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MEDITERRANEAN ACTION PLAN

Joint Third Meeting of the Task Teams on
Implications of Climate Change on Kastela Bay
and Cres/Losinj Islands

Mali Losinj, 16-18 July 1992

REPORT

OF THE JOINT THIRD MEETING OF THE TASK TEAMS ON IMPLICATIONS OF CLIMATE CHANGE ON KASTELA BAY AND CRES/LOSINJ ISLANDS

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BACKGROUND

As parts of the efforts of the United Nations Environment Programme (UNEP) to analyze the potential implications of predicted climate change and to assist the governments in designing policies and measures which may avoid or mitigate the expected negative effects of this change, or to adapt to them, task teams on the implications of climate change were established in 1987 for six regions covered by the UNEP-sponsored Regional Seas Programme (Mediterranean, Wider Caribbean, South Pacific, East Asian Seas, South Asian Seas, and South East Pacific regions), with the initial objective of preparing regional studies on expected climate change on coastal and marine ecosystems, as well as on the socio-economic structures and activities within these regions. Additional task teams were later established for the West and Central African, Eastern African, Persian/Arabian Gulf and Black Sea regions.

During the work on the Mediterranean regional study, it was felt that while the general effects may be similar throughout of the Mediterranean region, the response to this effects would have to be highly site-specific. Therefore in the framework of the Mediterranean Task Team six specific case studies were prepared (deltas of the rivers Ebro, Rhone, Po and Nile; Thermaikos Gulf and Ichkeul/Bizerte lakes) until 1989. Using the experience of these studies, in 1990 the preparation of the "second generation" of site-specific case studies has been initiated for the Island of Rhodes, Kastela Bay, the Syrian coast, the Bay of Izmir, the Maltese islands, and the Cres-Losinj archipelago.

The objectives of these studies are:

- to identify and assess the possible implications of expected climate change on the terrestrial, aquatic and marine ecosystems, population, land- and sea-use practices, and other human activities;
- to determine areas or systems which are most vulnerable to the expected impact of expected climate change; and
- to suggest policies and measures which may mitigate or avoid the negative effects of the expected impact, or adapt to them, through planning and management of coastal areas and resources;

using the presently available data and the best possible extrapolations from these data.

The Task Teams for the Bay of Kastela and the Cres-Losinj islands were established in 1991. The present joint meeting of the Task Teams was convened to review the results obtained during their work and to assist their members in preparing the final drafts of their reports which are planned to be presented and reviewed in Malta (15-19 September 1992) at the joint meeting of all task teams working on the "second generation" Mediterranean case studies.

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[1] Implications of expected climate changes in the Mediterranean. MAP Technical Reports Series No. 27. UNEP, Athens, 1989.

REPORT OF THE MEETING

Opening of the meeting - Agenda item 1

The meeting was opened by Mr. Andrija Randic, Head of the Office for the Adriatic of the Ministry of Environment Protection, Physical Planning, Housing and Communal Affairs, and Co-ordinator of the Task Team for the Cres-Losinj archipelago. He welcomed the participants and expressed his Government's appreciation for the support of the United Nations Environment Programme (UNEP) and the Co-ordinating Unit for the Mediterranean Action Plan (MAP) for the support provided for the work of the two Task Teams and for the organization of the present meeting. He also thanked the local authorities of the Cres-Losinj for hosting the meeting in Mali Losinj and for the received technical and logistic support.

The meeting was held in Hotel Bellevue in Mali Losinj, Croatia, 16-18 July 1992. The meeting participants are listed in Annex 1 to this report.

The meeting's participants were welcomed by Mr. Mario Hofmann, President of the Communal Assembly of the Cres-Losinj Commune, who emphasized the importance attached by the commune of Cres/Losinj, and by him personally, to environmental matters. He expressed his hopes that the meeting will be successful and that its results will contribute to the future environmentally sound development of the Cres-Losinj archipelago. He also wished the participants a pleasant stay in Losinj.

