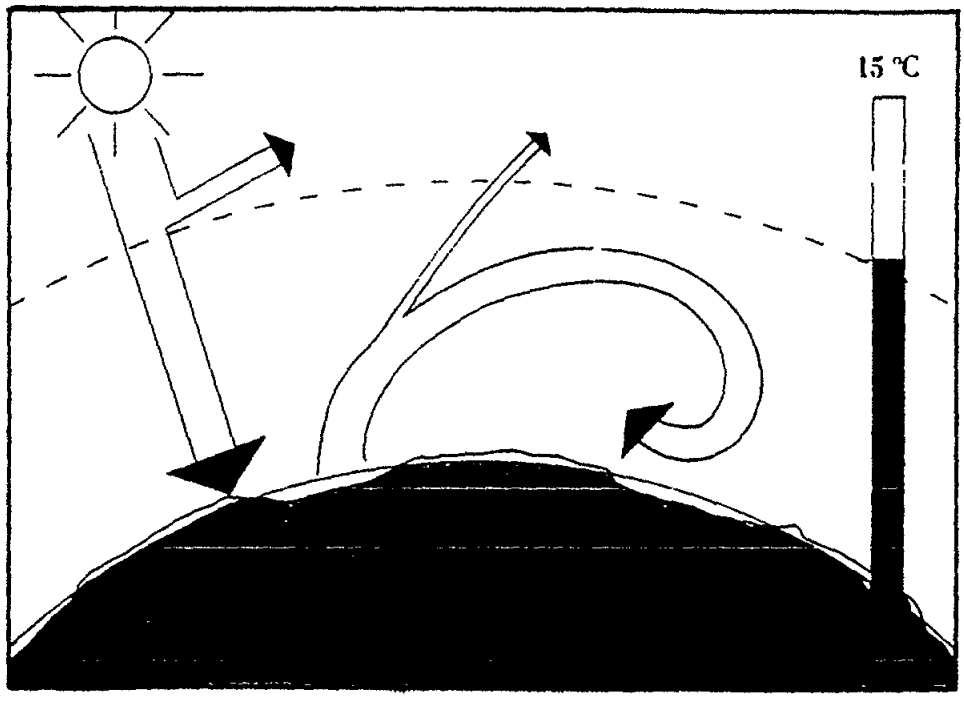
Since these transparencies were prepared for oral presentations only, by using various sources of open and grey literature, in a number of transparencies the source of information was not properly cited.

ANNEX IV

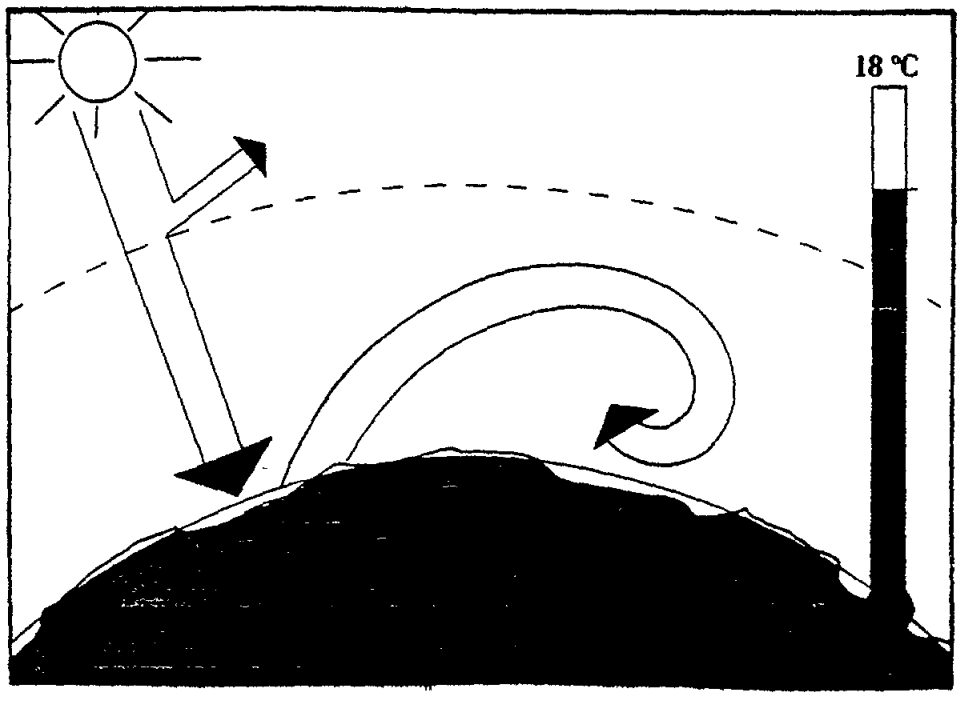
COMPONENTS OF THE COASTAL AREA MANAGEMENT PROGRAMME FOR THE KASTELA BAY

This programme which has been implemented in the frame of the Mediterranean Action Plan consists of the following components:

- Survey of land-based sources of pollution;
- Assessment of risk from pollution by oil and other harmful substances, and the preparation of a contingency plan;
- Collection of missing ecological and other relevant data on the Kastela Bay aquatorium for the construction of infrastructure systems and the implementation of other proposed activities (monitoring programme);
- Implications of expected climatic changes;
- Application of the Geographical Information System (GIS);
- Hazard assessment and management of environmental risks from energy, industries, transport an other activities (HARM);
- Development-environment scenarios covering the period until the year 2025;
- Environmental Impact Assessment (EIA) of the submarine outfall;
- Study to determine the optimum treatment level for municipal waste waters;
- Evaluation of Pantan, the area of special natural and historic value, and a proposal for the protection and management of the area;
- Survey of water resources of the western part of the area;
- Survey of water resources of the island of Drvenik Veli.

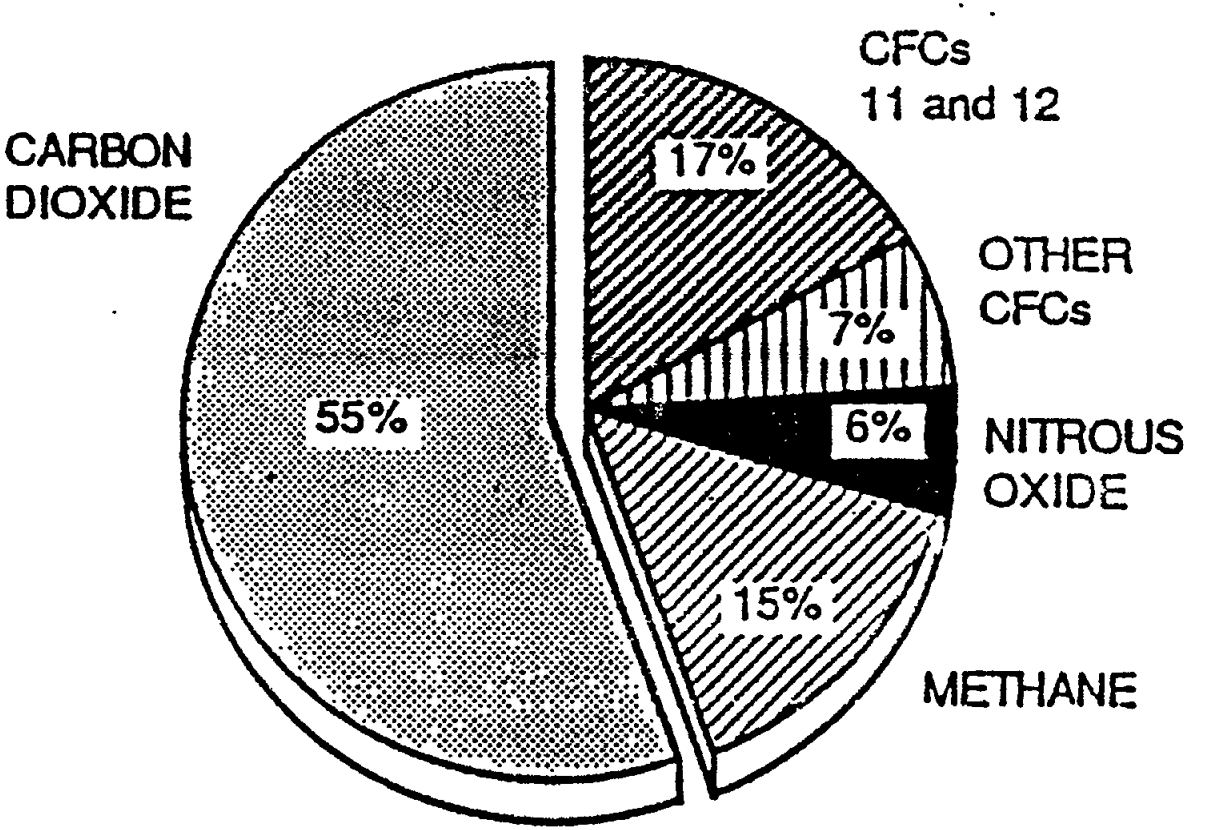


GREENHOUSE EFFECT AT PRESENT



GREENHOUSE EFFECT IN THE FUTURE

(From Maîtriser le réchauffement de la planète, Agence pour la Qualité de L'air, Paris)


CFCs
11 and 12
17%
OTHER
CFCs
7%
NITROUS
OXIDE
6%
METHANE
15%
CARBON
DIOXIDE
55%

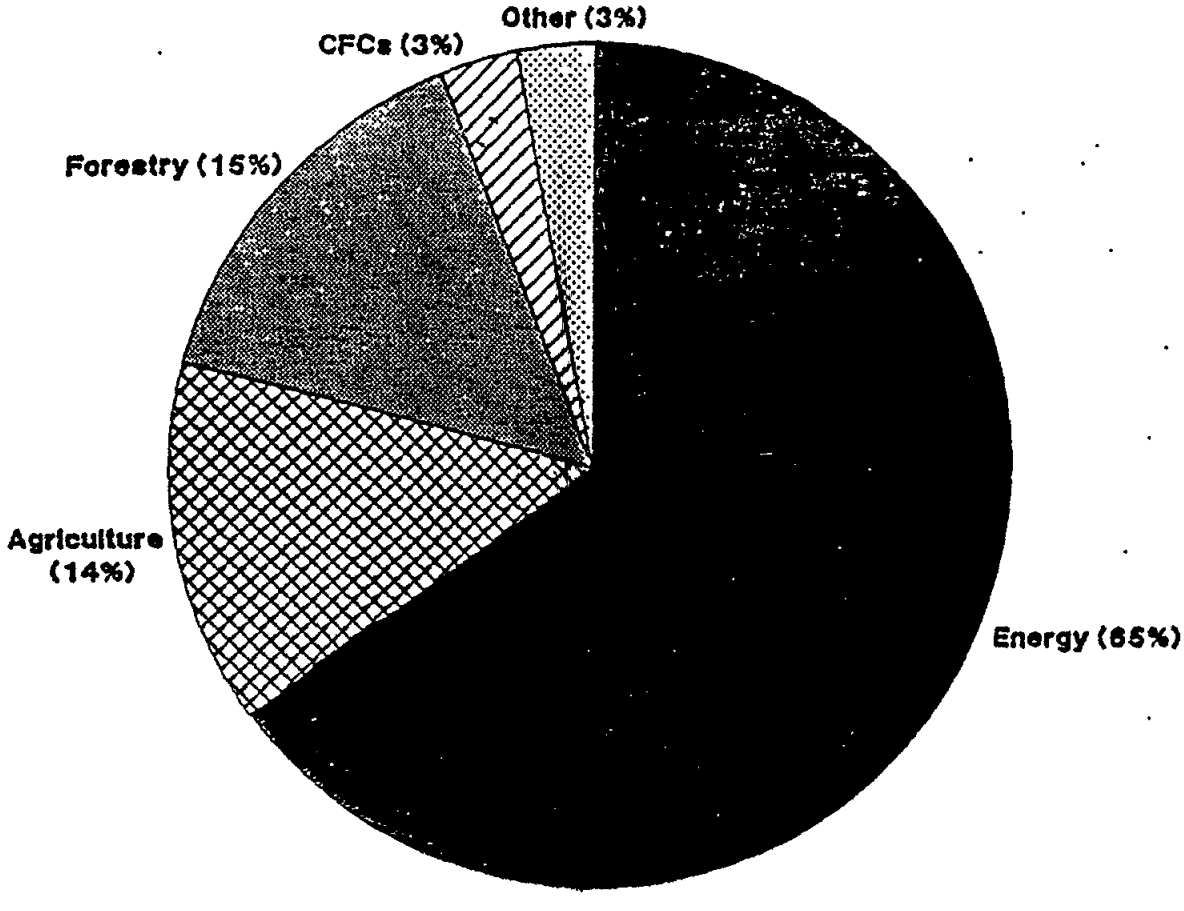
SUMMARY OF KEY GREENHOUSE GASES AFFECTED BY HUMAN ACTIVITIES					
	Carbon Dioxide	Methane	CFC-11	CFC-12	Nitrous Oxide
Atmospheric concentration	ppmv	ppmv	pptv	pptv	ppbv
Pre-industrial (1750-1800)	280	0.8	0	0	288
Present day (1990)	353	1.72	280	484	310
Current rate of change per year	1.8 (0.5%)	0.015 (0.9%)	9.5 (4%)	17 (4%)	0.8 (0.25%)
Atmospheric lifetime (years)	(50-200)†	10	65	130	150

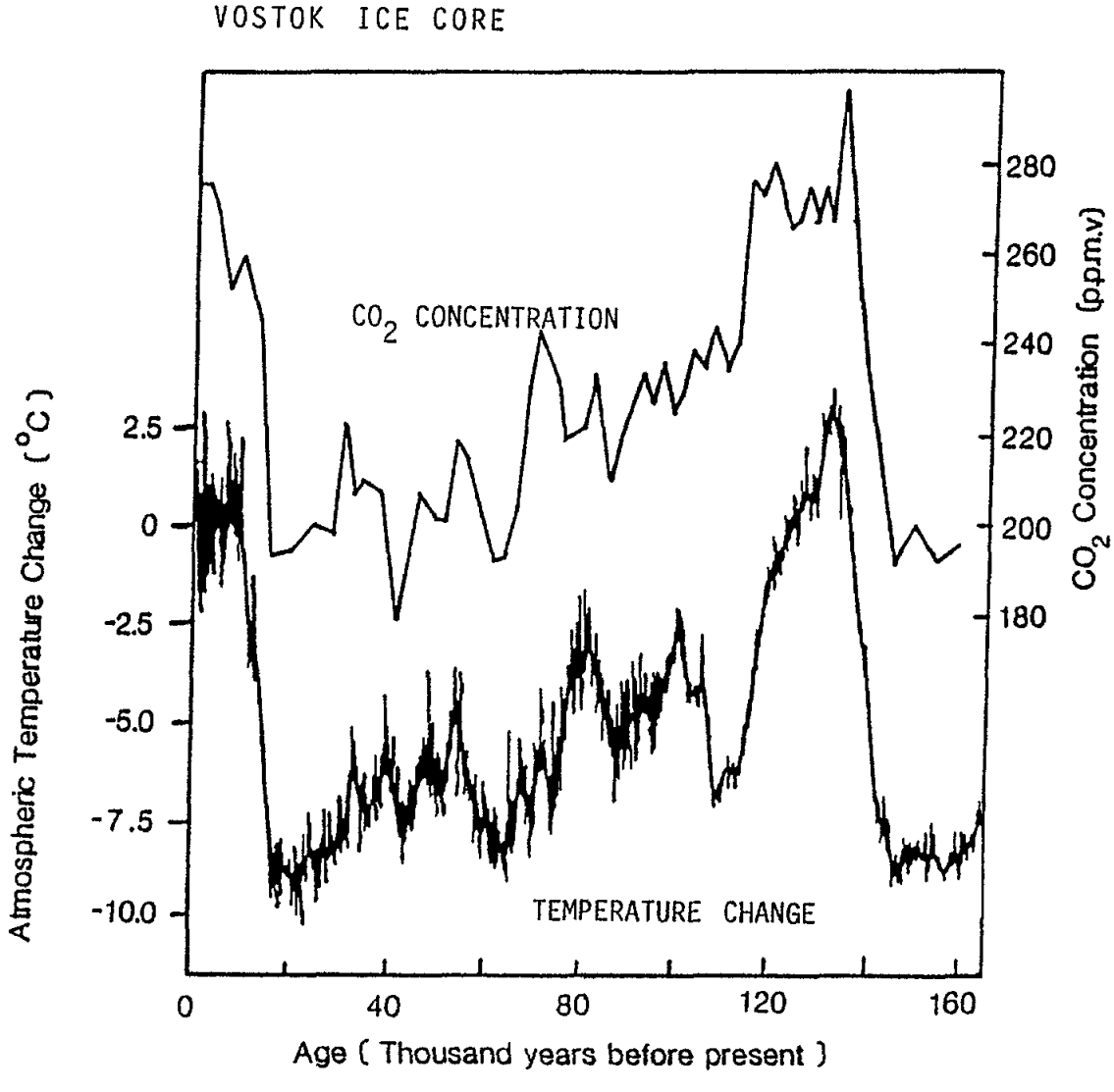
ppmv = parts per million by volume;
ppbv = parts per billion (thousand million) by volume;
pptv = parts per trillion (million million) by volume.

† The way in which CO_2 is absorbed by the oceans and biosphere is not simple and a single value cannot be given; refer to the main report for further discussion.