Mr. Ljubomir Jeftic, Senior Marine Scientist in the Co-ordinating Unit for the Mediterranean Action Plan of UNEP, welcomed the meeting on behalf of Mr. Mostafa Tolba, Executive Director of UNEP, expressed his appreciation for the work carried out by the members and co-ordinators of the Task Teams, and thanked the local authorities for their support and interest shown in the work of the Task Teams. He continued by reviewing the main events leading to the meeting, with emphasis on its objectives (see the background section of this report).

Election of Officers - Agenda item 2

The meeting unanimously elected Mr. Andrija Randic as Chairman, Mr. Ante Baric (Co-ordinator of the Task Team for the Bay of Kastela) as Vice-Chairman, and Mr. John Pernetta as Rapporteur of the meeting. Mr. Ljubomir Jeftic acted as the technical secretary of the meeting.

Adoption of the Agenda - Agenda item 3

The provisional agenda as proposed by the secretariat was adopted and appears as Annex 2 to this report.

Review of individual substantive sections - Agenda item 4

The drafts of the individual substantive sections of the Task Team reports were presented by their authors. In the ensuing discussions a number of suggestions was made about additional material to be included in the individual sections and topics which would have to be further elaborated. The following general and specific issues have been raised:

- the site-specific scenarios prepared by the University of East Anglia for the Bay of Kastela and Cres-Losinj islands, should be used to refine the predictions made by IPCC for global climate; scenarios based on the information from these two sources were elaborated during the present meeting (see Table 1 and 2 of this report);

- the possible influence of factors, such as the extent of snow cover and the

dynamics of its melting, on fresh-water resources should be assessed;

- factors which reveal an integrated long-term response to climate conditions (e.g. ecosystems and certain phytocenoses in particular) are among the best indicators for changes in the microclimatic conditions; analysis of the past ecological changes, and monitoring of the present ones, may reveal more about the trends in climate change than the analysis of individual climatic parameters;

- non-biological factors, such as spread of urban settlements, may have a marked effect on changing local climate conditions, particularly in the area covered by the Kastela Bay Task Team;

- the time-span of available reliable climate-related local data is too short (about 30 years) for the analysis of past trends in climate changes, although they can be successfully applied to gain a good insight in local climate variability;

- increased climate variability can be observed, as the result of climate change, before statistically significant trends in individual parameters are revealed; oscillations of parameters (e.g. extremes, shifts in their occurrence in the time of the year), may be of greater practical importance than changes in the means of these parameters;

- with predicted climate change evapotranspiration will increase and soil humidity will decrease, resulting in reduction of the agricultural potential production;

- agriculture will be favourably affected by increased air temperature;

- small changes in climate may cause significant alterations in the composition and geographic area occupied by some ecosystems, therefore the climate dependent critical habitats and species should be determined;

- climate impact on ocean systems may be considerable, but can not be considered on local scales only, because local climate changes have relatively little influence on the local ocean systems; ocean conditions are determined by influences exerted by large scale processes and therefore for the prediction of local changes in the marine environment a climatic changes over a wider geographic area would have to be taken into account;

- the mean sea and land temperatures will not change at the same rate; this may cause significant changes in the wind and sea-current regimes;

- it would be useful to analyze the changes in the energy inputs and balance in the studied areas as they are the underlying force driving the climate changes in these areas;

- a stronger interaction is needed between the experts dealing with cross-sectoral and inter-sectoral issues in order to improve the comparability and meaningfulness of the reports of the two Task Teams;

- vegetation, particularly forest biocenoses, are the best indictors of general climate changes and reflect changes in microclimatic conditions;

- the present and projected land-use practices should be taken into account when the effects of climate change are assessed;

- increase in sea-level may have a considerable effect on the foundation of coastal buildings, particularly in historic urban centres) and infrastructures, but extrapolations should be handled carefully;

- intrusion of seawater into the sewerage systems, and outlets of stormwaters and industrial effluents, may considerably interfere with their efficiency and function;

- subsidence and uplifting are important phenomena which should be taken into account when considering the dynamics of lithosphere; existing mareographic data from Bakar, Split and Rovinj should be analyzed;

- generation of cyclonic activities relevant to the studied areas should be studied;

- atmospheric dispersion of pollutants carried by small particles depends on winds; larger particles are washed out by precipitation;

- when analyzing the impact of climate change on atmospheric transport of pollutants, the known or predicted changes in the sources, types and amounts of pollutants may be taken into account;