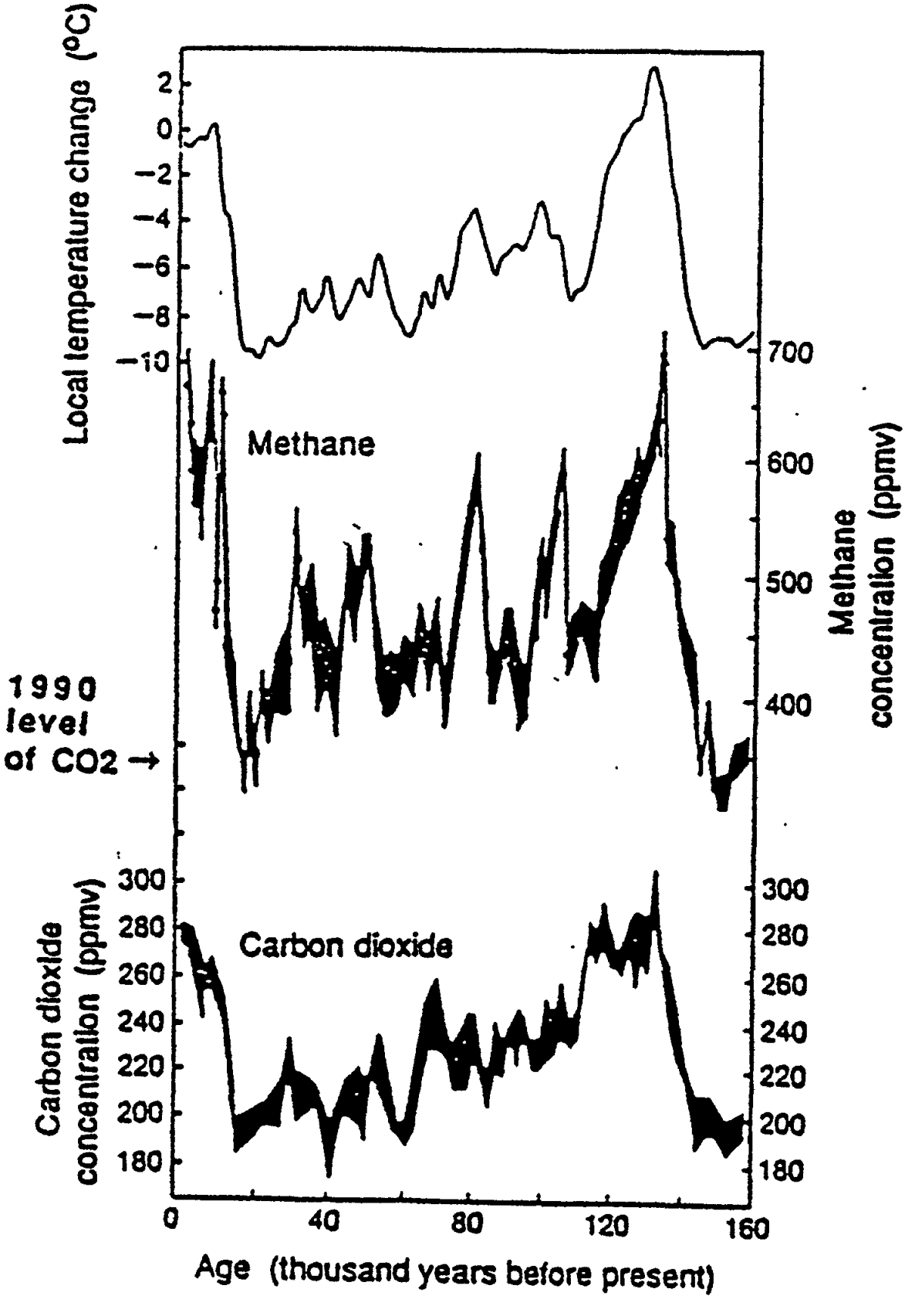
CONTRIBUTION TO RADIATIVE FORCING BY SECTOR: 2025 EMISSIONS

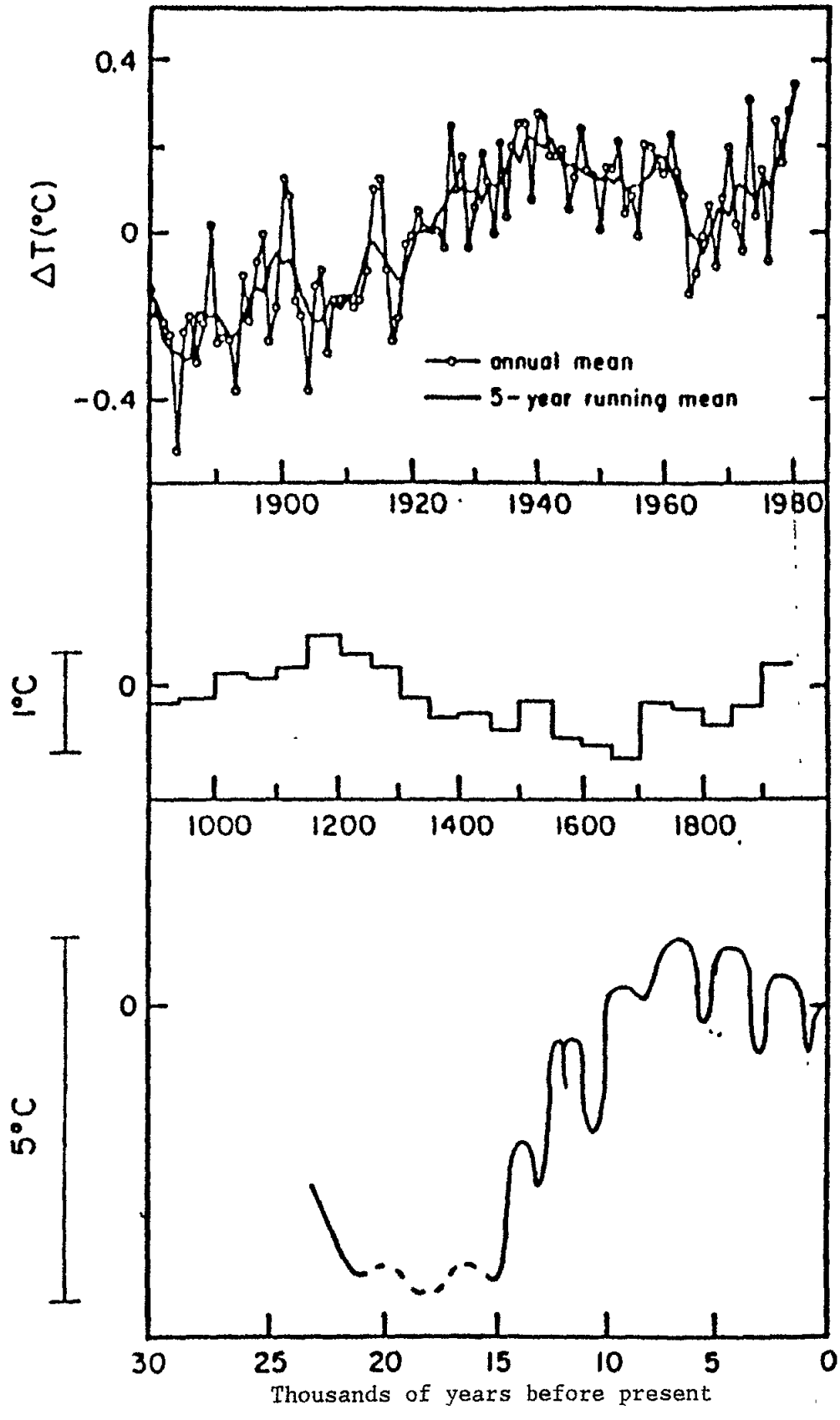
(Based on Global Warming Potentials For 100-Year Time Horizon)



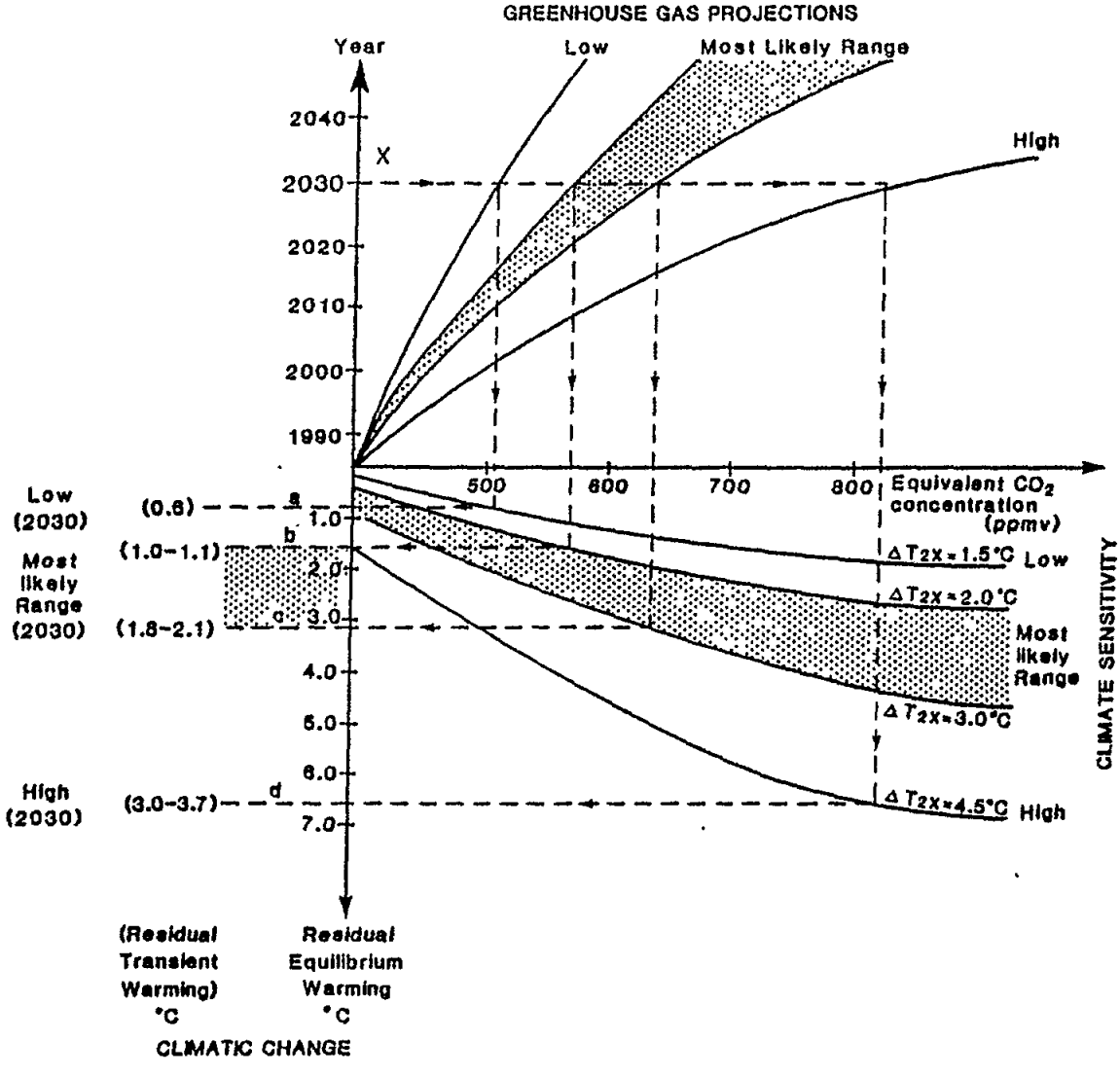


Source: Barnola (1987).


Local temperature change (°C)
2
0
−2
−4
−6
−8
−10
Methane
700
600
500
400
Methane concentration (ppmv)
1990 level of CO2 →
Carbon dioxide concentration (ppmv)
300
280
260
240
220
200
180
Carbon dioxide
0
40
80
120
160
Age (thousand years before present)


0.4
0
-0.4
ΔT(°C)
annual mean
5-year running mean
1900
1920
1940
1960
1980
1°C
0
1000
1200
1400
1600
1800
5°C
0
30
25
20
15
10
5
0
Thousands of years before present

Estimates of the Climate Sensitivity

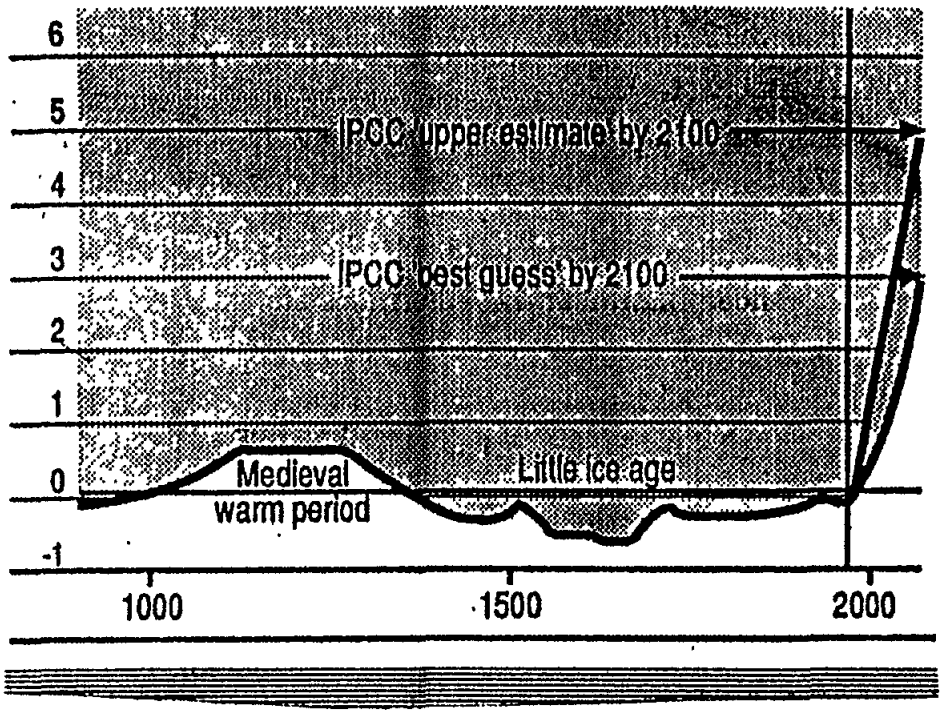


= 1.5 - 4.5°C warmer

for a CO_2 doubling

UN prediction of climate changes

Temperature change (°C) from today's average



ESTIMATES FOR CHANGES BY 2030

(IPCC Business-as-Usual scenario; changes from **pre-industrial**)

The numbers given below are based on high resolution models, scaled to be consistent with our best estimate of global mean warming of 1.8°C by 2030. For values consistent with other estimates of global temperature rise, the numbers below should be reduced by 30% for the low estimate or increased by 50% for the high estimate. Precipitation estimates are also scaled in a similar way.

Confidence in these regional estimates is low

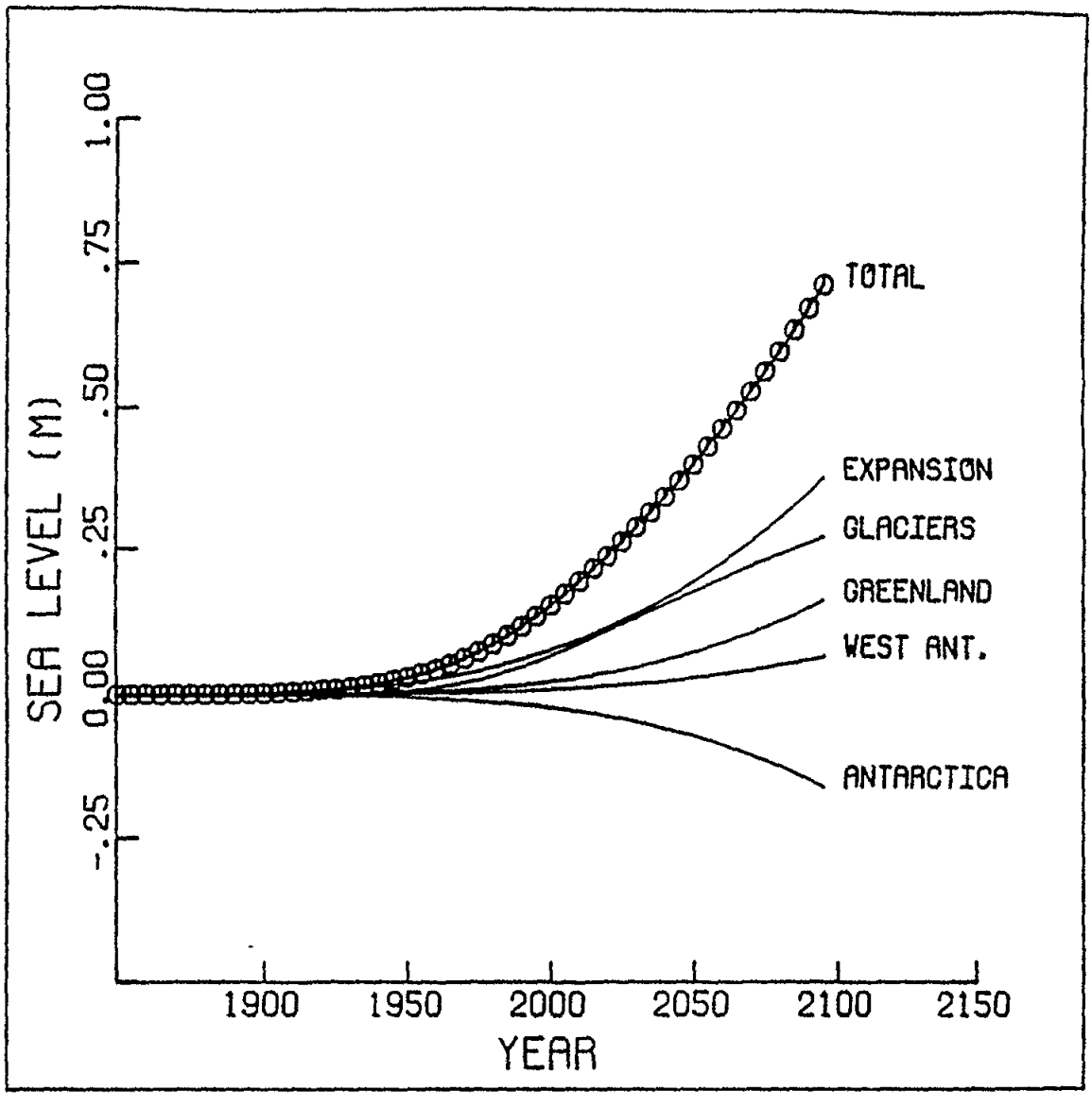
Central North America (35°-50°N 85°-105°W)
The warming varies from 2 to 4°C in winter and 2 to 3°C in summer. Precipitation increases range from 0 to 15% in winter whereas there are decreases of 5 to 10% in summer. Soil moisture decreases in summer by 15 to 20%.

Southern Asia (5°-30°N 70°-105°E)
The warming varies from 1 to 2°C throughout the year. Precipitation changes little in winter and generally increases throughout the region by 5 to 15% in summer. Summer soil moisture increases by 5 to 10%.

Sahel (10°-20°N 20°W-40°E)
The warming ranges from 1 to 3°C. Area mean precipitation increases and area mean soil moisture decreases marginally in summer. However, throughout the region, there are areas of both increase and decrease in both parameters throughout the region.

Southern Europe (35°-50°N 10°W- 45°E)
The warming is about 2°C in winter and varies from 2 to 3°C in summer. There is some indication of increased precipitation in winter, but summer precipitation decreases by 5 to 15%, and summer soil moisture by 15 to 25%.

Australia (12°-45°S 110°-115°E)
The warming ranges from 1 to 2°C in summer and is about 2°C in winter. Summer precipitation increases by around 10%, but the models do not produce consistent estimates of the changes in soil moisture. The area averages hide large variations at the sub-continental level.


SEA LEVEL (M)
1.00
.75
.50
.25
0.00
-.25
1900
1950
2000
2050
2100
2150
YEAR
TOTAL
EXPANSION
GLACIERS
GREENLAND
WEST ANT.
ANTARCTICA

PROJECTED GLOBAL MEAN SEA LEVEL RISE

1985-2030 (CMS)

(from Raper *et al.*, 1988)

GLOBAL MEAN SEA LEVEL RISE RESULTING FROM	LOW	BEST GUESS	HIGH
THERMAL EXPANSION	4	8 to 14	17
ALPINE GLACIERS	2	5 to 13	21
GREENLAND	1	1 to 2	3
ANTARCTICA*	-2	-3 to -1	3
	5	11 to 28	44

* Values chosen from analysis to maximise range.

SCENARIA OF REGIONAL CHANGES IN CLIMATE IN THE MEDITERRANEAN

Approach taken by
Climate Research Unit, University of East Anglia

Statistical link between the large-scale quid-point GCM predictions and the small-scale detail of regional climates was achieved through the following approach:

1. The approach is based on regression analysis techniques, whereby small-scale climate changes are related to regional-scale changes as predictors.

2. The basic assumption of the method is that GCM-derived, grid-point values for temperature and precipitation, are equivalent to regionally-averaged observations of the same variable.

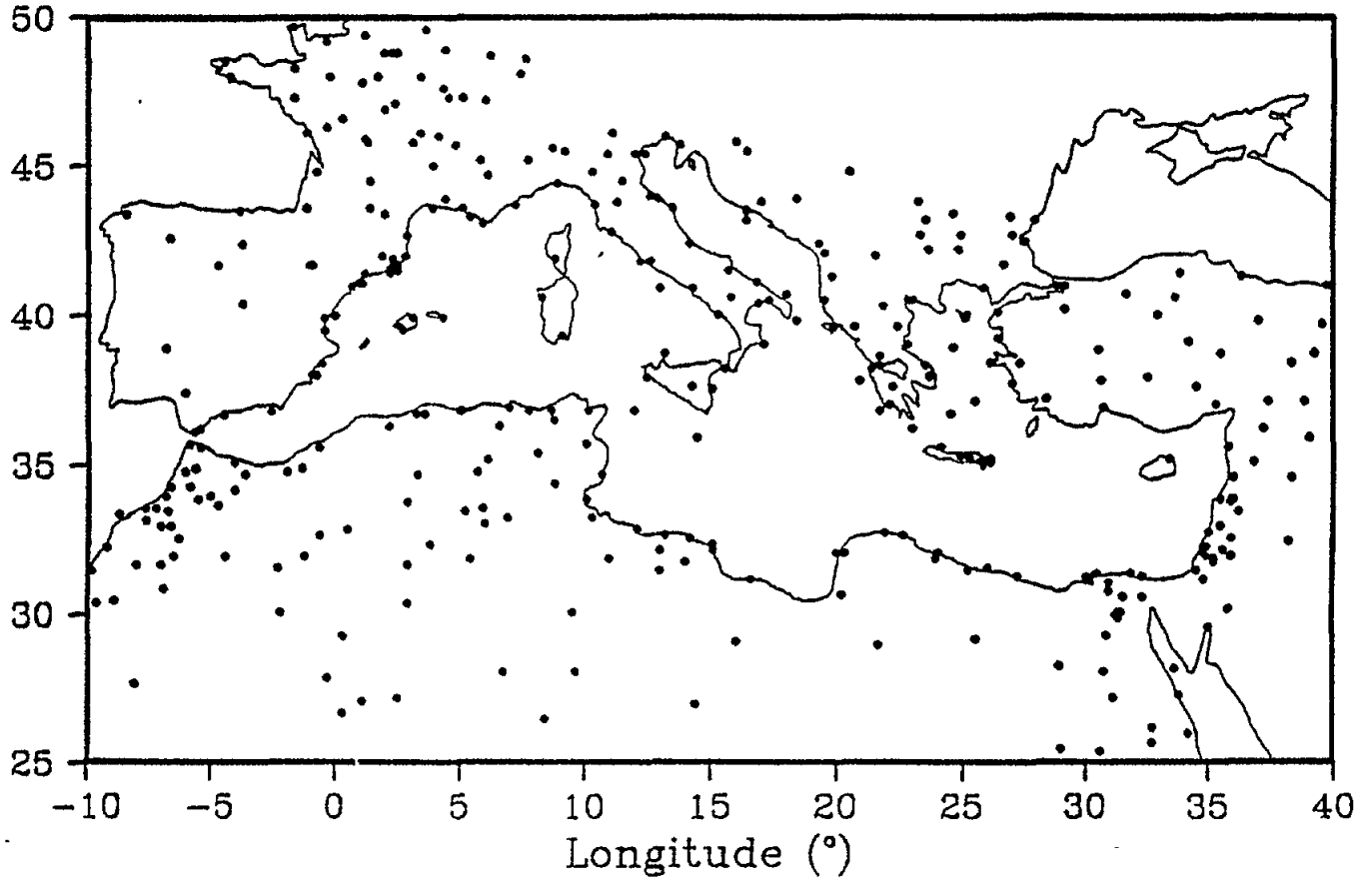
3. Using observed climate data, a set of regionally-averaged time series is built up for each of the climate parameters which are to be considered as predictor variables.

4. Regression equations are constructed using present-day instrumental climate data. These relate variations in regionally-averaged climate variables (the predictors) to variations in single-station values of the variables to be predicted.

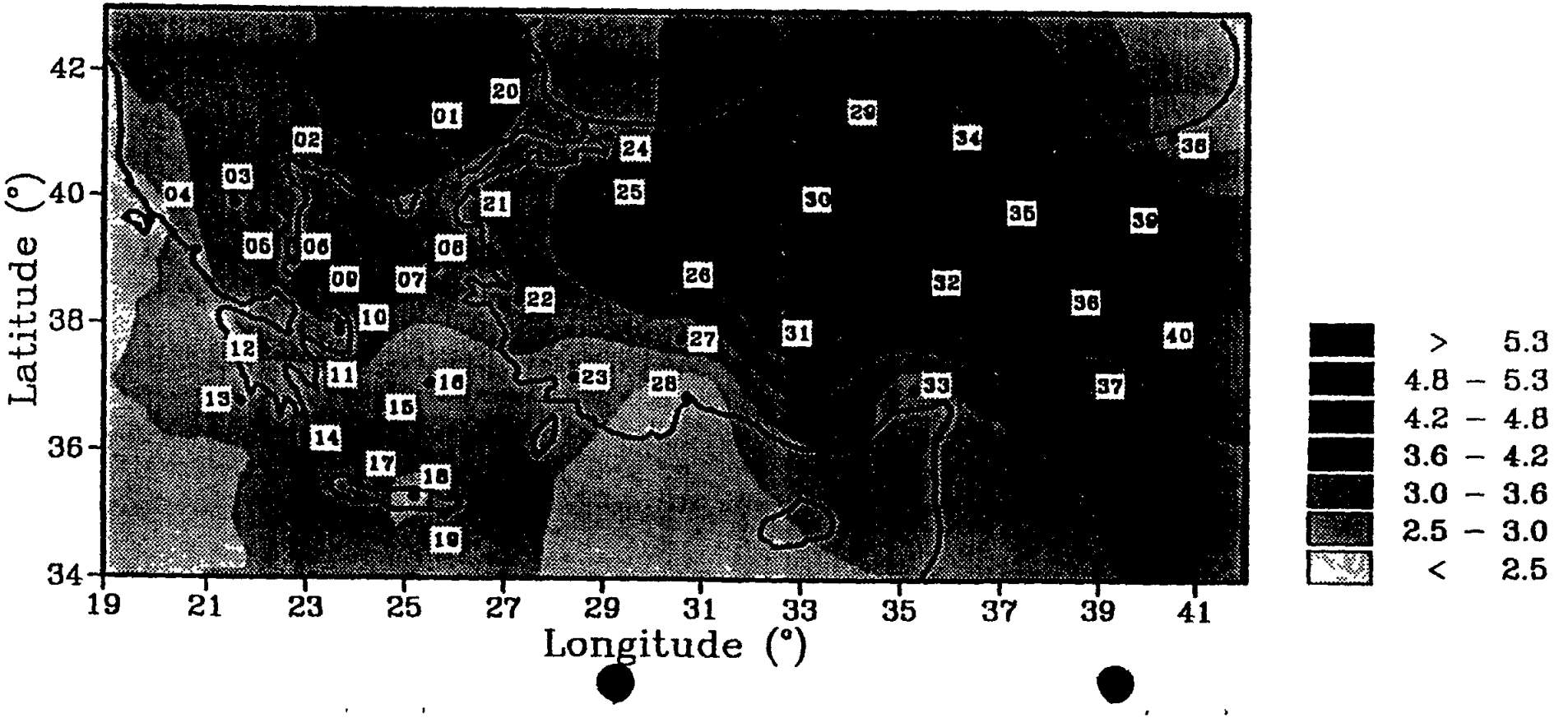
5. The regression equations are used to derive point values for the relevant climate variables in a high greenhouse gas world. The predictor variables used to construct the regression equations are replaced by GCM estimates of the perturbation due to a doubling of CO_2.

6. The climate values derived from the regression equations for a number of sites in a region are then contoured to produce a map of the climate perturbation expected for that region in a high greenhouse gas world.

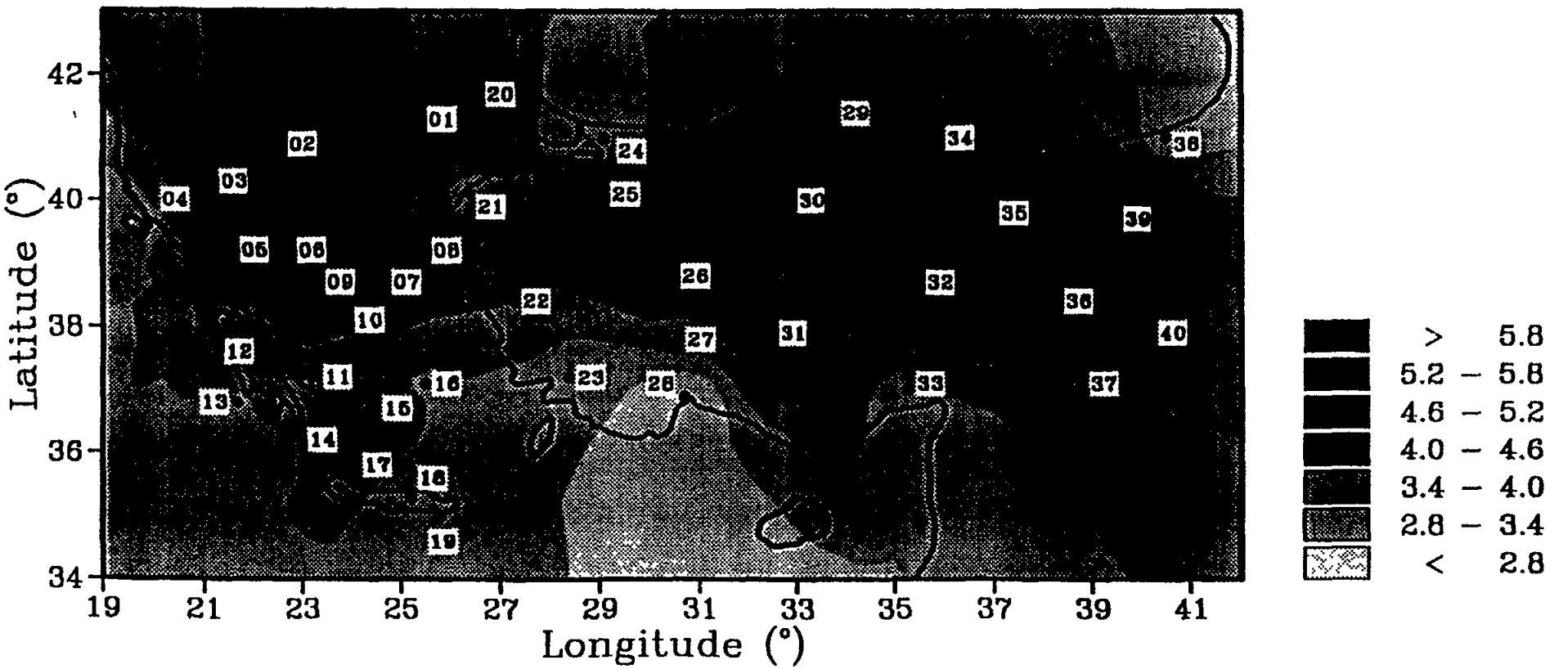
Fig. 1. Mediterranean stations for the UNEP project



$2xCO_2$ winter temperature increase (°C) in Turkey and Greece for OSU



$2xCO_2$ winter temperature increase (°C) in Turkey and Greece for CCM



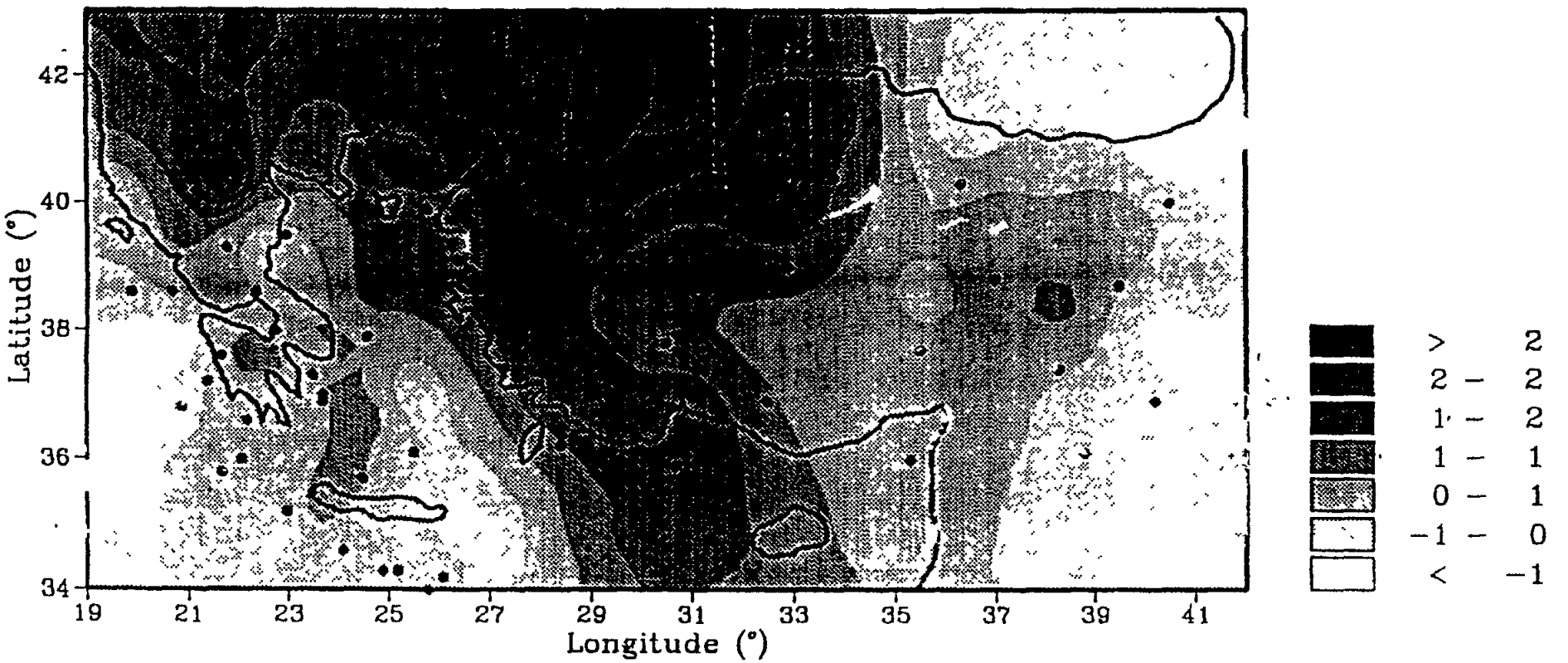


Fig. 15. Spring season 2xCO_2 CCM precipitation perturbation (mm/month) for Greece and Turkey.

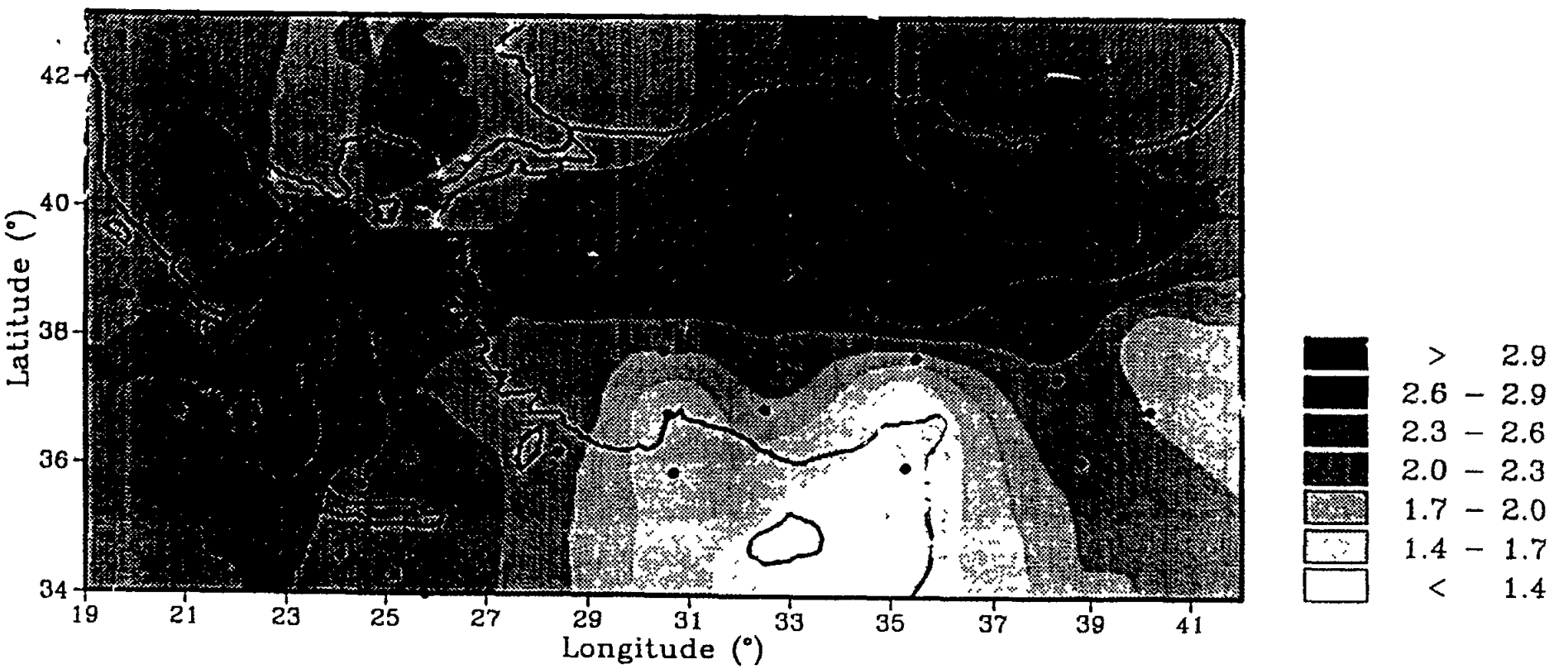
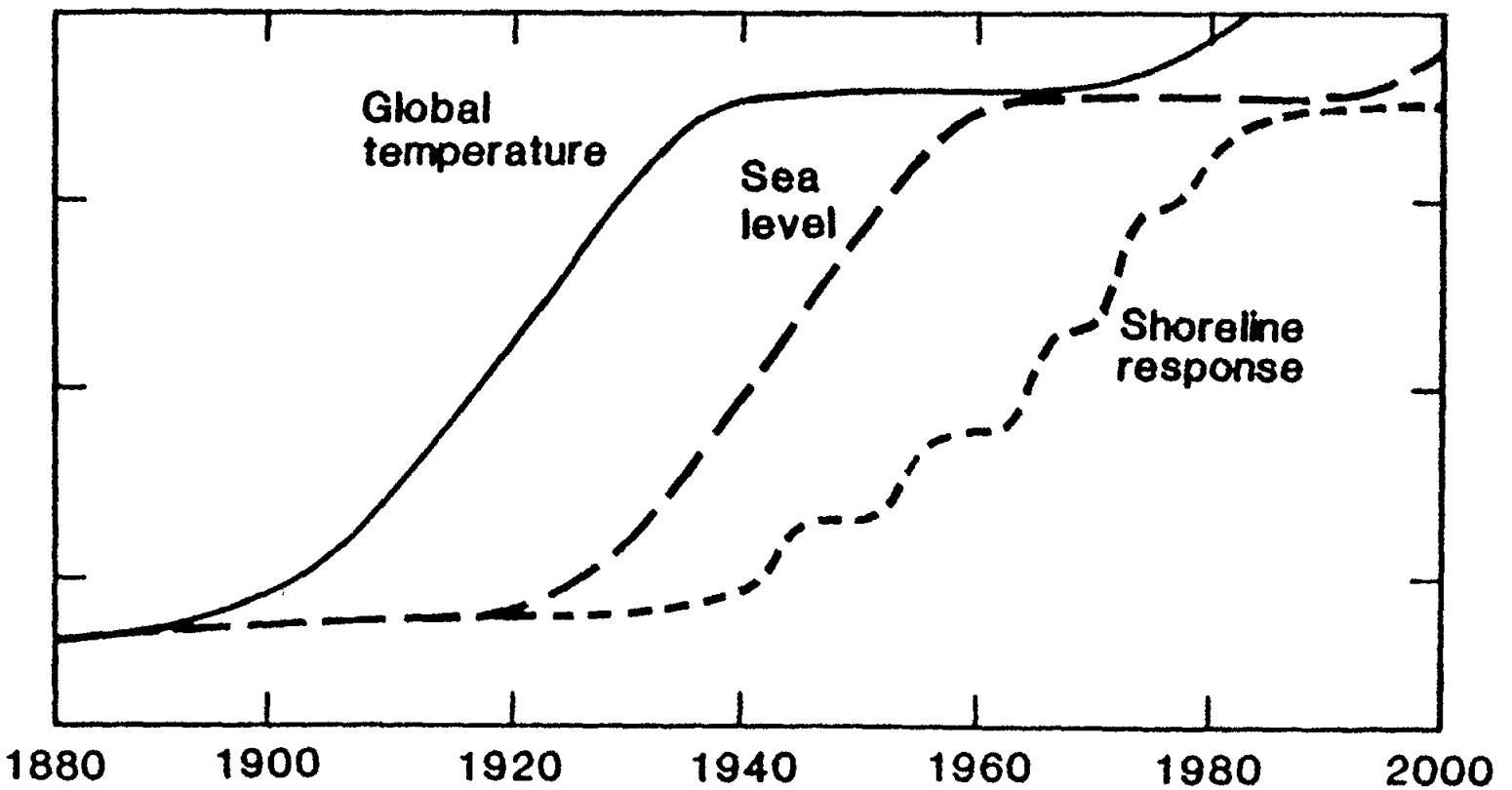
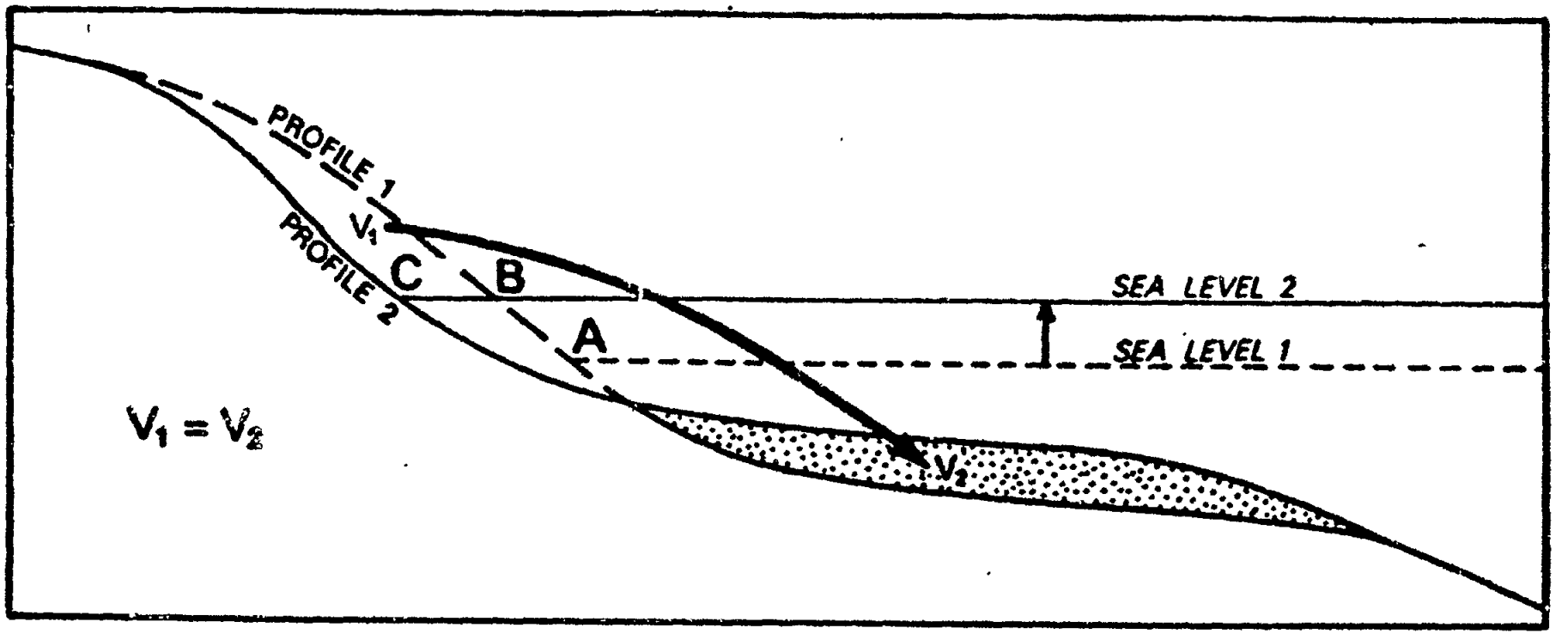


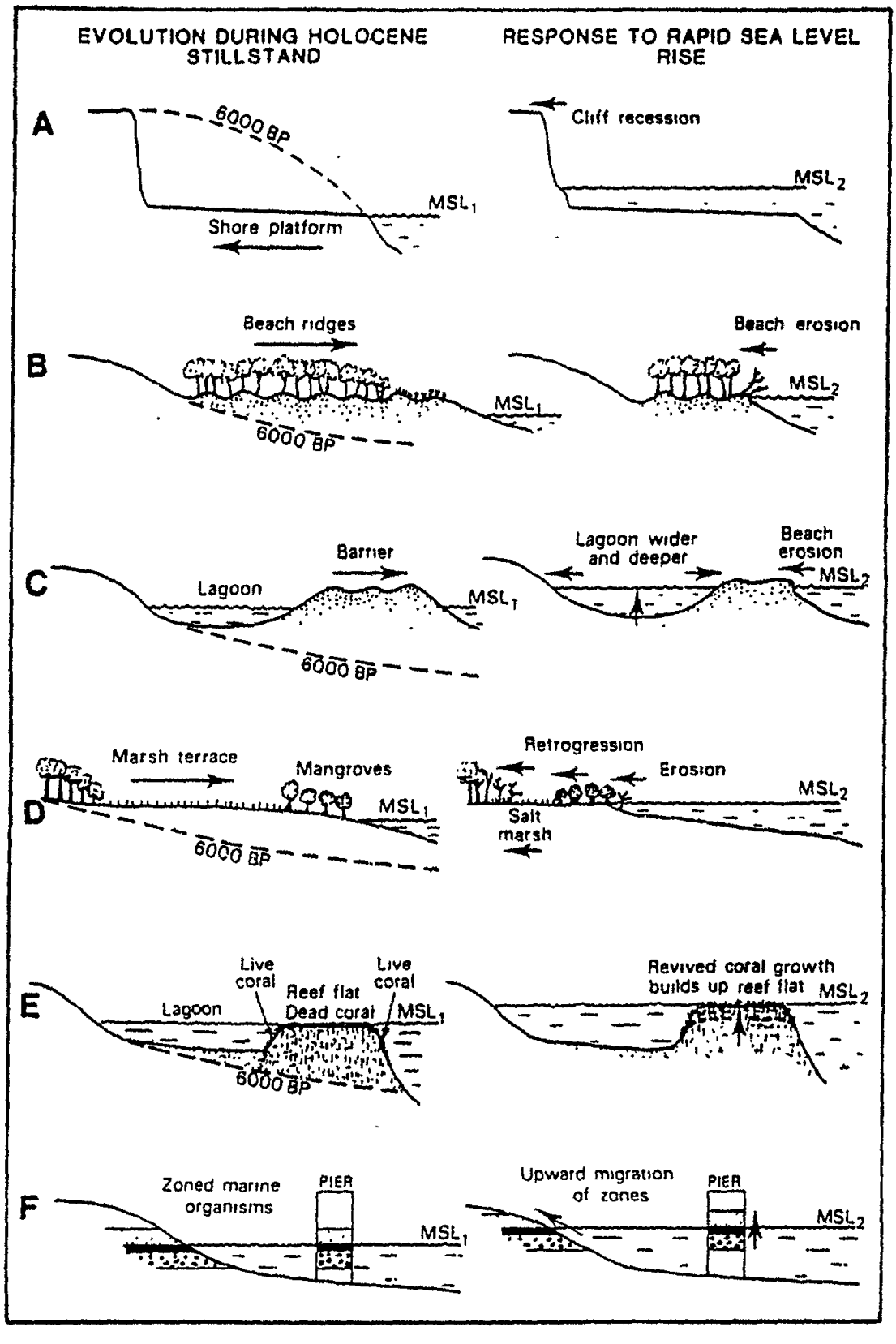
Fig. 12. Summer season $2xCO_2$ CCM temperature perturbation (°C) for Greece and Turkey.