- the terrestrial ecosystems may be able to adapt to the climatic changes; it is expected that in the contact zones there might be a shift in the zonation due to the climatic changes;

- there are already two specially protected areas and several protected zones are planned to be proposed on the Cres-Losinj archipelago;

- since the Kastela Bay area is urbanised, there are practically no natural ecosystems there; the Marjan peninsula is covered with planted pine forests;

- forest fires consumed the largest parts of indigenous forests in the Kastela Bay:

- there is no indication that the sea level rise will have any influence on the population of trouts in the Jadro river; doubts were expressed concerning that issue;

- barometric pressure may have a marked influence on the sea level, and should be taken into account when discussing the level of sea level rise;

- the decreased quality of the fish caught in the Bay of Kastela is mainly due to intensive overfishing and pollution;

- the formation of mucus produced by algal blooms does not seem to lead to serious oxygen depletion in sea water.

On the basis of the presented draft documents and the discussions which followed their presentation, summaries reflecting:

- past trends and present situation;

- expected effects, and most vulnerable systems and activities;

- suggestions for action to avoid or mitigate the effects;

- suggestions for action to adapt to the changes; and

- suggestions for follow-up to the work carried out by the Task Teams;

were prepared for each of the substantive section of the Task Team reports. The summaries were discussed by the meeting and revised by their authors in the light of comments received. The revised summaries are attached as Annex 3 and 4 to the report of the present meeting.

Future work programme and actions - Agenda item 5

As a follow-up to the present meeting the following deadlines for the preparation of the Task Team reports were agreed:

(a) The drafts of the individual chapters of the reports should be submitted by their authors to the respective co-ordinators by 1 August 1992;

(b) The final drafts of these chapters should be submitted to the respective co-ordinators by 10 August 1992; the text of individual chapters should not exceed 15 pages, plus tables and diagrams;

(c) The hard copies and diskettes (ASCI or standard word processor) of consolidated reports should be sent by the co-ordinators by courier post to Mr. Jeftic in Athens by 15 August 1992.

In preparing the individual chapters and the reports standardized maps on A/4 format should be used, whenever possible. References should be listed at the end of the report in alphabetical order, using the following example for style: Pernetta, J. and D. Elder. 1992. Climate, sea level rise and the coastal zone: management and planning for global change. Ocean and Coastal Management 18, 112-160

The relevant site-specific scenarios prepared by the University of East Anglia should be annexed to the Task Team reports.

Adoption of the report - Agenda item 6

The substantive parts of the draft report of the meeting were considered by the meeting, and the secretariat was requested to finalize the report of the meeting. The present document represents the final report of the meeting.

Closure of the meeting - Agenda item 7

Mr. Simoncic, Deputy Minister of the Ministry of Environment Protection, Physical Planning, Housing and Commercial Affairs of Croatia, expressed the Croatian Government's appreciation for UNEP's support of the work of the two Task Teams. He stressed the importance which the Croatian Government attaches to these studies and thanked the local authorities for their technical and logistic support and their warm hospitality.

In his closing remarks, Mr. Ljubomir Jeftic expressed satisfaction with the results of the meeting, and thanked its participants for their spirit of co-operation and the constructive manner in which they contributed to the success of the meeting. He also thanked the Ministry of Environment, Physical Planning, Housing and Communal Affairs, their Office for the Adriatic, and the local authorities, for their technical and logistic assistance, and their warm hospitality.

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

ANNEX I

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ANNEX II

AGENDA

1.Opening of the meeting

2.Election of Officers

3.Adoption of the Agenda

4.Review of individual substantive sections

5.Future work programme and actions

6.Adoption of the report

7.Closure of the meeting

ANNEX III

PRELIMINARY SUMMARIES OF THE SUBSTANTIVE SECTIONS OF CRES/LOSINJ TASK TEAM REPORT

2.1 CLIMATE CONDITIONS (K. Pandzic)

Past trends and present situation

Since 1890 there was no significant trend in temperature (annual average 12 - 15^{o}C) and precipitation (annual average 900 - 1500 mm) for the Cres-Losinj archipelago, although the precipitation was slightly decreasing at Crikvenica (nearby but not within the archipelago) in the same period.