Schematic representation of the relationships between global warming(°C), sea-level rise (m) and shoreline response (m). The latter is a step function associated with major storms. (From G.I. Pearman (Ed.), Greenhouse, Planning for climate change, CSIRO, 1989).



Brunn model of response of an equilibrium beach to a sea-level rise. The coastline retreats from A to C as the pre-existing transverse profile is restored by seaward transference of beach sediment. (From G.I. Pearman (Ed.), Greenhouse, Planning for climate change, CSIRO, 1989).



Response of coastal features to a sea-level rise. (From G.I. Pearman (Ed.), Greenhouse, Planning for climate change, CSIRO, 1989).

IMPACTS RESULTING FROM CLIMATIC CHANGES

FIRST ORDER IMPACTS

INCREASED AIR TEMPERATURE

INCREASED SEA SURFACE TEMPERATURE

CHANGES TO LOCAL CLIMATES AND WEATHER:

- CHANGED PATTERNS OF RAINFALL IN TIME AND SPACE;
- CHANGED PATTERNS OF WINDS IN TIME AND SPACE

IMPACTS RESULTING FROM CLIMATIC CHANGES

SECOND ORDER IMPACTS

CHANGES IN RELATIVE HUMIDITY

CHANGES IN RUN-OFF AND RIVER FLOW RATES

CHANGES IN SOILS

CHANGES IN LARGE SCALE COASTAL BIOME DISTRIBUTION

CHANGES IN COASTAL CURRENT AND WAVE REGIMES, AND STRATIFICATION/MIXING

CHANGES IN THE LOCATION AND/OR PERSISTENCE OF OCEANIC FRONTAL SYSTEMS

CHANGES IN SALINITY AND COASTAL WATER CHEMISTRY

CHANGES IN GEOGRAPHIC DISTRIBUTION, INTENSITY AND FREQUENCY OF STORMS

CHANGES IN PATTERNS OF COASTAL FLOODING AND OTHER EPISODIC EVENTS

CHANGES IN HUMAN COMFORT OF SPECIFIC LOCATIONS

IMPACTS RESULTING FROM CLIMATIC CHANGES

HIGHER ORDER IMPACTS

CHANGES IN RAINFALL AND TEMPERATURE WILL AFFECT RELATIVE HUMIDITY WHICH WILL ALTER EVAPO-TRANSPIRATION RATES HENCE AFFECTING:

- THE HYDROLOGICAL CYCLE AND LOCAL WATER BALANCE; WHICH WILL:
    - AFFECT VEGETATION DISTRIBUTION AND ABUNDANCE; HENCE AFFECTING:
        - ANIMAL DISTRIBUTION AND ABUNDANCE;
        - PRODUCTIVITY OF NATURAL AND AGRICULTURAL SYSTEMS;
        - SOIL DECOMPOSITION PROCESSES AND FERTILITY;
- HUMAN DRINKING WATER SUPPLIES; AND
- FRESHWATER MANAGEMENT PRACTICES;
- COASTAL WATER SALINITY AND MIXING; LEADING TO:
    - CHANGES IN COASTAL MARINE ECOSYSTEMS;
    - CHANGES TO FISHERIES PRODUCTIVITY AND MARICULTURE;

ALL OF WHICH WILL HAVE:

- SOCIAL AND ECONOMIC IMPACTS

IMPACTS RESULTING FROM SEA-LEVEL CHANGE

FIRST ORDER IMPACTS

INCREASED FREQUENCY OF FLOODING

INCREASED INLAND EXTENT OF FLOODING

REARRANGEMENT OF COASTAL UNCONSOLIDATED SEDIMENTS AND SOILS

INCREASED SOIL SALINITY IN AREAS PREVIOUSLY UNAFFECTED

CHANGED WAVE CLIMATES

ACCELERATED DUNE AND BEACH EROSION

UPWARD AND LANDWARD RETREAT OF THE BOUNDARY BETWEEN FRESHWATER AND BRACKISH WATERS

GREATER UPSTREAM INTRUSION OF SALTWATER WEDGES

CHANGES TO BANK AND WETLAND VEGETATION

CHANGES IN THE PHYSICAL LOCATION OF THE TERRESTRIAL-AQUATIC BOUNDARY

CHANGES IN COASTAL WATER CLARITY

CHANGES IN COASTAL WATER CIRCULATION PATTERNS, AND

CHANGES IN SEDIMENT SINK VOLUMES

IMPACTS RESULTING FROM SEA LEVEL CHANGE

SECOND ORDER IMPACT

CHANGES IN OFFSHORE BOTTOM PROFILES

CHANGES IN MARINE PRIMARY PRODUCTION, AND

CHANGES IN TERRESTRIAL (COASTAL) PRIMARY PRODUCTION

CHANGES IN SEDIMENT AND NUTRIENT FLUX RATES

IMPACTS RESULTING FROM SEA LEVEL CHANGE

HIGHER ORDER IMPACT

CHANGES IN BEACH PLAN FORM WILL ALTER:

- LOCAL CURRENT AND WAVE REGIMES; HENCE:
    - LOCAL PATTERNS OF EROSION AND DEPOSITION; AND
    - LOCAL DISTRIBUTION OF COASTAL SUBSTRATE TYPES; AND HENCE,
        - THE DISTRIBUTION PATTERNS OF BENTHIC ORGANISMS.
- SUSCEPTIBILITY OF THE COASTLINE TO WAVE ATTACK;
- CHANGE THE VULNERABILITY OF COASTAL AREAS TO EPISODIC FLOODING AND/OR SEASONAL OR PERMANENT INUNDATION; HENCE
    - AFFECTING CAPITAL INVESTMENT IN INFRASTRUCTURE; AND
    - SUITABILITY OF THE COASTLINE FOR HUMAN SETTLEMENT.

CHANGES IN MARINE PRIMARY PRODUCTION WILL AFFECT:

- ENERGY FLOW TO HIGHER TROPHIC LEVELS; HENCE
    - STANDING STOCKS OF HIGHER TROPHIC LEVELS; AND
    - OVERALL RATES OF SECONDARY PRODUCTION; AND ULTIMATELY
        - FINFISH AVAILABILITY FOR HUMAN CONSUMPTION.

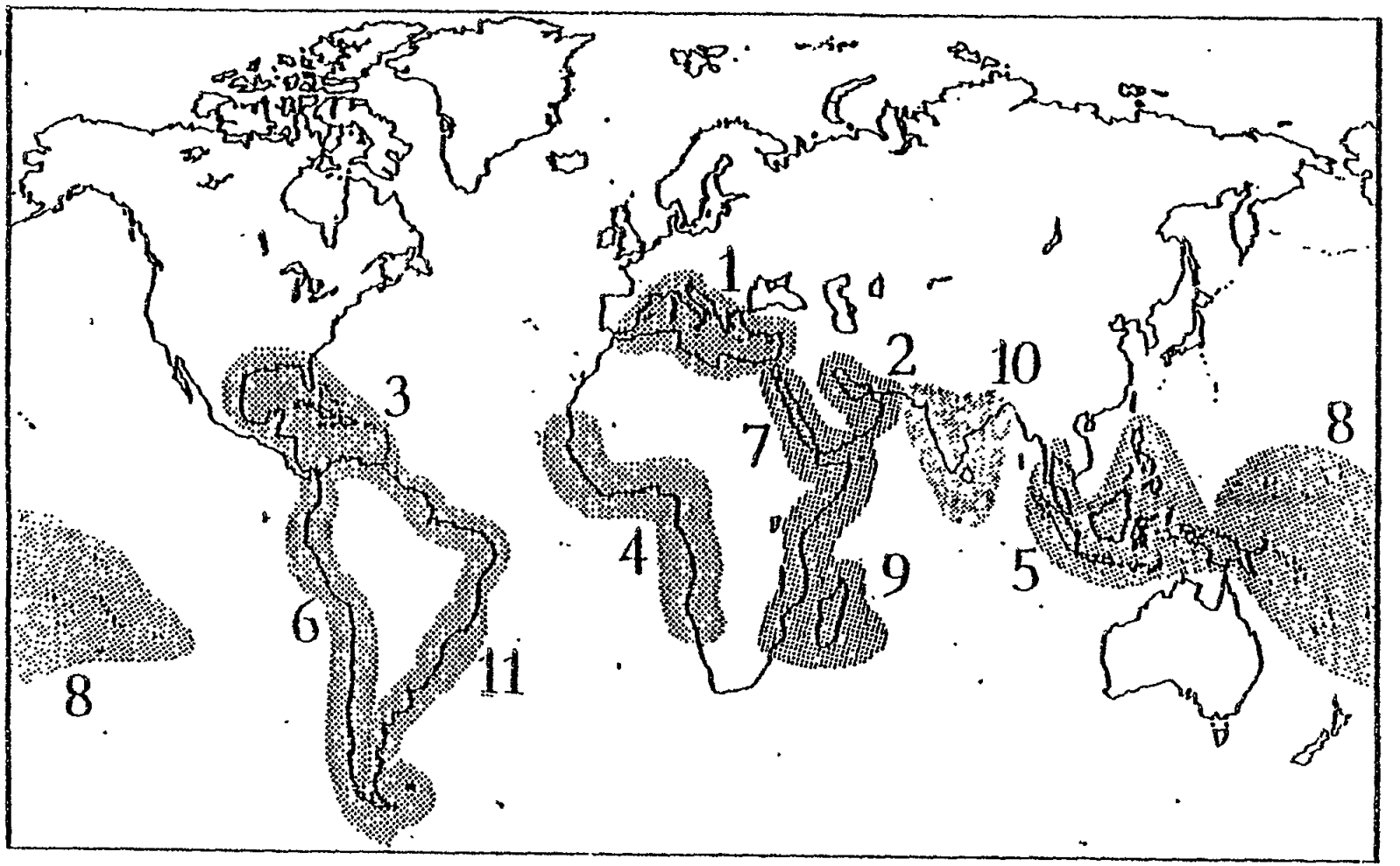
SEA LEVEL CHANGE
HIGHER ORDER IMPACT (2)

CHANGES IN COASTAL/TERRESTRIAL VEGETATION AND WETLANDS WILL:

- ALTER THE DISTRIBUTION AND ABUNDANCE OF DEPENDENT ANIMALS;
- AFFECT ECONOMIC ACTIVITIES BY AFFECTING COMMERCIALLY IMPORTANT SPECIES SUCH AS PENAEID PRAWNS AND SHRIMP;
- ALTER THE FLUX OF SEDIMENTS AND NUTRIENTS INTO THE MARINE ENVIRONMENT;
- ALTER DISTRIBUTIONS OF HUMAN DISEASE VECTORS; HENCE,
    - CHANGING THE EPIDEMIOLOGY OF VECTOR BORNE DISEASES.

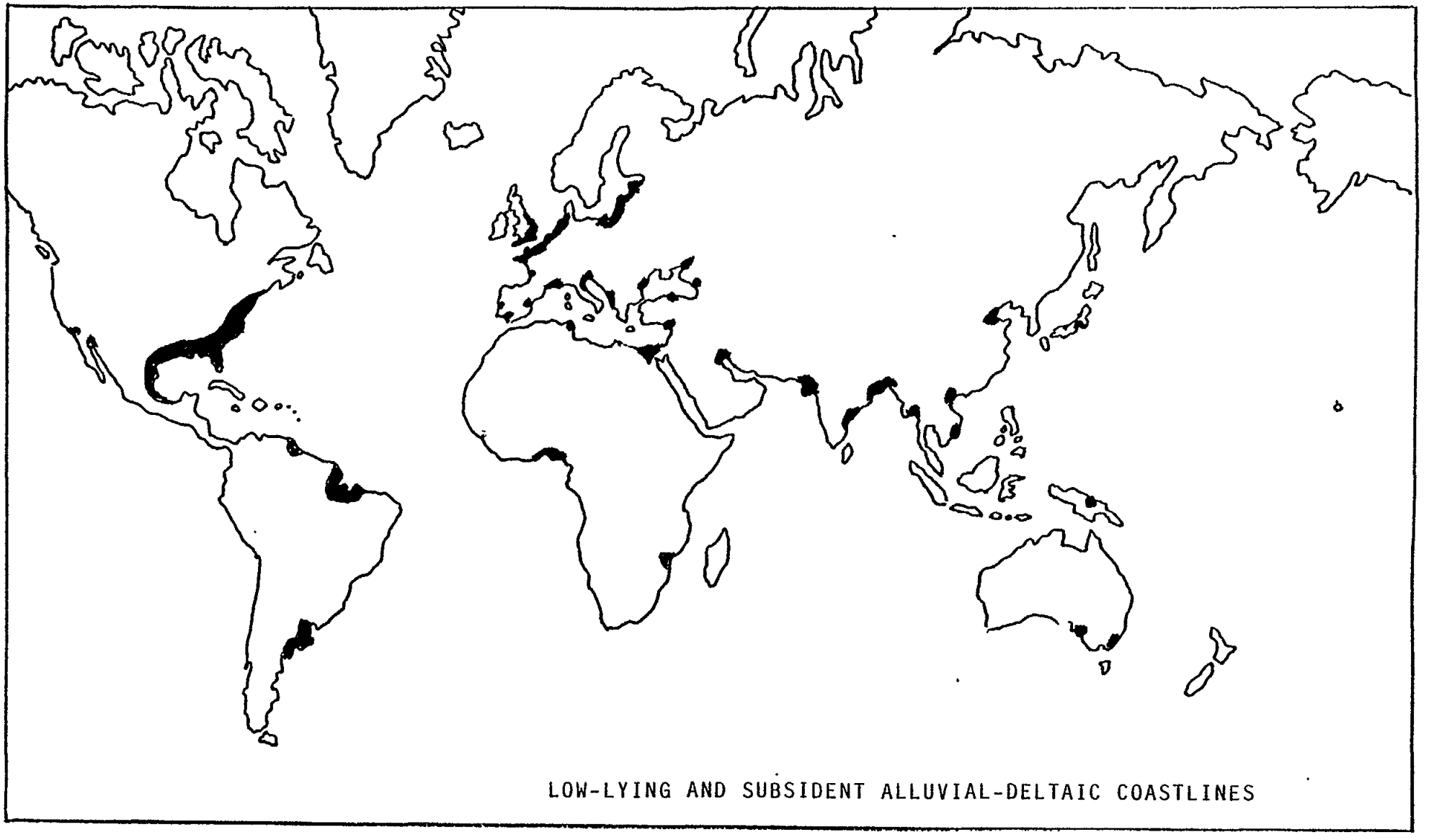
CHANGES IN NUTRIENT LEVELS IN COASTAL WATERS WILL CHANGE MARINE BASED PRIMARY PRODUCTIVITY; AND

- MAY CHANGE THE FREQUENCY OF HARMFUL ALGAL BLOOMS; WHICH MAY:
    - IMPACT FISH AND SHELLFISH RESOURCES; AND MAY THEREFORE:
        - AFFECT SUBSISTENCE AND COMMERCIAL ACTIVITIES IN HUMAN SOCIETIES.



1. Mediterranean Region
2. Kuwait Action Plan Region
3. Wider Caribbean Region
4. West and Central African Region
5. East African Region
6. South East Pacific Region
7. Red Sea and Gulf of Aden Region
8. South Pacific Region
9. Eastern African Region
10. South Asian seas Region
11. South West Atlantic Region

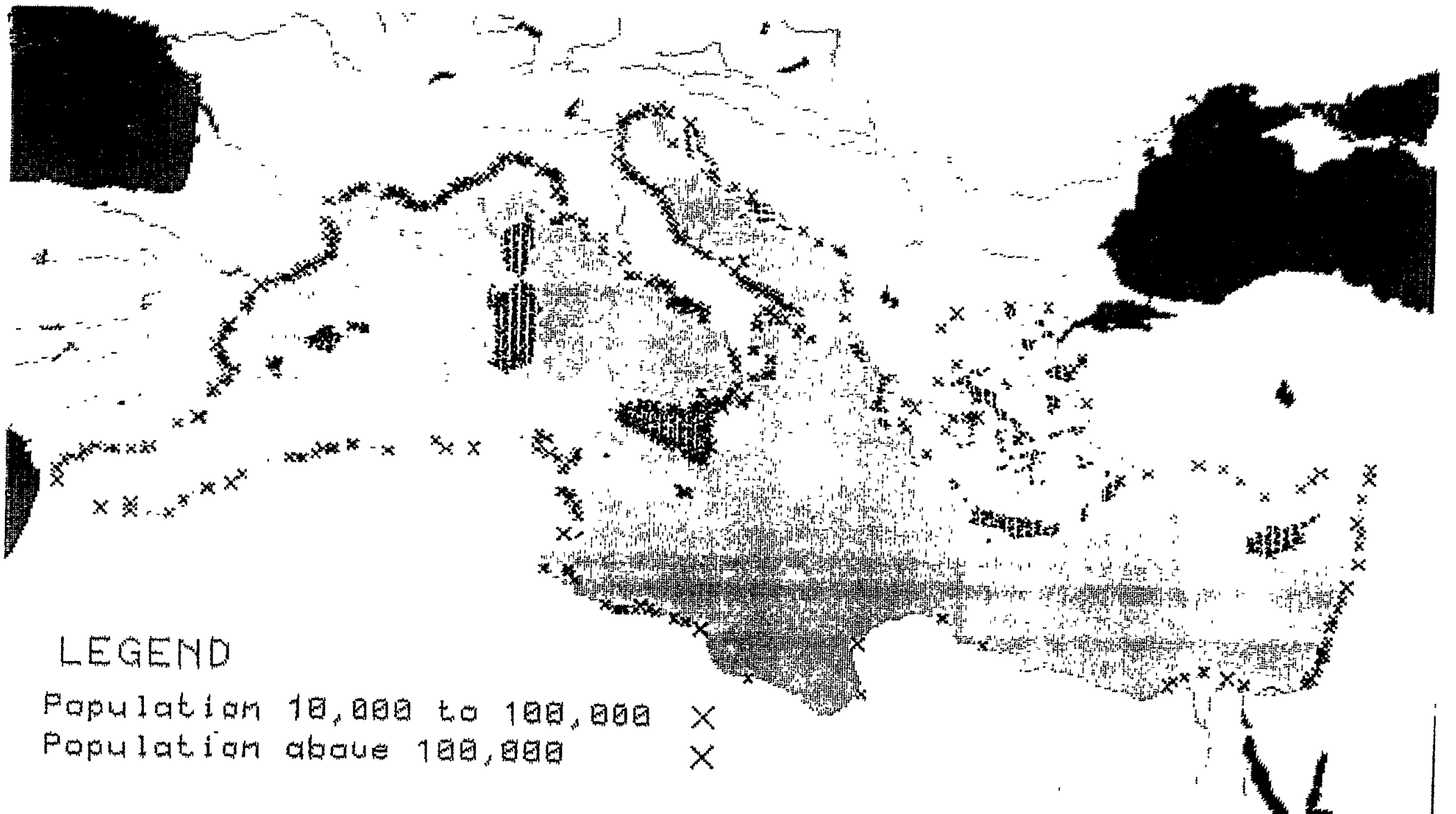
Fig. 1 - Geographic coverage of UNEP Regional Seas Programme



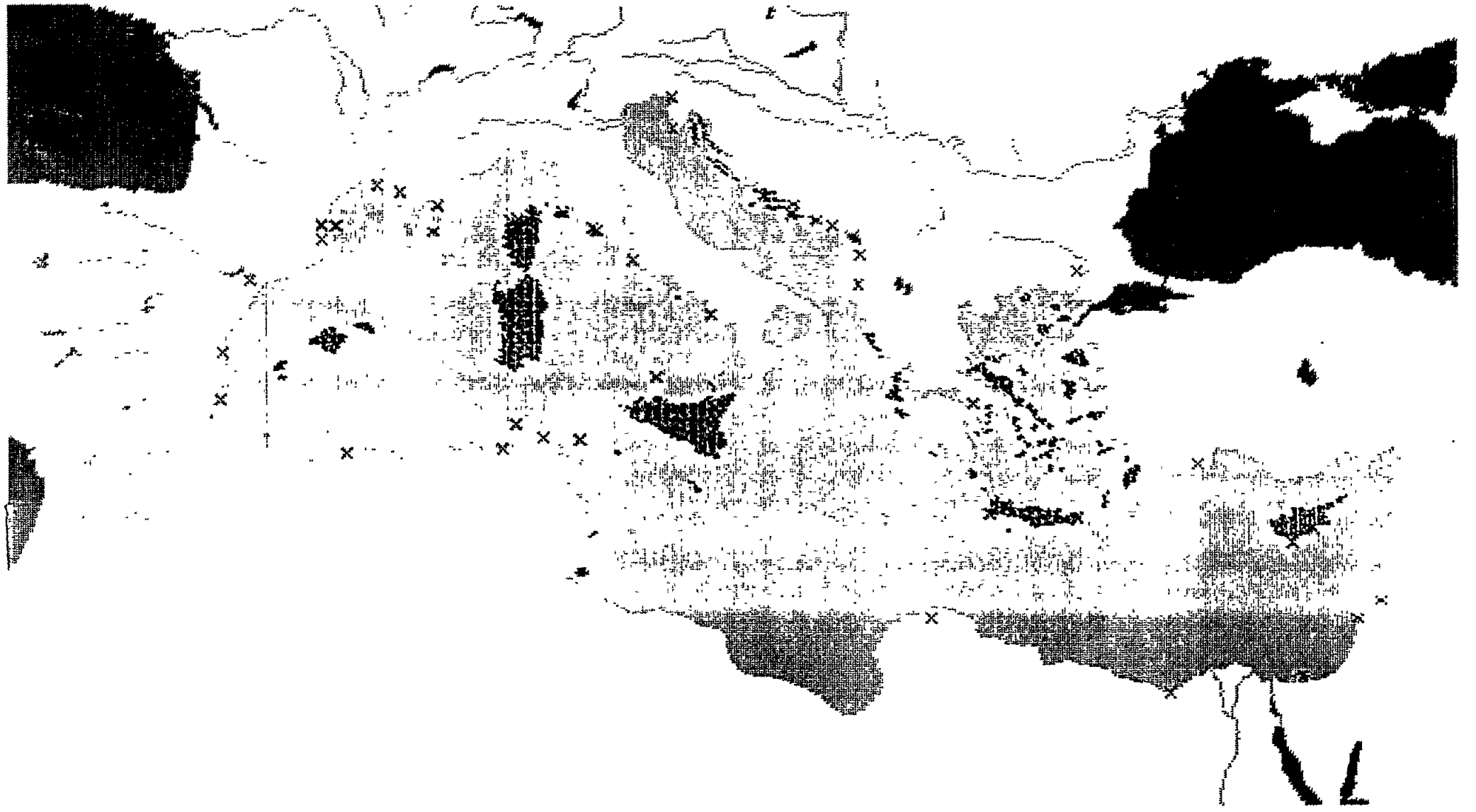
LOW-LYING AND SUBSIDENT ALLUVIAL-DELTAIC COASTLINES

Mediterranean Coastal Cities

(Population above 10,000)

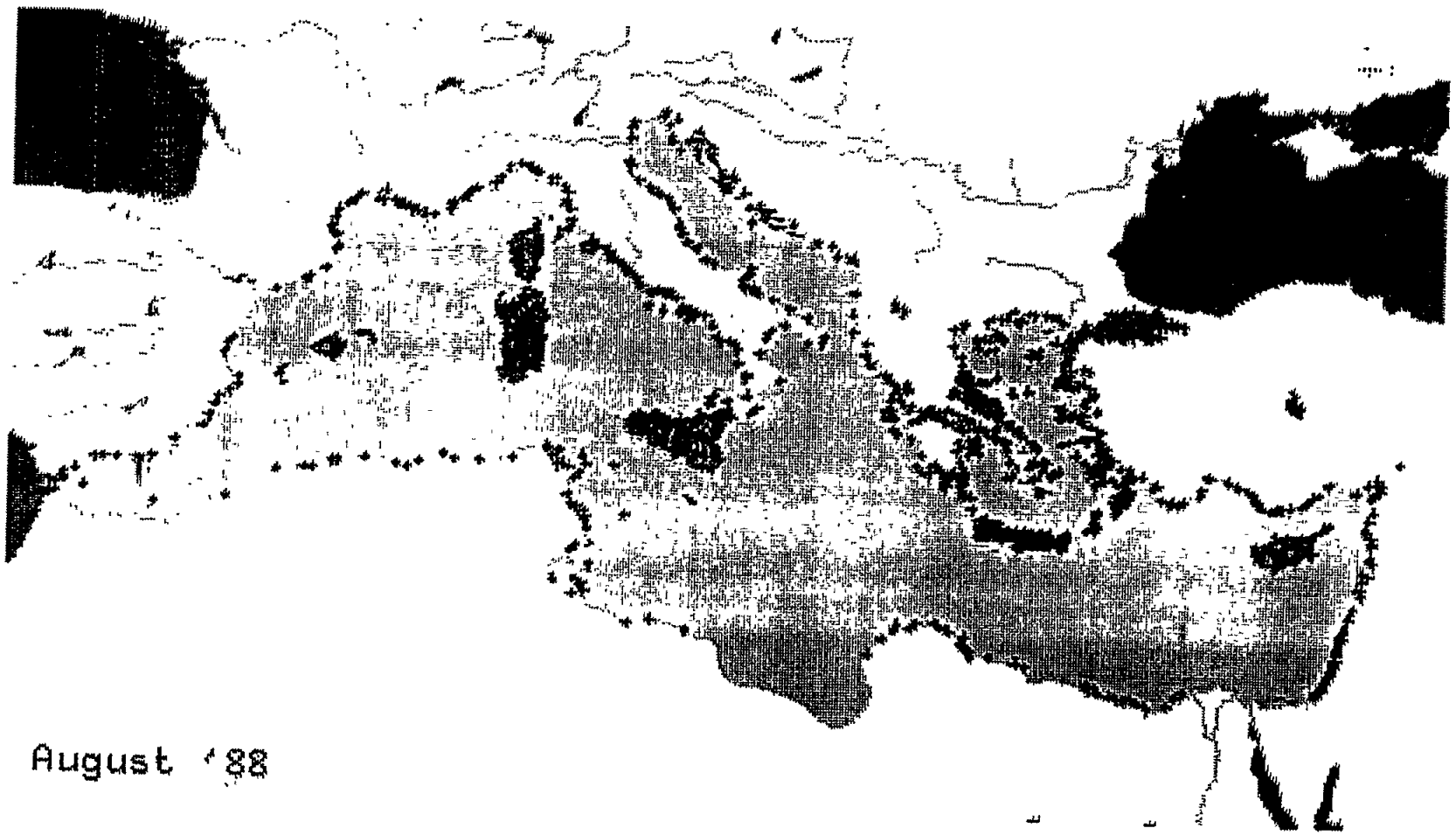


Mediterranean Specially Protected Areas



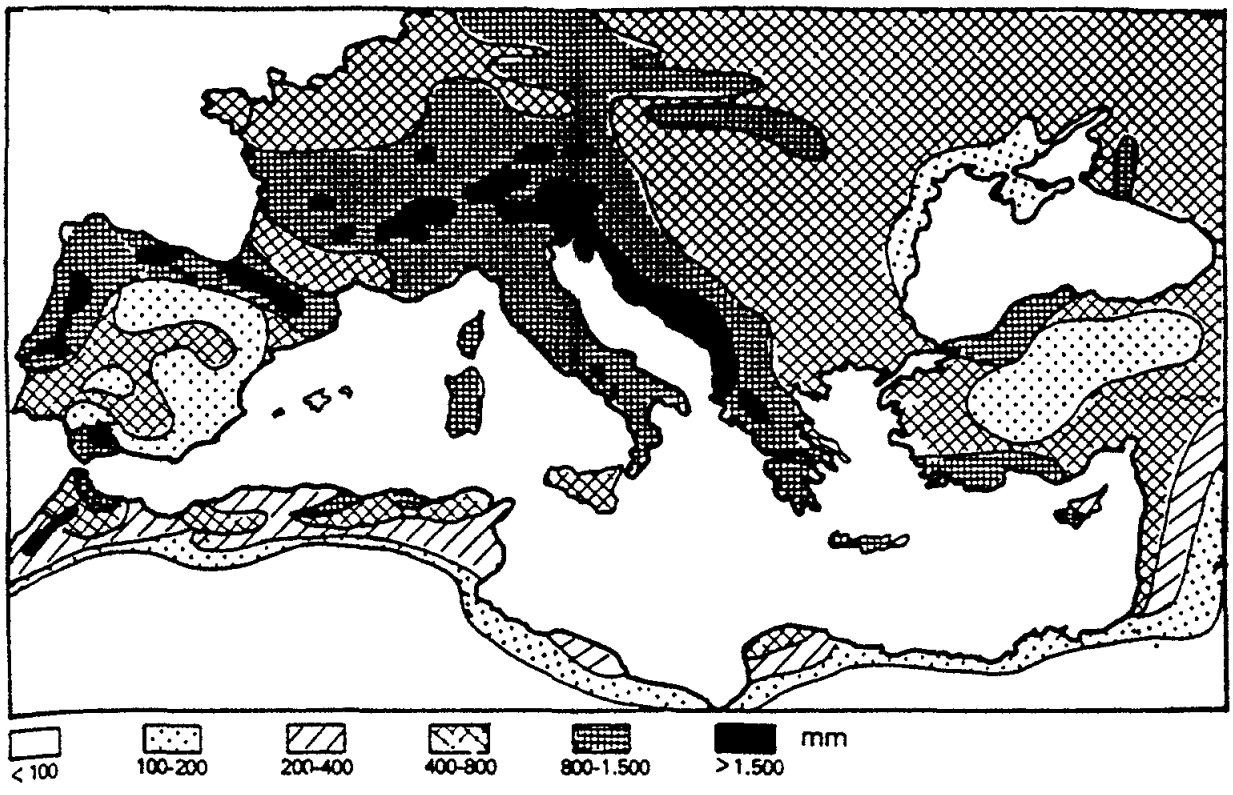
Coastal Archaeological Sites in the Mediterranean

(Source: N.C. Flemming)



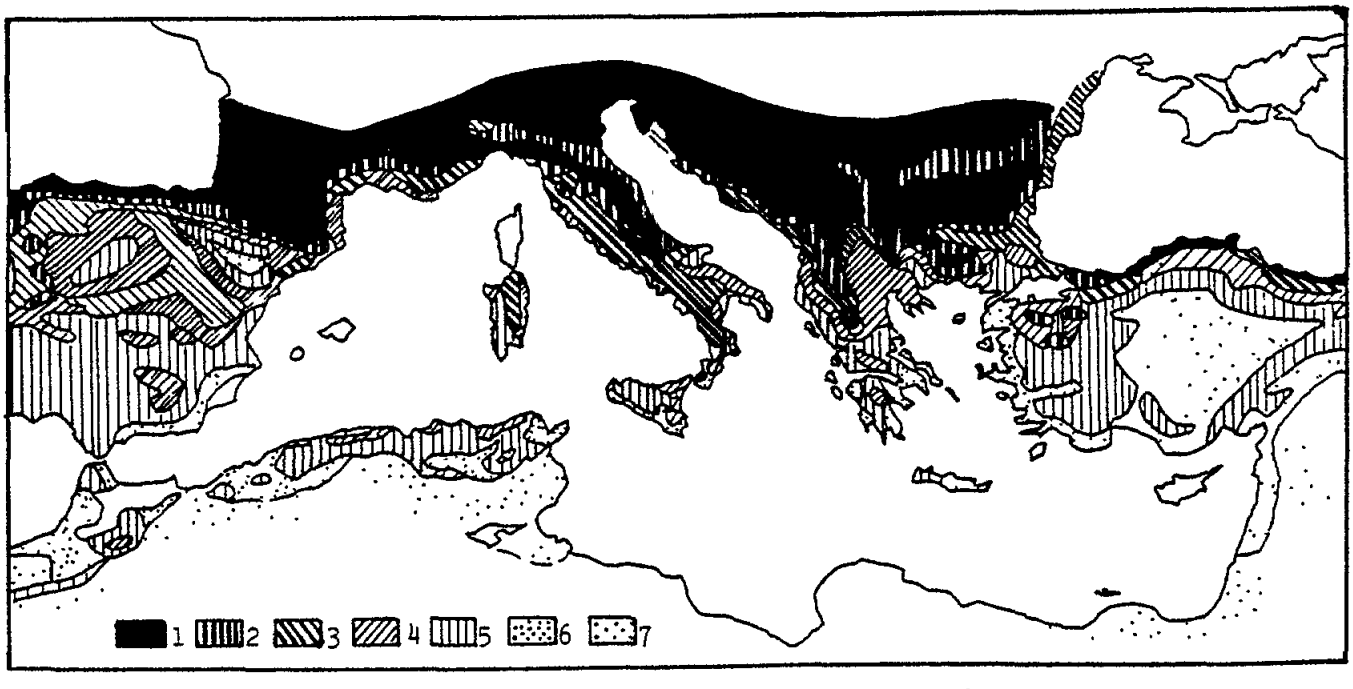
August '88

Mediterranean Historic Sites



Distribution of annual rainfall in the Mediterranean region

Fig. 6



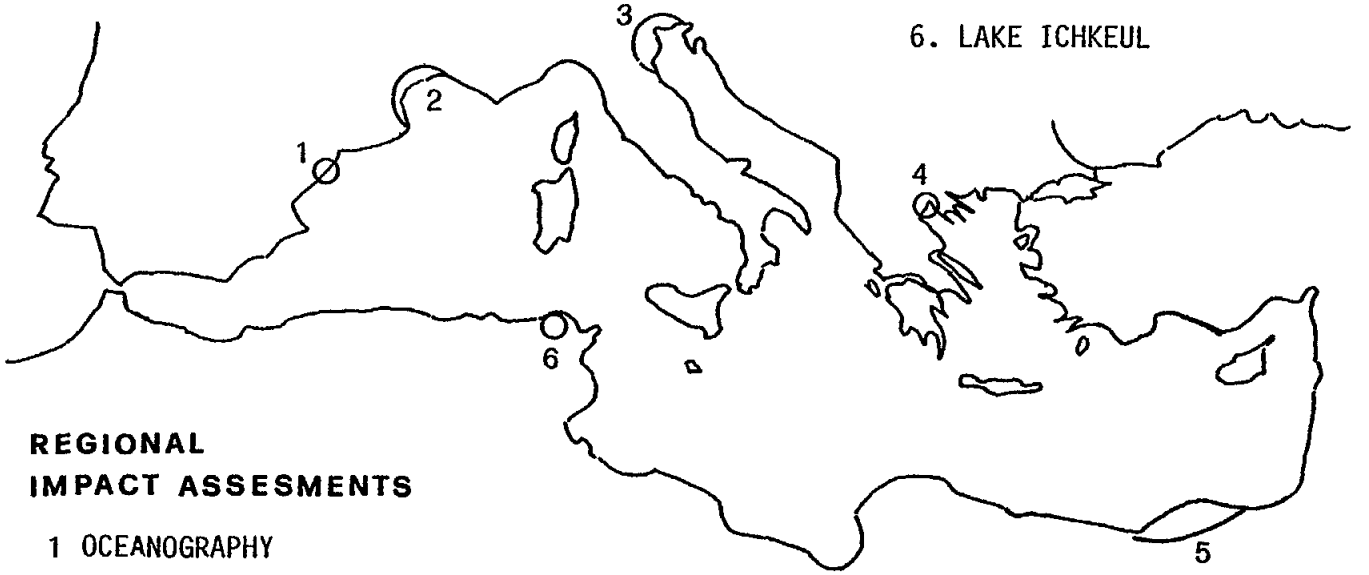
Extent of the dry season in the Mediterranean region (number of dry months: 1. None 2. One-two 3.Two-three 4.Three-four 5. Four-five 6. Five-seven 7. More than seven).