The Cres-Losinj archipelago has a maritime climate, with rather warm summers and no cold winters. The average temperature in the warmest month is 22^{o} C (July) an in the coldest 6 - 8^{o} C (January). The prevailing winds are bora and sirocco. The maximum of precipitation occurs in autumn and the minimum in summer, with the respective seasonal averages of 300 - 350 and 150 - 200 mm.

Expected effects, and most vulnerable systems and activities

In addition to the expected increase in mean temperature by several degrees, a change in extremes can also be expected. The precipitation is expected by several per cent to be higher in winter and somewhat lower in summer than at present.

Changes in atmospheric circulation may occur and they could influence a redistribution of atmospheric systems in time and space, causing changes in wind intensity as well as in some other weather parameters (e.g. cloudiness, insolation). Precipitation extremes may become higher if convective precipitation would prevail.

Some subtropical climate characteristics will move northwards.

Suggestions for action to avoid or mitigate the effects

None.

Suggestions for action to adapt to the changes

Try to live in a way similar to that in areas which have the same climate characteristics.

Suggestions for follow-up

Further study of climate change using global circulation models and empirical climate data over the whole globe, including energy characteristics of the oceans.

2.2 LITHOSPHERE (B. Biondic)

Past trends and present situation

The islands of the Cres-Losinj archipelago are predominantly built of limestone and dolomite, and that gives them the major morphological characteristics. The coastal areas are in general stable, with the exception of the western parts of Cres island which is built of flish sediments subject to erosion. The aeolic sediments on the islands of Unije and Susak are exposed to erosion, as well as the low-lying coastal zones (e.g. at Punta Kriza, Osor, Cres, Valun, Mali Losinj), which are even at present sometimes under the attack of sea.

Expected effects, and most vulnerable systems and activities

Although less than 1 per cent of the total area of the archipelago is endangered by the predicted sea-level rise, some problems can be expected in the low-lying coastal zones which could be permanently flooded in the second half of the next century. Stronger erosion could be expected in these zones which may particularly affect urbanized areas. The flish sediments in the coastal areas between Lubenica and Martinscica may experience landslides. Similar phenomena may occur on the islands of Unije, Susak and Sarkane.

Temperature elevations combined with decreased precipitation may lead to erosion of the topsoil, which is relatively thin and without contact with very deep groundwater reservoirs.

Suggestions for action to avoid or mitigate the effects

Flood control with current small dams.

Suggestions for action to adapt to the changes

Elevation of the protective structures in coastal urban areas.

Suggestions for follow-up

Research for determining the geotechnical conditions in some low-lying coastal areas in rise sea level replacement zone.

2.3 HYDROSPHERE (B. Biondic)

Past trends and present situation

There are no significant surface streams on the archipelago. The few coastal and submarine springs have no value for the development of the islands' freshwater supplies.

Lake Vrana on the island of Cres is the only supply of fresh water for the archipelago. It has a surface of 5 km^2, and a volume of about 220 million m^3.The surface of the lake is about 10 m above the sea level, the deepest point is about 65 m below the sea level. At present it supplies annually about 2.2 million m^3 (140 litres per second maximally) of fresh water; the planned maximal discharge is 306 litres per second. The salinity of the lakewater is between 60 and 70 mg per litre. In the last ten years the water level was low and showed a decreasing tendency. During the same period the precipitation over the lake was decreasing, while the temperature had an increasing trend.

Expected effects, and most vulnerable systems and activities

Increasing evaporation trend and further decrease in the level of the Vrana lake could be expected. There is a possibility that the Vrana lake may not be able to satisfy the freshwater supply requirements of the Cres-Losinj islands.

Suggestions for action to avoid or mitigate the effects

In case the origin of the water in Lake Vrana is exclusively or predominantly from the local catchment basin, the use of water should be better controlled and the possibility of water mining or water supply connection with the continent should be explored.

Suggestions for action to adapt to the changes

It is impossible to change the natural hydrological system of the Lake Vrana.

Suggestions for follow-up

The origin of water in Lake Vrana (it may be from the continent) should be clarified. Before a decision is made about the future development of freshwater supply system for the archipelago, detailed research and monitoring is needed, on subjects such as the age of the lake water, recharge area of the lake, water balance and residence time, hydro-chemical disturbances of the lake waters.

2.4 ATMOSPHERE (S. Vidic)

Past trends and present situation

On the archipelago there are no significant sources of pollutants carried by air; they mostly originate from the emissions in the Kvarner Bay.

During the period 1986-1989 data were collected at Veli Losinj on daily mean SO_2 concentration, precipitation acidity (pH), prevailing weather types and a number of meteorological parameters (temperature, wind, precipitation, insolation, cloudiness). The data and observations revealed that higher levels of air pollution are generally more frequent in autumn and winter when cyclonic activities with stronger southerly winds, and anticyclonal conditions with northerly winds are frequent. The recorded SO_2 concentrations were ranging from 6 µg per m^3 in summer to 27 in winter. Higher levels (the 95 percentile value was 40 µg per m^3) and episodes (up to 190 µg per m^3) are predominantly associated with northerly winds when transport from Kvarner Bay dominates. Half of the precipitation pH values were within the range of 4 to 5, particularly in autumn and winter.

Expected effects, and most vulnerable systems and activities

The predicted changes in temperature, precipitation and frequency of extreme events, might enhanced the air pollution in the area related to the emissions from the whole Kvarner Bay. Due to temperature rise, orographically induced effects and local circulation in the Kvarner Bay could intensify, and stronger northerly winds might be more frequent, causing the transport of pollutants towards the Cres-Losinj archipelago.

Changes which may occur in the air circulation over the western Mediterranean region could also affect the levels of air pollution in the archipelago and the processes related to it (e.g. transformation of pollutants, chemical reactions, wet and dry deposition).

However, since the present concentrations of SO_2 are generally low (on average about 15 µg per m^3) significant changes are not to be expected, although extreme events might be more frequent.

Increase in the winter precipitation might lead to stronger acidification of soils and vegetation.

Suggestions for action to avoid or mitigate the effects

The Cres-Losinj area is extremely sensitive to pollution originating from the area of Rijeka. The events of higher pollution could be avoided by
technical measures and by lowering the emission levels in the Kvarner Bay area.

Suggestions for action to adapt to the changes

None.

Suggestions for follow-up

Proper air pollution control and monitoring system to be implemented. Studies of the frequencies of extreme events and how these frequencies relate to climate conditions should continue.

2.5.1 TERRESTRIAL ECOSYSTEMS (E. Draganovic)

Past trends and present situation

In the past the archipelago was covered by two types of climazonal forests: the eumediterranean forest of evergreen oak, and the submediterranean deciduous forest. Large parts of the these natural forests had been changed by human activities and turned into pastures of grassland and agricultural land. The animal component, especially the predators (mammals), became scarce. However, bird populations are still present, almost unchanged.

There are two separate specially protected areas at the eastern coast of the island Cres, both of them are protected as ornithological reserves because they are nesting grounds of vultures.

Five zones are recognized as important from the standpoint of nature protection and will be proposed to be protected as specially protected landscapes. The small island of Veli Osir and forest Niska at Tramontana will be proposed to be protected as botanical reserve. The area of Lake Vrana will be proposed to be protected as geographical and hydrological reserve. The pine forest in the Cikat will be proposed to be protected as park forest.

Expected effects, and most vulnerable systems and activities

The predicted climate change may affect the natural forests, primarily in the contact zones between the two main types of forests. The areas covered by submediterranean forests may be expanding at expense eumediterranean forests, and may be loosing submediterranean elements form their lower zones. For example, chestnuts on the northern part of Cres are on the limit of their natural area, and may disappear altogether from the archipelago.

Effects on animal life, as well within the already protected areas, are not expected.

Suggestions for action to avoid or mitigate the effects

The impact of climate changes on the archipelago's ecosystems cannot be avoided.

Suggestions for action to adapt to the changes

None.

Suggestions for follow-up

Monitoring of ecological changes.

2.5.2 FRESHWATER ECOSYSTEMS (B. Biondic)

Past trends and present situation

The freshwater ecosystem is closely connected with the hydrosphere of Lake Vrana described in section 2.3. The ecosystem is under special protection covering the whole lake area, which forbids any activity not connected with the use of the lake as source of water supply for the archipelago. It consists of elements typical for freshwater lakes with stable temperature and hydrochemistry below the depth of 20 m.