GENERAL CHAPTERS

1. OVERVIEW
2. CLIMATE CHANGES

CASE STUDIES

1. EBRO
2. GULF OF LIONS - RHONE
3. PO - NW ADRIATIC
4. AXIOS - THESSALONIKI
5. NILE DELTA
6. LAKE ICHKEUL

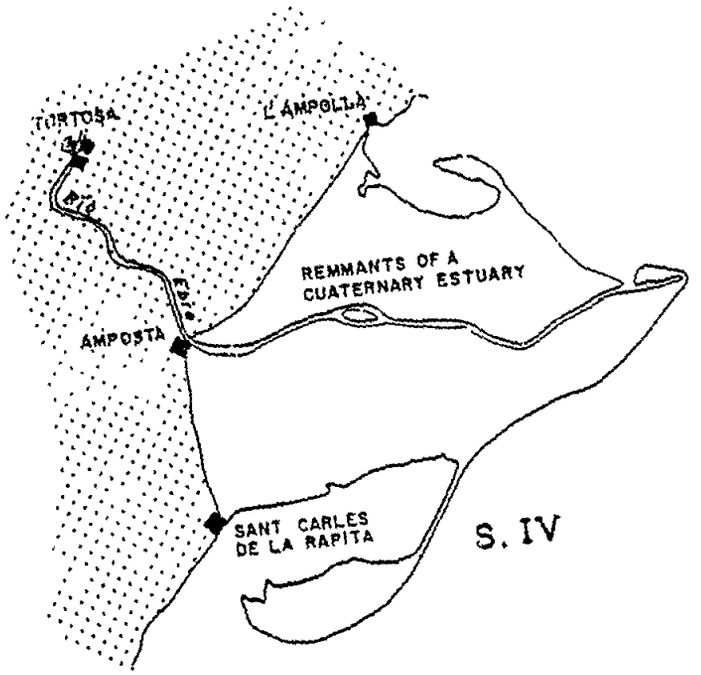


REGIONAL IMPACT ASSESMENTS

1 OCEANOGRAPHY
2 COASTAL STABILITY
3 SEA LEVEL CHANGES
4 HYDROLOGY
5 ECOSYSTEMS
6 VEGETATION
7 SOCIO - ECONOMICS

IMPLICATIONS OF CLIMATIC CHANGE IN THE MEDITERRANEAN REGION

(UNEP 1989)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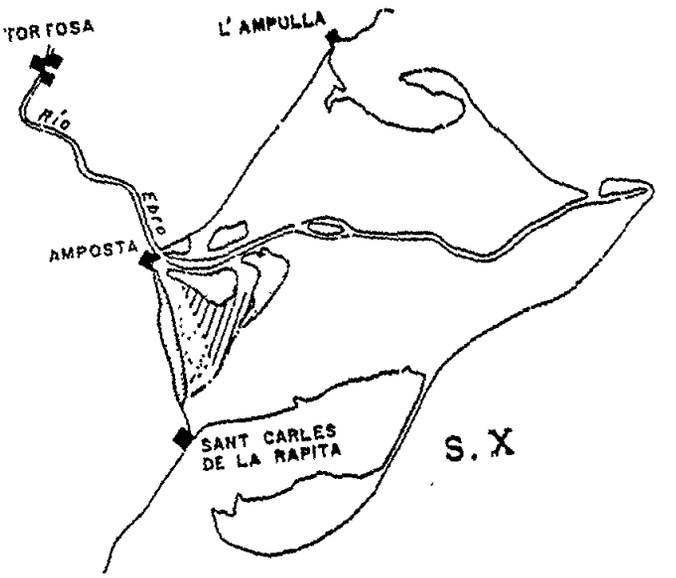
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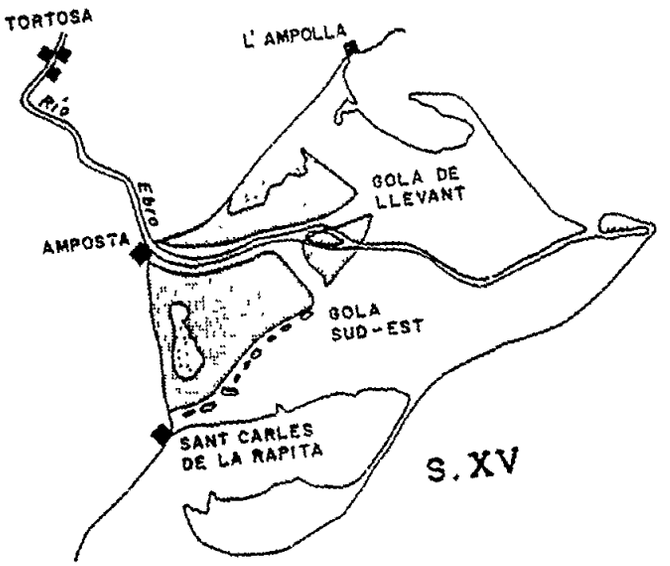
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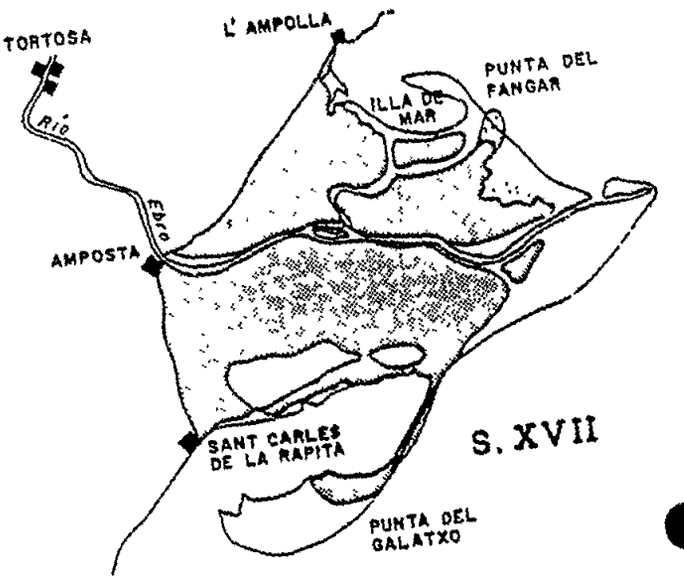
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PUNTA DEL
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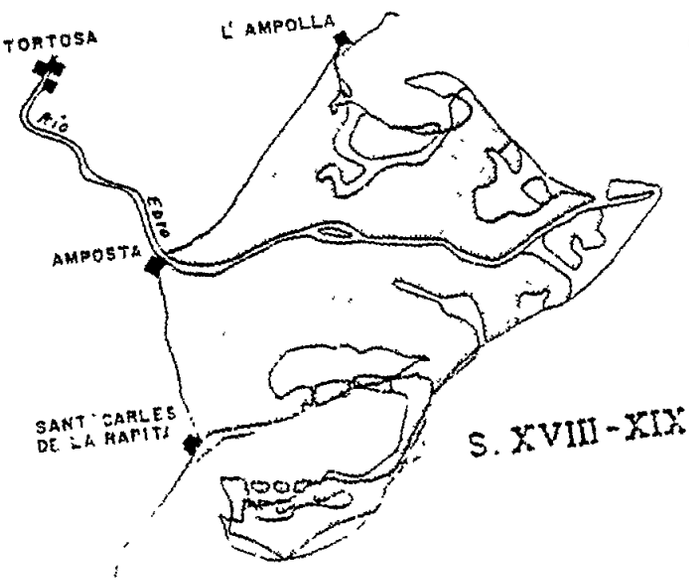
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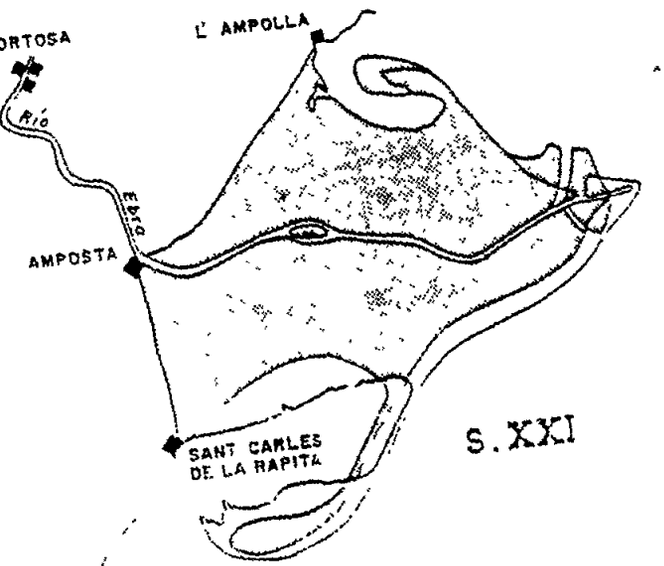
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IMPACT OF CLIMATIC CHANGE

Changed mean annual and seasonal temperature, general air circulation and precipitation will affect:

(a) surface and groundwater flow and river regimes, that is surface and ground-water availability, the incidence of floods and the amount of sediment transported and delivered to the sea;

(b) the movement of marine water masses (waves, currents, tides), especially in terms of direction and intensity of storms (i.e. erosion of the coasts) and of tidal range;

(c) natural ecosystems, due mainly to increased temperature and its effects on water and soil qualities;

(d) occupation and use of the coastal lowland regions (0-5 m) because of sea-level rise, and altered parameters of agriculture, fishing, industry, tourism and the quality of the environment.

SUMMARY OF IMPACTS

Potential evapo-transpiration will increase throughout the Mediterranean, coupled with a possible decrease in precipitation in the south and an increase in the northern part. Climatic changes generally will occur gradually and will not be specifically manifested for another 3-4 decades. Hot dry summers and exceptional events of drought or rainfall and floods, marine storms, tidal surges and of water stagnation and eutrophication, however, could increase in frequency.

Increase in temperature would lead to an increase of land degradation, deterioration of water resources, decline in agricultural production and damage to natural terrestrial and aquatic ecosystems. Salinization of irrigation water would have negative consequence on sensitive grain yield. Consequently new varieties of crops have to be introduced, adapted to the new natural setting and yield standards.

Marine circulation could be altered both in the Mediterranean and the Atlantic, thus affecting marine productivity and the pattern of pollutant dispersal.

Generally marine and land weeds are expected to benefit from warmer, CO_2 richer atmosphere. Flora and fauna of the wetlands will be forced to a gradual adaptation to induced conditions which might be crucial for the species that possess reduced tolerance to high salinities. As bioclimatic zonation will gradually shift northwards, several species will migrate to the north, and insect populations might increase. There will be favourable conditions for an increasing risk of agricultural pests, bacteria and diseases, especially in the swamps.

The effects of sea level rise are most predictable even though the extent of sea level rise is difficult to foresee: 1) direct wave impact on exposed coasts (e.g. the Venice lagoon coastal barrier, beach resorts) and on harbour installations (Alexandria, Port Said, La Golette-Tunis, etc); 2) flooding of estuaries, canals, lagoons, which should be more serious for agriculture than for the increasingly more valuable lagoonal fishing. Degradation of lagoons (e.g. Venice Lagoon), however, could seriously affect wildlife and fish resources; 3) a sea level rise of 10-20 cm will aggravate existing shore erosion problems.

A global mean eustatic rise in sea level of about 20 cm by 2025 would not, in itself, have a significant impact in the Mediterranean, except locally (e.g. lagoons). However, local sea level changes could be up to five times this amount because of natural land subsidence, that could be enhanced by excessive groundwater withdrawal. Particularly negative effects of this impact will be felt in low lying areas, deltas and coastal cities.

The future impacts on Mediterranean society by non-climatic factors (e.g. population increases, present development plans) may far exceed the direct impacts of climate change. Non-climatic factors will cause continuous increases in society's vulnerability to climatic stress, particularly in the south. Together, these demographic and climatic changes should increase the probability of catastrophic events and hasten their occurrence.

Most of the deltaic lowlands of the Mediterranean Sea are experiencing serious environmental problems because of agricultural, industrial, urban and tourist developments during the last two decades. Problems range from water pollution and salinization to land subsidence, shoreline erosion, and restriction and deterioration of wildlife habitats. This vulnerability is increased by adverse socio-economic conditions, the effect of which will be superimposed upon those of climatic change.

FUTURE STRATEGIES

To develop a strategy for responding to the impacts of change, it is essential to identify those parts of the Mediterranean coastal regions where knowledge is still inadequate.

The physical impact of sea level rise on the Mediterranean lowland coasts can be predicted, even modelled quantitatively on the basis of the present parameters of morphology, hydrodynamics, sediment budgets, land subsidence and the effects of artificial structures. Equally, the impacts of altered rainfall distribution on surface and groundwater could be modelled quantitatively, and the effects of increased air temperatures and changed soil-water parameters on biosystems can be estimated, at least qualitatively, which then give some idea of impacts on agriculture and fisheries. What is much more difficult to estimate, however, is the impact of these physical and biological changes on the future socio-economic framework of the threatened lowlands.

Coastal zone management must be based on "cost-effectiveness", which means an assessment of the "value" of the threatened land uses, not only in terms of their present functions, in the context of the local needs and of the importance of the lowland concerned to its hinterland and further, but especially of those of decades ahead.

Regarding sea level change, perspective actions can be either preventive or reactive. For example, entire coasts and lagoon margins can be walled in, or choices must be made between irreplaceable coastal uses (e.g. national and military harbours, towns of historical-artistic value, lagoonal resources, specialized agriculture) and adaptations. Examples of such relative actions would be (a) shifting land uses and (b) a different approach to beach recreation (i.e. less urbanized), the replacement of extensive, uneconomical crops in sub-zero lands, with lagoons destined to aquaculture and nature reserves. The lagoons would act as a buffer belt, since their inner margins can be more easily protected than the exposed coast.

Close attention needs to be paid to the conservation of soil, groundwater and wetlands resources in the Mediterranean, because they contribute substantially to environmental stability. The overall adverse effects on downstream human settlements and ecosystems by large dam schemes have not been considered sufficiently in past planning. Future water management plans must be scrutinized more closely in relation to climatic change.

Studies of the frequencies of extreme events (high temperatures, high and low precipitation events, storms surges, etc), and how these frequencies relate to mean climatic conditions, are required to help predict probabilities of occurrence.

The implications of climate impacts for some regions and processes are of very high complexity and therefore systems analysis seems to be the best approach to their study.

Attention should be given to identifying and accessing data that can be used for climatic impact assessment. The value of long-term data series is stressed. Monitoring programmes to collect such data should be maintained and/or extended.

Of particular importance is the need to initiate research on all climatically-induced changes and to control and plan coastal development well in advance of the postulated sea-level rise in order to minimize the negative effects of man-made dis-equilibriums already experienced in many parts and to make future protection cost-effective.

It is recommended that organisational and legal instruments be developed to control coastal development, land reclamation and groundwater exploitation. Lowlands could be analysed and zoned in high, medium and low risk categories.

PROPOSED CASE STUDIES IN THE MEDITERRANEAN REGION

A. MEDITERRANEAN ISLANDS

1. RHODES ISLAND
2. ISLAND OF MALTA
3. ADRIATIC ISLANDS

B. MEDITERRANEAN COASTAL AREAS

1. IZMIR BAY
2. KASTELA BAY
3. COASTAL REGION OF SYRIA

ANNEX V

BASIC FACTS ABOUT THE KASTELA BAY AND ITS' IMMEDIATE ENVIRONS

The Bay of Kastela is the largest bay in the coastal region of central Dalmatia. It is an oblong, 14.8 km long, 6.6 km wide and on average 23 metres deep basin, with a surface area of 61 square kilometres and a volume of 1.4 cubic kilometres.

The sea shore is surrounded by a relatively small and narrow coastal plain, with higher mountainous regions rising in the immediate hinterland.

The main input of freshwater into the Bay is through the River Jadro (annual inflow of about 0.32 cubic kilometres), and to a lesser extent from a number of underwater springs.

To date the Bay itself and its immediate surrounding are home to more than 300,000 inhabitants, concentrated in the towns of Split (250,000), Solin (15,000), Trogir (10,000), and in smaller settlements, such as the seven Kastelas.

In the post-war period the region underwent rapid development: the initial number of inhabitants increased sixfold; a number of larger industrial plants were built and the existing ones were significantly expanded; the commercial harbour reached a capacity of 1 million tonnes per year; the agricultural production was substantially increased; and Split developed as the major centre of passenger transit to Dalmatian islands. Due to the geographic configuration of the Bay and of its surroundings, most of this development took place in the narrow coastal zone.

Unfortunately this intensive economic development and population growth have not been accompanied by adequate development of infrastructure, such as urban sanitation (sewerage in particular), treatment and disposal of industrial wastes, surface transport systems for goods and people, etc.

The geographic area covered by the study on the impact of climatic changes is shown in the map attached to this Annex.

ANNEX VI

IMPLICATIONS OF EXPECTED CLIMATIC CHANGES ON THE KASTELA BAY AREA

OBJECTIVES

- To identify and assess possible implications of expected climatic changes on the terrestrial, aquatic and marine ecosystems, populations, land-use and sea-use practices and other human activities;

- To determine areas or systems which appear to be most vulnerable to the expected climatic changes;

- To give recommendations for planning and management of coastal areas and resources, as well as for planning and design of major infrastructure and other systems;

- To provide an input into the Comprehensive Coastal Area Management Programme for the Kastela Bay of the Mediterranean Action Plan, and into other projects and developments relevant to the subject of the study.

ASSUMPTIONS

For the specific purpose of the study a sea level rise of 24-52 cm and a temperature elevation of 1.5 to 3 degrees Centigrade by the year 2050 will be used, taking into account:

- The best available information, knowledge and insights into the problems relevant to the Kastela Bay area including major projects, planned or under consideration;

- The assumptions accepted at the Second World Climate Conference (1990), ie an increased temperature of 2-5ºC and sea level rise of 65 +/- 35 cm before the end of the 21st Century;

- The IPCC statement concerning potential changes to the climate of Southern Europe (35º - 50ºN 10ºW - 45ºE) that: " warming would be about 2ºC in winter and would vary from 2º to 3º C in summer. There is some indication of increased precipitation in winter but summer precipitation decreases by 5 to 15%, and summer soil moisture by 15 to 25%.";

- The expected results of the University of East Anglia's Scenario analysis for the Mediterranean Basin with sub-regionally specific scenarios.

OUTPUTS

The main outputs of the study will be:

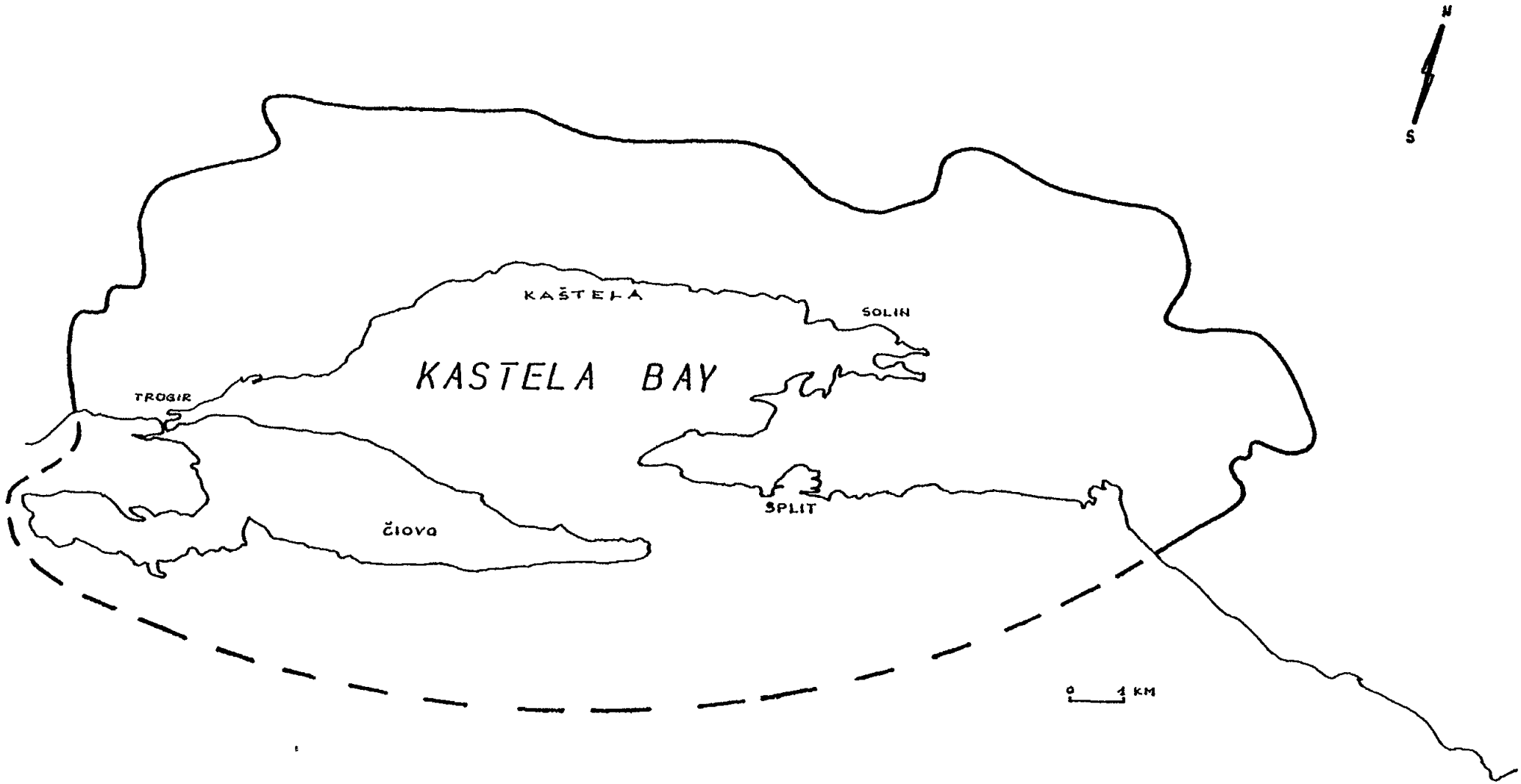
- Identified impacts of predicted climatic changes and sea level rise;

- An assessment of the magnitude and implications of the identified impacts;

- Proposed policies and measures to mitigate or avoid the predictable consequences of expected climatic change.

ANNEX VII

AREA OF THE STUDY



AREA OF THE STUDY

ANNEX VIII

OUTLINE OF THE REPORT*

EXECUTIVE SUMMARY (Baric)

1. INTRODUCTION (Baric)

1.1 **Background**

1.2 **Basic Facts concerning Kastela Bay**

1.3 **Methodology and assumptions used in the study**

2. IDENTIFICATION AND ASSESSMENT OF THE POSSIBLE CONSEQUENCES OF CLIMATIC CHANGE

2.1 **Climate Conditions** (Gacic)

Climatic conditions and evidence of long-term changes will be studied through analysis of historical data. Special attention will be given to extreme weather conditions (wind, precipitation, temperature). Spatial analysis of available time series will be undertaken in order to assess typical time scales of current variability.

The aim of this chapter will include assessment of the long-term changes of some selected oceanographic variables (sea level, salinity, water temperature). Special attention will be given to the response of these variables to meteorological forcing on the climatic scale. Relationships between sea level and atmospheric pressure, wind, thermal effects and their inter-relationship will be studied.

Long-term changes in salinity and sea temperatures will be explained in terms of meteorological forcing and variations in water exchange between the Kastela Bay and adjacent basins.

2.2 **Lithosphere** (Milos)

The soil types and the properties of soil components within the area, their spatial distribution and potential will be reviewed. The implications of climatic changes for soil processes and properties will be reviewed including soil physics, erosion, water balance, soil chemistry (nutrients and contaminants) and soil biology (organic content, C/N ratio and humus quality) with a view to preparing soil classifications and potential under future climatic conditions.

2.3 **Hydrosphere** (Margeta)

The influence of climatic changes on the natural hydrological balance of the area will be analysed. Analysis will cover all environmental elements including atmospheric, biosphere and lithospheric elements as they relate to the hydrosphere. This will necessitate evaluation of all elements of the hydrological cycle (air, soil, ground, surface, etc.). On the basis of expected changes to the hydrological cycle assessment will be made of future available water resources including marine and freshwater resources. Climatic changes will be analysed in terms of their potential effects on water quality and distribution of water in space and time (changes in streamflow and groundwater flows, water table and exchange rates).

The impacts of these changes on the characteristics of the water resources will be reviewed in terms of environmental characteristics and impacts on the urban water system (supply; storm and waste water disposal systems). Two major elements in this analysis will be flooding and saline intrusion.

The consequences of the predicted changes for management of water resources and their future rational use will be detailed together with assessment of possible structural and non-structural mitigation measures.

2.4 **Atmosphere** (Grbec)

Physical properties of the atmosphere over the area will be examined with special attention being given to air quality, especially during extreme events. Climatic changes will be discussed in terms of their influence on air quality.

2.5 **Natural Ecosystems**

2.5.1 Terrestrial Ecosystems (Onofri): Characteristics, type and distribution. Present degree of degradation. Potential impacts of expected climatic changes.

2.5.2 Freshwater ecosystems (Baric): Characteristics and present degree of degradation. Potential impacts of expected climatic changes.

2.5.3 Marine Ecosystems (Baric): Characteristics and present degree of degradation. Potential impacts of expected climatic changes

2.6 **Managed Ecosystems**

2.6.1 Agriculture (Milos)

2.6.2 Fisheries (Baric)

2.6.3 Aquaculture (Baric)

2.6.4 Sylviculture (Onofri)

2.7 **Energy and Industry** (Baric)

Type of energy and consumption by major sector (industry transport, etc). Changes in energy demand as a consequence of climatic changes, alternative energy sources (solar, wind, etc.)