Expected effects, and most vulnerable systems and activities

No changes in the temperature of Lake Vrana are expected because it is believed to be connected with deep groundwaters. However, sea level rise might influence the level of the lake's salinity and thus affect its ecosystem and the use of the lake as water supply for the archipelago.

Suggestions for action to avoid or mitigate the effects

None.

Suggestions for action to adapt to the changes

None.

Suggestions for follow-up

Monitoring of the ecological changes, and the parameters which may influence them.

2.5.3 MARINE ECOSYSTEMS (N. Smodlaka)

Past trends and present situation

The marine environment around the Cres-Losinj archipelago is typically oligotrophic. It is characterized by high salinity (36.5 - 38.5 x 10^{-3}) surface temperature fluctuations (10 - 24ºC), low primary productivity, and variety of marine organisms. Nanoplankton (< 20 µm) is dominating throughout the year, except during diatom blooms in autumn and late winter. Small blue fish, white fish and scampi are the most important commercially exploited species.

The area is under the influence of meteorological, oceanographic and hydrological changes occurring in a much larger region. The hydrographic and biological properties of the whole area are under the influence of the central Adriatic during most of the year, although during summer water exchanged with northern Adriatic may play substantial role. Aside from the waters around the northern parts of Cres Island, which are affected by the freshwater discharges in the Kvarner region, there is no major local influence on the ecosystem.

Sea currents have a northward direction throughout the year, with the exception in Rijeka Bay and Kvarner during summer, when currents from opposite direction prevail. Due to temperature gradients strong thermocline is established during summer in the whole area. Waves forced by southern winds can occasionally reach a hight of up to 3 m.

Since 1956 relative sea-level increase is observed (about 0.5 mm per year).

Expected effects, and most vulnerable systems and activities

Temperature elevations will increase the temperature differences in the column of sea water and thus make it more stable (less vertical mixing). The stability could be further enhanced by the input of surface freshwater. However, the predicted higher wind frequency and intensity may act as a destabilizing force.

Higher seawater temperatures and freshwater inputs will increase the primary productivity, with general benefits for the whole ecosystem. The possible negative consequence of increased productivity could be an increase in oxygen demand in the bottom layer, if the water exchange is reduced. This could affect the composition of the benthic community by favouring species with higher tolerance for the fluctuation of oxygen levels. The positive effects of increased primary production could be cancelled if the produced organic matter ends up in the form of mucus (resulting from excessive phytoplankton production) floating on the surface of the sea, or nonedible parts of the foodweb. Such development would negatively affect the tourist industry of the area and, probably, the fisheries.

Due to the expected sea-level rise (8-75 cm by the year 2050 and 14-194 cm by the year 2100), and likely increase in wave heights, the wave zones will increase in height, causing flooding of low-lying coastal areas, interference with the functioning of sewerage systems, threat to coastal buildings, installations and infrastructures.

The residual currents will be most probably reduced due to the expected lower input of freshwater into the greater area, thus extending the frequency and intensity of the influence of northern Adriatic waters to the western maritime area of the Cres-Losinj archipelago, and diminishing the now predominant influence of the central Adriatic.

Suggestions for action to avoid or mitigate the effects

Sea-level changes, as well as other effects mentioned above, could not be avoided by local action as they depend on global human activities.

The psychological effect of the undesirable mucus formation on tourism could be mitigated by informing the public at large about the fact that it is not a consequence of pollution but a natural phenomenon which does not affect public health. Protective barriers could be also applied to prevent the mucus floating towards tourist beaches.

Suggestions for action to adapt to the changes

Sea-level changes will necessitate adjustments of the sewerage system, port facilities, coastal roads, etc.

If, as a consequence of climate change, certain fisheries stocks become endangered, stricter control over their fishing should be established.

Suggestions for follow-up

Monitoring of the relevant parameters should be established for a wider area, so that the already observed changes could be systematically followed. In view of considerable local tectonic activity, sea-level measurements should be extended to a greater number of measuring points.