Review of the type and size of present industry in the region. Development of new industrial activities. Implications of climatic changes for existing and planned industrial capacity and capabilities.

2.8 **Tourism** (Veldic)

Present demands from the tourist sector in terms of spatial requirements and projections for future growth will be examined. The potential threat posed by climatic change in terms of altered climates and weather; increased demands for limited space; changes to the overall carrying capacity of the Kastela Bay area.

2.9 **Transport and services** (Veldic and Baric)

In examining the present state of this sector and the potential impacts of climatic change special attention will be given to the climatic conditions (particularly extreme events) and their influence on the state of transportation and its infrastructure.

2.10 **Health and sanitation** (?)

2.11 **Population and settlement pattern** (Veldic)

In the first phase this study will consist of an analysis of the present state of the population in terms of its size, distribution and projected growth. The second phase will involve a demographic projection based on the different scenarios and sets of environmental conditions envisaged as arising under conditions of climatic change.

3. SYNTHESIS OF FINDINGS (Baric)

3.1 **Present situation**

3.2 **Major expected changes and their impacts**

4. RECOMMENDATIONS FOR ACTION (Baric)

4.1 **Preventative policies and measures**

4.2 **Adaptive policies and measures**

References

* Texts which are missing for several sub-sections will be developed by the 15th of May 1991.

ANNEX IX

WORKPLAN AND TIMETABLE*

-	Nomination of the Co-ordinator of the Task Team	January 1991
-	Establishment of the Task Team	February 1991
-	First (preparatory) meeting of the Task Team	April 1991
-	Collection of data and relevant documentation by the members of the Task Team	May-Sept. 1991
-	Analysis and evaluation of data and documentation by the members of the Task Team	May-Sept. 1991
-	Preparation of the first outline of individual substantive sections (Chpt. 2 of the outline; Annex VIII) by the members of the Task Team, highlighting the main issues	May 1991
-	Second meeting of the Task Team to review the first outlines of substantive sections	May 1991
-	Preparation of extended versions of substantive sections by the members of the Task Team	May-Sept. 1991
-	Submission of individual substantive sections by the Task Team members to the Co-ordinator	September 1991
-	Third meeting of the Task Team, with external participation, to review and revise the substantive sections of the report, and prepare the conclusions and recommendations	October 1991
-	Preparation of the final draft report, by the Co-ordinator of the Task Team	November 1991
-	Fourth meeting of the Task Team to finalise and adopt the report December 1991	
-	Publication of the report by the Co-ordinating Unit of the Mediterranean Action Plan	February 1992
-	Presentation to the national and local authorities	March 1992

* In addition to the formal meetings of the Task Team it is envisaged that the core members will meet frequently between meetings of the full Team. The Co-ordinator of the Task Team will keep the external members informed of progress on a regular basis, by providing them with materials produced by the Core members of the Task Team.

APPENDIX

SECOND WORLD CLIMATE CONFERENCE
(GENEVA, 29 OCTOBER-7 NOVEMBER 1990)

CONFERENCE STATEMENT

MINISTERIAL DECLARATION

Second World Climate Conference

INTERNATIONAL CONFERENCE CENTRE

GENEVA, SWITZERLAND

29 OCTOBER - 7 NOVEMBER 1990

Sponsors

World Meteorological Organization (WMO)
United Nations Environment Programme (UNEP)
United Nations Educational, Scientific and Cultural Organization (UNESCO)
and its Intergovernmental Oceanographic Commission (IOC)
Food and Agriculture Organization (FAO)
International Council of Scientific Unions (ICSU)

Financial Supporters

The Second World Climate Conference has benefited from the encouragement and support of many countries and organizations. The sponsors are pleased to acknowledge in particular the substantial financial support of: Canada, the Federal Republic of Germany, Italy, France, Japan, the Netherlands, Norway, Switzerland, the United Kingdom, the United States of America, the European Community, the Stockholm Environment Institute and the Environmental Defense Fund (USA)

CONFERENCE STATEMENT

FOREWORD

The Second World Climate Conference was convened in Geneva, Switzerland, from 29 October through 7 November, 1990, under the sponsorship of the World Meteorological Organization; the United Nations Environment Programme; the United Nations Educational, Scientific, and Cultural Organization and its Intergovernmental Oceanographic Commission; the Food and Agriculture Organization; and the International Council of Scientific Unions. This Statement was adopted by the participants in the scientific and technical sessions from 29 October to 3 November 1990, on the basis of the presentations at the Conference, the deliberations of task groups of participants organized to address various specific issues, and plenary discussions involving all participants. The scientific and technical sessions involved 747 participants from 116 countries.

The Conference discussed the results of the first decade of work under the World Climate Programme (WCP), the First Assessment Report of the Intergovernmental Panel on Climate Change (August, 1990) and the development of the International Geosphere-Biosphere Programme (IGBP) and other relevant global programmes. In particular, the Conference considered the role, priorities, and programme structure for the future development of the World Climate Programme.

FOR FURTHER INFORMATION

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7 November 1990

SECOND WORLD CLIMATE CONFERENCE
FINAL CONFERENCE STATEMENT

SUMMARY

1. Climate issues reach far beyond atmospheric and oceanic sciences, affecting every aspect of life on this planet. The issues are increasingly pivotal in determining future environmental and economic well-being. Variations of climate have profound effects on natural and managed systems, the economies of nations and the well-being of people everywhere. A clear scientific consensus has emerged on estimates of the range of global warming which can be expected during the 21st century. If the increase of greenhouse gas concentrations is not limited, the predicted climate change would place stresses on natural and social systems unprecedented in the past 10,000 years.

2. At the First World Climate Conference in 1979, nations were urged "to foresee and to prevent potential man-made changes in climate that might be adverse to the well-being of humanity". The Second World Climate Conference concludes that, notwithstanding scientific and economic uncertainties, nations should now take steps towards reducing sources and increasing sinks of greenhouse gases through national and regional actions, and negotiation of a global convention on climate change and related legal instruments. The long-term goal should be to halt the build-up of greenhouse gases at a level that minimizes risks to society and natural ecosystems. The remaining uncertainties must not be the basis for deferring societal responses to these risks. Many of the actions that would reduce risk are also desirable on other grounds.

3. A major international observational and research effort will be essential to strengthen the knowledge-base on climate processes and human interactions, and to provide the basis for operational climate monitoring and prediction.

PART I

MAIN CONCLUSIONS AND RECOMMENDATIONS

A. Greenhouse Gases and Climate Change

1. Emissions resulting from human activities are substantially increasing atmospheric concentrations of the greenhouse gases. These increases will enhance the natural greenhouse effect, resulting on average in an additional warming of the Earth's surface. The Conference agreed that this and other scientific conclusions set out by the IPCC reflect the international consensus of scientific understanding of climate change. Without actions to reduce emissions, global warming is predicted to reach 2 to 5 degrees C over the next century, a rate of change unprecedented in the past 10,000 years. The warming is expected to be accompanied by a sea level rise of 65 cm ± 35 cm by the end of the next century. There remain uncertainties in predictions, particularly in regard to the timing, magnitude and regional patterns of climate change.

2. Climate change and sea level rise would seriously threaten low-lying islands and coastal zones. Water resources, agriculture and agricultural trade, especially in arid and semi-arid regions, forests, and fisheries are especially vulnerable to climate change. Climate change may compound existing serious problems of the global mismatch between resources, population and consumption. In many cases the impacts will be felt most severely in regions already under stress, mainly in developing countries.

3. Global warming induced by increased greenhouse gas concentrations is delayed by the oceans; hence, much of the change is still to come. Inertia in the climate system due to the influence of the oceans, the biosphere and the long residence times of some greenhouse gases means that climate changes that occur may persist for centuries.

4. Natural sources and sinks of greenhouse gases are sensitive to a change in climate. Although many of the response or feedback processes are poorly understood, it appears likely that, as climate warms, these feedbacks will lead to an overall increase rather than a decrease in greenhouse gas concentrations.

5. The historical growth in emissions has been a direct consequence of the increase of human population, rising incomes, the related exploitation of fossil fuels by industrialized societies and the expansion of agriculture. Under "Business-as-Usual" assumptions*, it is projected that emissions will continue to grow in the future as a consequence of a projected doubling of energy consumption in the first half of the 21st century and an expected doubling of population by the latter half. As a result, the effect of human-induced greenhouse gas concentrations on the earth's radiation balance would by 2025 correspond to a doubling of carbon dioxide unless remedial actions are taken.

6. Over the last decade, emissions of carbon dioxide (CO_2) contributed 55% of the increased radiative forcing produced by greenhouse gases from human activities. The CFCs contributed about 24% of the past decade's changes, and methane 15%, with the balance due to other greenhouse gases. With controls on CFCs under the Montreal Protocol, the relative importance of CO_2 emissions will increase, provided the substitutes for CFCs have minimal

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* "Business-as-Usual" assumes that few or no steps are taken to limit greenhouse gas emissions. Energy use and clearing of tropical forests continue and fossil fuels, in particular coal, remain the world's primary energy source. The Montreal Protocol comes into effect but without strengthening and with less than 100 percent compliance.

greenhouse warming potential. Some 75% of total CO_2 emissions have come from the industrialized countries.

7. The above emissions can be expected to change the planet's atmosphere and climate, and a clear scientific consensus has been reached on the range of changes to be expected. Although this range is large, it is prudent to exercise, as a precautionary measure, actions to manage the risk of undesirable climate change. In order to stabilize atmospheric carbon dioxide concentrations by the middle of the 21st century at about 50% above pre-industrial concentrations, a continuous world-wide reduction of net carbon dioxide emissions by 1 to 2% per year starting now would be required. The Intergovernmental Panel on Climate change (IPCC) also considered three other emissions scenarios, which would not lead to stabilization of CO_2 concentrations in the 21st century. A 15 to 20% reduction in methane emissions would stabilize atmospheric concentrations of that gas.

8. This Conference concludes that technically feasible and cost-effective opportunities exist to reduce CO_2 emissions in all countries. Such opportunities for emissions reductions are sufficient to allow many industrialized countries to stabilize CO_2 emissions from the energy sector and to reduce these emissions by at least 20 percent by 2005. The measures include increasing the efficiency of energy use and employing alternative fuels and energy sources. As additional measures to achieve further cost-effective reductions are identified and implemented, even greater decreases in emissions would be achieved in the following decades. In addition, reversing the current net losses in forests would increase storage of carbon. The economic and social costs and benefits of such measures should be urgently examined by all nations. An internationally coordinated assessment should be undertaken through the IPCC.

9. Countries are urged to take immediate actions to control the risks of climate change with initial emphasis on actions that would be economically and socially beneficial for other reasons as well. Nations should launch negotiations on a convention on climate change and related legal instruments without delay and with the aim of signing such a convention in 1992.

B. Use of Climate Information in Assisting Sustainable Social and Economic Development

Climate data, analyses, and eventually climate predictions, can contribute substantially to enhancing the efficiency and security of economic and developmental activities in environmentally sustainable ways. These benefits are particularly important in food and wood production, water management, transportation, energy planning and production (including assessment of potential resources of biomass, hydropower, solar and wind energy), urban planning and design, human health and safety, combatting of drought and land degradation, and tourism. This requires both data on the climate system, and its effective application. Data acquisition, collection, management and analysis must be more vigorously supported in all countries and special assistance provided to developing countries through international cooperation. Transfer of techniques for applying climate information should be accelerated through more widespread use of software (e.g. CLICOM) for readily available personal computers and other means. Further development of methods for predicting short-term variations in climate and the environmental and social impacts should be vigorously pursued. These advances would provide enormous economic and other welfare benefits in coping with droughts, prolonged rain, and periods of severe hot and cold weather. Such predictions will require major steps forward in ocean-atmosphere-biosphere observing systems. Much greater efforts are also needed to increase involvement in these fields by developing countries, especially through increased education and training.

C. Priorities for Enhanced Research and Observational Systems

1. A consensus exists among scientists as summarized in the Report of Working Group I of the IPCC that climate change will occur due to increasing greenhouse gases. However, there is substantial scientific uncertainty in the details of projections of future climate change. Projections of future regional climate and climate impacts are much less certain than those on a global scale. These uncertainties can only be narrowed through research addressing the following priority areas:

- clouds and the hydrological cycle
- greenhouse gases and the global carbon and biogeochemical cycles
- oceans: physical, chemical and biological aspects; and exchanges with the atmosphere
- paleo-climatic studies
- polar ice sheets and sea ice
- terrestrial ecosystems.

2. These subjects are being addressed by national programmes, the World Climate Research Programme and the International Geosphere-Biosphere Programme and other related international programmes. Increased national support and substantially increased funding of these programmes is required if progress on the necessary time scale is to be made in reducing the uncertainties.

3. Present observational systems for monitoring the climate system are inadequate for operational and research purposes. They are deteriorating in both industrialized and developing regions. Of special concern is the inadequacy of observation systems in large parts of the southern hemisphere.

4. High priority must be placed on the provision and international exchange of high-quality, long-term data for climate-related studies. Data should be available at no more than the cost of reproduction and distribution. A full and open exchange of global and other data sets needed for climate-related studies is required.

5. There is an urgent need to create a *Global Climate Observing System* (GCOS) built upon the World Weather Watch Global Observing System and the Integrated Global Ocean Service System and including both space-based and surface-based observing components. GCOS should also include the data communications and other infrastructure necessary to support operational climate forecasting.

6. GCOS should be designed to meet the needs for:
   (a) climate system monitoring, climate change detection and response monitoring, especially in terrestrial ecosystems
   (b) data for application to national economic development
   (c) research towards improved understanding, modelling and prediction of the climate system.

7. Such a GCOS would be based upon:
   (1) an improved World Weather Watch Programme
   (2) the establishment of a global ocean observing system (GOOS) of physical, chemical and biological measurements
   (3) the maintenance and enhancement of monitoring programmes of other key components of the climate system, such as the distribution of important atmospheric constituents (including the Global Atmosphere Watch), changes in terrestrial ecosystems, clouds and the hydrological cycle, the earth's radiation budget, ice sheets, and precipitation over the oceans.

8. The further development and implementation of the GCOS concept should be pursued, with urgency, by scientists, governments and international organizations.

9. The impacts of climate variability on human socio-economic systems have provided major constraints to development. Climate change may compound these constraints. In semi-arid regions of Africa, drought episodes have been directly responsible for major human disasters. Research undertaken during the first decade of the WCP and through other international and national programmes has improved drought early warning systems, including FAO's Global Early Warning System, and increased the reliability of climate impact analyses. But much more remains to be done. Intensified efforts are required to refine further our ability to predict short-term climate variability, anticipate climate impacts, and identify rational strategies to mitigate or prevent adverse effects. The threat of climate change brings new challenges to the future well-being of people. This requires greater efforts to understand impacts of climate change. Mitigation and adaptation strategies are also essential. Immediate steps to be taken include:

(a) national and regional analyses of the impacts of climate variability and change on society, and study of the range of response and adaptation options available
(b) closer co-operation and communication among natural and social scientists, to ensure that climate considerations are accounted for in development planning
(c) significant increases in resources to carry out impact/adaptation studies.

10. Improvements in energy efficiency and non-fossil fuel energy technologies are of paramount importance, not only to reduce greenhouse gas emissions but to move to more sustainable development pathways. Such advances will require research and development, as well as technology transfer and co-development.

11. A specific initiative would create a network of regional, interdisciplinary research centres, located primarily in developing countries, and focussing on all of the natural science, engineering and social science disciplines required to support fully integrated studies of global change and its impacts and policy responses. The centres would conduct research and training on all aspects of global change and study the interaction of regional and global policies.

D. Public Information

People need better information on the crucial role climate plays in development and the additional risks posed by climate change. Governments, intergovernmental and non-governmental organizations should give more emphasis to providing accurate public information on climate issues. The public information and education and training component in the WCP and IGBP must also be expanded.

PART II

SPECIFIC ISSUES

1. Water

1.1 Among the most important impacts of climate change will be its effects on the hydrological cycle and water management systems, and through these, on socio-economic systems. Increases in incidence of extremes, such as floods and droughts, would cause increased frequency and severity of disasters.

1.2 The design of many costly structures to store and convey water, from large dams to small drainage facilities, is based on analyses of past records of climatic and hydrological parameters. Some of these structures are designed to last 50 to 100 years or even longer. Records of past climate and hydrological conditions may no longer be a reliable guide to the future. The design and management of both structural and non-structural water resource systems should allow for the possible effects of climate change.

1.3 Data systems and research must be strengthened to predict water resources impacts, detect hydrological changes, and improve hydrological parameterization in global climate models.

1.4 Existing and novel technologies, for more efficient use of water for irrigation, should be made available to developing countries in semi-arid zones.

2. Agriculture and Food

2.1 Important uncertainties remain regarding the prediction of the magnitude and nature of potential impacts of changing climate and higher CO_2 levels on global food security. The potential impact on food production in developing countries, with more than half the world's population, could be more uncertain than recent reviews suggest.

2.2 High priority should therefore be given to research on the direct effects of rising CO_2 concentrations on food and fibre crop productivity and equal priority should be given to research on agricultural emissions so as to determine agriculture's present and potential role as a source of and sink for greenhouse gases, and to clarify the costs and possible trade-offs arising from limitation measures.

2.3 New or strengthened institutional mechanisms are required to upgrade natural resource inventories, research strategies and extension services to raise agricultural productivity and minimize emissions. These mechanisms should include collaborative programmes between FAO and international and national agencies with stress on interdisciplinary activities on food security and related topics.

3. Oceans, Fisheries and Coastal Zones

3.1 The earth's climate including shorter-term variations is influenced by the coupled atmosphere - ocean system. Coastal zones and their associated high biological productivity, including fisheries, are especially affected. Thus, an improved data base of oceanic parameters is considered indispensable for operational climate forecasting. It is recommended that a global ocean observing and data management system be developed for improving predictions of climate change. Research on the oceans will provide quantification of important feedback loops in climate processes. Observation and research on the El Niño - Southern Oscillation phenomena, on upwelling areas and on biological productivity of the open sea are also important.

3.2 Coastal zones, which are the source of most of the global fish catch, are especially susceptible to effects of global warming and sea level rise. Predicting the impact of changes

would be of enormous benefit to the increasing number of people living in coastal areas. Thus, it is also recommended that a programme of coastal zone research and monitoring be established to identify the effects of climate change on the coast and coastal ecosystems, and to assess the vulnerability of various natural and managed ecosystems such as coral reefs, mangroves and coastal aquaculture.

3.3 Action should be taken now to develop coastal zone adaptation strategies and policies.

4. Energy

4.1 In order to stabilize atmospheric concentrations of greenhouse gases while allowing for growth in emissions from developing countries, industrialized countries must implement reductions even greater than those required, on average, for the globe as a whole. However, even where very large technical and economic opportunities have been identified for reducing energy-related greenhouse gas emissions, and even where there are significant and multiple benefits associated with these measures, implementation is being slowed and sometimes prevented by a host of barriers. These barriers exist at all levels — at the level of consumers, energy equipment manufacturers and suppliers, industries, utilities, and governments. Overcoming the barriers obstructing least-cost approaches to meeting energy demands will require responses from all parts of society — individual consumers, industry, governments, and non-governmental organizations.

4.2 Developing countries also have an important role in limiting climate change. Maintaining development as a principal objective, energy and development paths can be chosen that have the additional benefit of minimizing radiative forcing.

5. Land Use and Urban Planning

Population growth, increasing urbanization, and competing demands for finite areas of arable land will produce increasingly severe problems of food supply, energy production, and water resources. Climate changes may exacerbate these problems in some regions. Prudent planning will require baseline analyses of land use, quality and quantity of water resources, and the assessment of vulnerability of urbanized societies to environmental change. In particular, improved adaptation of urban areas to local climatic regimes needs to be achieved by more appropriate layouts and building densities, and improved building construction through modifications to building and planning regulations. Because conurbations make a major contribution to energy-related greenhouse gas emissions, the design and efficiency of all aspects of urban systems should be enhanced.

6. Health and Human Dimensions

6.1 The direct impact of climate change on people, their health and cultural heritage, could be severe. There is likely to be increased health inequity between peoples of developing and developed countries. Climatic change could result in increasing numbers of environmental refugees with associated increases of ill-health, disease and death among them.

6.2 Global warming is likely to shift the range of favourable conditions for certain pests and diseases, causing additional stresses on people, particularly those of the semi-arid tropics. It must be appreciated however that serious problems may arise in all parts of the world.

6.3 Research into how human behaviour contributes to and responds to climate change must have increased emphasis. Public awareness and education programmes are particularly essential in this regard.

7. Environment and Development

7.1 Climate change, superimposed on population pressures, excessive consumption, and other stresses on the environment imperils the sustainability of socio-economic development

throughout the world. In addition, slowing climate change will give countries more time to enhance their prospects for sustainable development. The developed countries need to reduce emissions and assist the developing countries to adopt new, clean technologies.

7.2 Climate change has such important implications for the sustainability of development that policy responses, including measures to reduce greenhouse gases, measures to reduce deforestation, and the commitment of financial and other resources, are justified for that reason alone. Economic policies, such as subsidies and trade restraints, can distort markets so they harm the environment and contribute to global warming and sea level rise. There is an imperative need for development policies that not only reduce global warming trends but also increase economic and social resilience.

8. Forests

While increasing forest cover can contribute to the slowing of global climate change, this is not the major cure for the problem.

Five priority actions are recommended:

(1) Assessing national opportunities to increase forest carbon storage commensurate with national resource development policies, developing an approach by 1992 and completing assessment by 1995

(2) Managing the world's forests to optimize biomass and resultant carbon storage in addition to the maintenance of sustainable yields of forest products, biological diversity, water quality and the many other values that forests provide

(3) Accelerating research to assess the added contribution that forests can make to atmospheric CO_2 reduction and the impacts of climate change on the world's forests

(4) Designing and implementing international monitoring systems to determine conditions and changes in forest ecosystems in response to anticipated climate changes

(5) Supporting the development of an international instrument on conservation and development of the world's forests linked with climate and biodiversity conventions.

PART III

ORGANIZATIONAL AND POLICY ISSUES FOR INTERNATIONAL ACTIVITIES

1. The Future Structure of the WCP

1.1 The WCP should be broadened and closely coordinated with related programmes of other agencies in response to increased emphasis on the prediction of climate and its impacts.

1.2 The World Climate Data Programme, renamed the World Climate System Monitoring Programme, should be redefined to take into account new objectives.

1.3 Greater emphasis in the strengthened WCP (WCP-2) should be given to adaptation, mitigation and education, with adaptation and mitigation activities closely linked to the Impact Studies Programme (WCIP).

1.4 The World Climate Applications Programme should be renamed the World Climate Applications and Services Programme (WCASP) to reflect the need for intensifying efforts to provide climatological services to a wide variety of users. There should be strong interaction between WCIP and WCASP.

1.5 The organizational framework for international scientific research is in place, constituted by the WCRP, emphasizing the physical aspects, and the IGBP, covering bio-geochemical aspects.

1.6 Governments should establish national committees for the WCP to mobilize support for national activities and to coordinate efforts. The UN agencies and ICSU should work towards ensuring regular contact and exchange of information with national committees.

1.7 The mechanism established for overall coordination of the WCP, involving meetings of the chairs of steering bodies for the various components, should be actively supported by WMO, the other UN bodies concerned and ICSU. Annual meetings of Executive Heads should consider their recommendations.

1.8 Restructuring and strengthening of the WCP will also be necessary to support new activities, such as the development of the proposed GCOS. The Conference recommended that a proposal for the new structure of WCP be formulated by the organizations involved, taking into account the above comments, and presented to the Eleventh World Meteorological Congress, May 1991, and at appropriate meetings of other participating organizations.

2. Special Needs of the Developing Countries

2.1 As stated in the IPCC report, industrialized and developing countries have a common but differentiated responsibility for dealing with the problems of climate change. The problem is largely the consequence of past patterns of economic growth in the industrial countries. However, in future the much needed economic growth in the developing countries could play an important role in determining the rate of climate change.

2.2 Developing countries are being asked to participate in the alleviation of the legacy of environmental damage from prior industrialization. If they are to avoid the potentially disastrous course followed by industrialized countries in the past, they need to adopt modern technologies early in the process of development, particularly in regard to energy efficiency. They also must be full partners in the global scientific and technical effort that will be required. It is clear that developing countries must not go through the evolutionary process of previous industrialization but rather, must "leapfrog" ahead directly from a status of under-development through to efficient, environmentally benign, technologies.

2.3 Although developing countries have collaborated in providing data, and participated to a degree in meetings and research, they have benefited to a lesser extent from the analyses developed from their contributions, and even less so from the applications derived therefrom.

2.4 Therefore, a massive and sustained flow of scientific and technological expertise towards the development of the intellectual resources, technical and institutional capacity of the developing countries is a necessary complement to the efforts of those countries.

2.5 Developing countries should be assisted to build up their capabilities

- to monitor, assess and apply climate information
- to prepare inventories of greenhouse gases emissions and future emissions projections
- to identify impacts of potential global warming
- to prepare cost estimates and priorities for response strategies to adapt and mitigate problems posed by climate change
- to participate in the World Climate Programme.

2.6 The mechanisms of the transfer of technology and provision of technical assistance and co-operation to developing countries should take into account considerations such as the need for preferential and assured access, intellectual property rights, the environmental soundness of such technology and the financial implications.

2.7 Taking note that industry plays a significant role in the development and transfer

of science and technology, efforts by industry to promote further the development and transfer of environmentally sound technologies should be encouraged, and policies to encourage such efforts should be formulated.

2.8 Additional financial resources will have to be channelled to developing countries for those activities which contribute both to limiting greenhouse gas emissions and/or adapting to any adverse effects of climate change, and promoting economic development. Areas for co-operation and assistance could include the efficient use of energy, land use planning, forest management, soil and water conservations, strengthening of observational systems and scientific and technological capabilities.

3. Co-operation in International Research

3.1 The existing and planned research projects of the WCRP and the IGBP address the highest priority scientific issues related to the understanding and prediction of climate variability and change.

3.2 These programmes should be implemented completely and rigorously. It is particularly important that adequate funding, including long-term funding commitments, be provided.

3.3 In view of the progress made in climate research, it is now timely to proceed to the detailed design of an operational global climate observing system (Section C, paras. 5 - 8), together with the data communications and other infrastructure needed to support operational climate forecasting. Governments should enter into early discussions aimed at international cooperation in operational climate forecasting.

4. Co-ordinated International Activities and Policy Development

4.1 The Conference endorsed the three streams of international activity:

a. Global measurement and research efforts through the WCP, IGBP, and other related international programmes
b. Assessment functions of a continuing IPCC to support negotiation of and provide technical input to a Convention
c. Development of a Convention on Climate Change.

It is essential that all parties to a Convention and related legal instruments should, as part of their obligations, be required to participate fully in the free exchange and flow of information necessary for technical input to the convention. Such a convention should include a technical annex to provide for:

- International co-operation in research, systematic observation and exchange of related information
- Adjustments based on up-dates of scientific knowledge
- Strengthening national scientific and environmental capabilities of developing countries.

4.2 The development of policy regarding climate change requires on the part of policy makers an understanding of the underlying science and a weighing of the scientific uncertainties associated with the prediction of climate change and its likely impacts. An important aspect of future work is therefore a continued dialogue between scientists and policy makers.

4.3 The UN Conference on Environment and Development (Brazil 1992) provides a valuable opportunity to relate the above three themes to the other environment/development issues and objectives being examined by the Conference. It is therefore essential that the three streams should interact effectively with UNCED.

4.4 It is proposed that the sponsoring agencies for the SWCC consider the possibility of holding a Third World Climate Conference at an appropriate time about the year 2000.

Second World Climate Conference

INTERNATIONAL CONFERENCE CENTRE

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MINISTERIAL DECLARATION

FOREWORD

The Ministerial Sessions of The Second World Climate Conference (SWCC) took place at the International Conference Centre in Geneva, Switzerland, on 6 and 7 November 1990. There were 908 participants, including 730 delegates from 137 countries. From these countries, there were 66 National Government Ministers. Also present were 99 observers from the Sponsoring Agencies, other UN Agencies, UN Specialised Agencies and related Organizations, 28 observers from other Intergovernmental Organizations and 51 observers from Non-Governmental Organizations.

During the final Session of the conference on 7 November, the Ministerial Declaration was endorsed by the delegations present.

FOR FURTHER INFORMATION

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MINISTERIAL DECLARATION OF THE SECOND WORLD CLIMATE CONFERENCE

PREAMBLE

1. We, the Ministers and other representatives from 137 countries and from the European Communities, meeting in Geneva from 6 to 7 November 1990 at the Second World Climate Conference, declare as follows:

2. We *note* that while climate has varied in the past and there is still a large degree of scientific uncertainty, the rate of climate change predicted by the Intergovernmental Panel on Climate Change (IPCC) to occur over the next century is unprecedented. This is due mainly to the continuing accumulation of greenhouse gases, resulting from a host of human activities since the industrial revolution, hitherto particularly in developed countries. The potential impact of such climate change could pose an environmental threat of an up to now unknown magnitude; and could jeopardize the social and economic development of some areas. It could even threaten survival in some small island States and in low-lying coastal, arid and semi-arid areas.

3. We *appreciate* the work of the World Climate Programme (WCP) during the past decade which has improved understanding of the causes, processes and effects of climate and climate change. We also *congratulate* the IPCC, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) on its First Assessment Report on Climate Change. It has identified causes and possible effects and strategies to limit and adapt to climate change, and in the light of the United Nations General Assembly resolutions, has identified possible elements for inclusion in a framework convention on climate change.

4. Recognizing climate change as a common concern of mankind, we commit ourselves and intend to take active and constructive steps in a global response, without prejudice to sovereignty of States.

I. GLOBAL STRATEGY

5. Recognizing that climate change is a global problem of unique character and taking into account the remaining uncertainties in the field of science, economics and response options, we *consider* that a global response, while ensuring sustainable development [1] of all countries, must be decided and implemented without further delay based on the best available knowledge such as that resulting from the IPCC assessment. Recognizing further that the principle of equity and the common but differentiated responsibility of countries should be the basis of any global response to climate change, developed countries must take the lead. They must all commit themselves to actions to reduce their major contribution to the global net emissions and enter into and strengthen co-operation with developing countries to enable them to adequately address climate change without hindering their national development goals and objectives. Developing countries must, within the limits feasible, taking into account the problems regarding the burden of external debt and their economic circumstances, commit themselves to appropriate action in this regard. To this end, there is a need to meet the requirements of developing countries, that adequate and additional financial resources be mobilized and the best available environmentally-sound technologies be transferred expeditiously on a fair and most favourable basis.

II. POLICY CONSIDERATIONS FOR ACTION

6. We *reaffirm* that, in order to reduce uncertainties, to increase our ability to predict climate and climate change on a global and regional basis, including early identification of as yet unknown climate-related issues, and to design sound response strategies, there is a need to strengthen national, regional and international research activities in climate, climate change and sea level rise. We *recognize* that commitments by governments are essential to sustain and strengthen the necessary research and monitoring programmes and the exchange of relevant data and information, with due respect to national sovereignty. We *stress* that special efforts must be directed to the areas of uncertainty as identified by the IPCC. We *maintain* that there is a need to intensify research on the social and economic implications of climate change and response strategies. We *commit*

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(1) Statement of sustainable development as agreed at the 15th session of UNEP Governing Council (Annex II UNEP/GC 15/L.37)

ourselves to promoting the full participation of developing countries in these efforts. We *recognize* the importance of supporting the needs of the World Climate Programme, including contributions to the WMO Special Fund for Climate and Atmospheric Environmental Studies. The magnitude of the problem being addressed is such that no nation can tackle it alone and we stress the need to strengthen international cooperation. In particular, we *invite* the 11th Congress of the World Meteorological Organization, in the formulation of plans for the future development of the World Climate Programme, to ensure that the necessary arrangements are established in consultation with UNEP, UNESCO (and its IOC), FAO, ICSU and other relevant international organizations for effective coordination of climate and climate change related research and monitoring programmes. We *urge* that special attention be given to the economic and social dimensions of climate and climate change research.

7. In order to achieve sustainable development in all countries and to meet the needs of present and future generations, precautionary measures to meet the climate challenge must anticipate, prevent, attack, or minimize the causes of, and mitigate the adverse consequences of, environmental degradation that might result from climate change. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent such environmental degradation. The measures adopted should take into account different socio-economic contexts.

8. The potentially serious consequences of climate change, including the risk for survival in low-lying and other small island States and in some low-lying coastal, and arid and semi-arid areas of the world, give sufficient reasons to begin by adopting response strategies even in the face of significant uncertainties. Such response strategies include phasing out the production and use of CFC's, efficiency improvements and conservation in energy supply and use, appropriate measures in the transport sector, sustainable forest management, afforestation schemes, developing contingency plans for dealing with climate related emergencies, proper land use planning, adequate coastal zone management, review of intensive agricultural practices and the use of safe and cleaner energy sources with lower or no emissions of carbon dioxide, methane, nitrous oxide and other greenhouse gases and ozone precursors, paying special attention to new and renewable sources. Further actions should be pursued in a phased and flexible manner on the basis of medium and long-term goals and strategies and at the national, regional or global level, taking advantage of scientific advances and technological developments to meet both environmental and economic objectives.

9. We *note* that per capita consumption patterns in certain parts of the world along with a projected increase in world population are contributing factors in the projected increase in greenhouse gases.

10. We *agree* that the ultimate global objective should be to stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with climate.

11. We *stress*, as a first step, the need to stabilize, while ensuring sustainable development of the world economy, emissions of greenhouse gases not controlled by the Montreal Protocol on Substances that Deplete the Ozone Layer. Contributions should be equitably differentiated according to countries' responsibilities and their level of development. In this context, we acknowledge efforts already undertaken by a number of countries to meet this goal.

12. Taking into account that the developed world is responsible for about 3/4 of all emissions of greenhouse gases, we *welcome* the decisions and commitments undertaken by the European Community with its Member States, Australia, Austria, Canada, Finland, Iceland, Japan, New Zealand, Norway, Sweden, Switzerland, and other developed countries to take actions aimed at stabilizing their emissions of CO_2, or CO_2 and other greenhouse gases not controlled by the Montreal Protocol, by the year 2000 in general at 1990 level, yet recognizing the differences in approach and in starting point in the formulation of the above targets. We also acknowledge the initiatives of some other developed countries which will have positive effects on limiting emissions of greenhouse gases. We *urge* all developed countries to establish targets and/or feasible national programmes or strategies which will have significant effects on limiting emissions of greenhouse gases not controlled by the Montreal Protocol. We *acknowledge*, however, that those developed countries with as yet relatively low energy consumption (measured on a per capita or other appropriate basis) which can be reasonably expected to grow, and some countries with economies in transition, may establish targets, programmes and/or strategies that accommodate socio-economic growth, while improving the energy efficiency of their economic activities.

13. We *urge* developed countries, before the 1992 UN Conference on Environment and Development, to analyze the feasibility of and options for, and, as appropriate in light of these analyses, to develop

programmes, strategies and/or targets for a staged approach for achieving reductions of all greenhouse gas emissions not controlled by the Montreal Protocol, including carbon dioxide, methane and nitrous oxide, over the next two decades and beyond.

14. We *recommend* that in the elaboration of response strategies, over time, all greenhouse gases, sources and sinks be considered in the most comprehensive manner possible and also that limitation and adaptation measures be addressed.

15. We *recognize* that developing countries have as their main priority alleviating poverty and achieving social and economic development and that their net emissions must grow from their, as yet, relatively low energy consumption to accommodate their development needs. Narrowing the gap between the developed and the developing world would provide a basis for a full partnership of all nations and would assist the developing countries in dealing with the climate change issue. To enable developing countries to meet incremental costs required to take the necessary measures to address climate change and sea-level rise, consistent with their development needs, we *recommend* that adequate and additional financial resources should be mobilized and best available environmentally sound technologies transferred expeditiously on a fair and most favourable basis. Developing countries also should, within the limits feasible, take action in this regard.

16. The specific difficulties of those countries, particularly developing countries, whose economies are highly dependent on fossil fuel production and exportation, as a consequence of action taken on limiting greenhouse gas emissions, should be taken into account.

17. We *recommend* that consideration should be given to the need for funding facilities, including the proposed World Bank/UNEP/UNDP Global Environmental Facility, a clearing house mechanism and a new possible international fund composed of adequate additional and timely financial resources and institutional arrangements for developing countries; taking into account existing multilateral and bilateral mechanisms and approaches. Such funding should be related to the implementation of the framework convention on climate change and any other related instruments that might be agreed upon. In the meantime, developed countries are urged to co-operate with developing countries to support immediate action in addressing climate change including sea-level rise without

imposing any new conditionality on developing countries.

18. We *recommend* further that resources be assessed. Such assessments, to be conducted as soon as possible, should include country studies and mechanisms to meet the financing needs identified, taking note of the approaches developed under the Montreal Protocol.

19. Financial resources channelled to developing countries should, *inter alia*, be directed to:

(i) Promoting efficient use of energy, development of lower and non-greenhouse gas emitting energy technologies and paying special attention to safe and clean new and renewable sources of energy;

(ii) Arranging expeditious transfer of the best available environmentally sound technology on a fair and most favourable basis to developing countries and promoting rapid development of such technology in these countries;

(iii) Co-operating with developing countries to enable their full participation in international meetings on climate change;

(iv) Enhancing atmospheric, oceanic and terrestrial observational networks, particularly in developing countries, to facilitate conducting research, monitoring and assessment of climate change and the impact on those countries;

(v) Rational forest management practices and agricultural techniques which reduce greenhouse gas emissions;

(vi) Enhancing the capacity of developing countries to develop programmes to address climate change, including research and development activities and public awareness and education.

Funding should also be directed to the creation of regional centres to organize information networks on climate change in developing countries.

20. Appropriate economic instruments may offer the potential for achieving environmental improvements in a cost-effective manner. The adoption of any form of economic or regulatory measures would require careful and substantive analyses. We *recommend* that relevant policies make use of economic instruments appropriate to each country's socio-economic

conditions in conjunction with a balanced mix of regulatory approaches.

21. We *note* that energy production and use account for nearly half of the enhanced radiative forcing resulting from human activities and is projected to increase substantially in the absence of appropriate response actions. We *recognize* the promotion of energy efficiency as the most cost-effective immediate measure, in many countries, for reducing energy-related emissions of carbon dioxide, methane, nitrous oxide and other greenhouse gases and ozone precursors, while other safe options such as no or lower greenhouse gas emitting energy sources should also be pursued. These principles apply to all energy sectors. Transport energy use attracts special attention of many of us in the light of its role in many developed countries and of its expected importance in many developing countries.

22. We *recognize* that there is no single quick-fix technological option for limiting greenhouse gas emissions. However, we are *convinced* that technological innovation as well as individual and social behaviour and institutional adaptations is a key element of any long-term strategy that deals with climate change in a way that meets the goal of sustainable development. Therefore, we *urge* all countries, the developed countries in particular, to intensify their efforts and international cooperation in technological research, development and dissemination of appropriate and environmentally sound technologies, including the reassessment and improvement of existing technologies and the introduction of new technologies.

23. We *urge* that environmentally sound and safe technologies be utilized by all sectors in all countries to the fullest extent possible and further *urge* all countries, developed and developing, to identify and take effective measures to remove barriers to the dissemination of such technologies. To this end, the best available environmentally sound and safe technologies should be transferred to developing countries expeditiously on a fair and most favourable basis.

24. We *note* that the conservation of the world's forests in their role as reservoirs of carbon along with other measures are of considerable importance for global climatic stability, keeping in mind the important role of forests in the conservation of biological diversity and the protection of soil stability and of the hydrological system. We *recognize* the need to reduce the rate of deforestation in consonance with the objective of sustained yield

development and to enhance the potential of the world's forests through improved management of existing forests and through vigorous programmes of reforestation and afforestation, and to support financially the developing countries in this regard through enhanced and well-coordinated international cooperation including strengthening Tropical Forest Action Plan (TFAP) and International Tropical Timber Organization (ITTO). We *recommend* that the protection and management of boreal, temperate, sub-tropical and tropical forest ecosystems must be well-coordinated and preferably compatible with other possible types of action related to reduction of emission of greenhouse gases, rational utilization of biological resources, provision of financial resources, and the need for more favourable market conditions for timber and timber products. The developing countries should be able to realize increased revenue from these forests and forest products.

25. We also *recognize* that forests and forest products play a key social and economic role in many nations and communities. We *recognize* that States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

26. We *recommend* that appropriate precautionary and control measures be developed and implemented at regional, sub-regional and country levels as appropriate to counter the increasing degradation of land, water, genetic and other productive resource bases by drought, desertification and land degradation. Observatories on climate and climate change and observatories on ecosystems should be encouraged to work together on drought risks consequences. Studies must be undertaken on drought and desertification. We *stress* that stepped-up financial and scientific contributions be provided to facilitate these efforts.

27. We *recommend* that similar measures be adopted to address the particular problems and needs, including funding, of low-lying coastal and small vulnerable island countries, some of whose very existence is placed at risk by the consequences of climate change.

III. GLOBAL FRAMEWORK CONVENTION ON CLIMATE CHANGE

28. We *call* for negotiations on a framework convention on climate change to begin without delay after a decision is taken by the 45th Session of the General Assembly of the United Nations recommending ways, means and modalities for further pursuing these negotiations. Taking note of all the preparatory work, particularly the recommendations adopted 26 September 1990 by the *ad hoc* working group of government representatives and regional economic integration organizations to prepare for negotiations on a framework convention on climate change, we *urge* all countries and regional economic integration organizations to join in these negotiations and *recognize* that it is highly desirable that an effective framework convention on climate change, containing appropriate commitments, and any related instruments as might be agreed upon on the basis of consensus, be signed in Rio de Janeiro during the United Nations Conference on Environment and Development. We *welcome* the offer of the Government of the United States of America to host the first negotiating meeting.

29. We *recommend* that such negotiations take account of the possible elements compiled by the IPCC, and that the framework convention on climate change be framed in such a way as to gain the support of the largest possible number of countries while allowing timely action to be taken. We *reaffirm* our wish that this convention contain real commitments by the international community. We *stress*, given the complex and multi-faceted nature of the problem of climate change, the need for new and innovative solutions including the need to meet the special needs of developing countries.

30. We also *welcome* the invitations of Thailand and Italy to host workshops, respectively on the feasibility of forestry options, and on all technologies for energy production and use and their transfer to developing countries.

31. We *believe* that a well-informed public is essential for addressing and coping with as complex an issue as climate change, and the resultant sea-level rise, and *urge* countries, in particular, to promote the active participation at the national and when appropriate, regional levels of all sectors of the population in addressing climate change issues and developing appropriate responses. We also *urge* relevant United Nations organizations and programmes to disseminate relevant information with a view to encouraging as wide a participation as possible.