2.6.1 AGRICULTURE (I. Toic)

Past trends and present situation

The islands of Cres and Losinj have about 600 hectares suitable for intensive agricultural production, but today only about 25 per cent of that surface is used. Additional areas suitable for agriculture are too fragmented and inaccessible for mechanisation, thus suitable only for extensive agriculture requiring considerable labour. Olive growing (about 120,000 trees) and sheep breeding (about 25,000 sheep) is practised on about 13,500 hectares. Both of these activities have an uncertain future. Vegetables are produced on a smaller scale around the towns of Cres and Veli Losinj. On the island of Unije about 80 hectares are under wheat and on the island of Susak there are about 10 hectares of vineyards.

During the last 50 years agriculture and sheep breeding showed a decreasing trend, due to depopulation of the island and orientation towards tourism and maritime activities. A number of vineyards and olive plantations were abandoned, and pastures turned into macchia.

Expected effects, and most vulnerable systems and activities

The predicted increase in dry periods might affect agriculture negatively. For example, the growing of olive trees is quite dependent on precipitation in the months when it is predicted to be decreased. Extensive sheep breeding is heavily dependent on availability of rains for grass-growing and to fill the natural and man-made watering places.

Suggestions for action to avoid or mitigate the effects

Reservoirs and storage tanks should be built to collect and preserve rainwater for use during the dry periods, because there is no possibility to use the water of Lake Vrana for irrigation.

The cultivation of vegetables and fruit trees which ripen before the dry period, or which are resistant to draught, should be introduced.

Suggestions for action to adapt to the changes

Degraded pastures, particularly those which already turned into macchia, should be afforested, in order to preserve the humidity of the soil and create fertile soil.

The present agricultural practices would have to be modified, e.g. by introduction of greenhouses or by a more intensive vegetable production in winter.

Suggestions for follow-up

Part of fees collected for the use of freshwater should be used to build water tanks and reservoirs, and to protect the agricultural land from further erosion.

Research on most suitable variety of fruit and vegetable cultures which could be used under the changed climate conditions.

2.6.2 FISHERIES (D. Balenovic)

Past trends and present situation

In the past, fishing was one of the principal activity of the local population and fish was a very common food. At present the number of people involved in fisheries is much smaller but they catch more fish for commercial purposes.

There is no change in the total catch of small blue fish (sardines), cephalopods and scampi. The catches of bigger blue fish (e.g. mackerel and tuna) are decreasing for reasons which are not clear. The catches of white bottom fish (e.g. scorpaena, sparus, corvina, dentex, chrysophrys, gadus, merluccius) are decreasing and some species are close to be overfished.

About 150 bigger and 400 smaller fishing boats operate in the area of the archipelago. According to a rough estimate (fisheries statistics are quite inaccurate), the annual catch is about 1500 tons of blue fish and 800 tons of white fish.

Expected effects, and most vulnerable systems and activities

Elevated sea temperature may increase the productivity of the waters around the archipelago, and this may have a positive effect on fisheries.

Suggestions for action to avoid or mitigate the effects

Climate extremes, wind in particular, may require the use of larger and stronger fishing vessels. This, in turn, will require the enlargement of the harbours, particularly in the small islands of the archipelago (e.g. Susak, Unije, Ilovik).

Suggestions for action to adapt to the changes

Stricter control over fishing activities would have to be established to avoid overfishing of certain stocks and to protect the endangered species.

Suggestions for follow-up

Monitoring of fish migration over the whole Adriatic and the Ionian Sea.

2.6.3 AQUACULTURE (N. Smodlaka)

Past trends and present situation

At the turn of the century some shellfish cultures were introduced in the Cres-Losinj area (up to 100.000 oysters were annually produced in Cres), but the cultures were discontinued before 1914. Presently no aquaculture is practised on the archipelago, although the revitalisation of this activity is envisaged by long-term development plans.

Expected effects, and most vulnerable systems and activities

The expected climate change is not likely to affect substantially the mariculture potential of the area, because the fish species planned to be used are eurytherm and euryhaline, and thus easily adaptable to the predicted changes. The reduced water exchange in some areas which may be used for fish-farming might affect the productivity of this areas.

Suggestions for action to avoid or mitigate the effects

In selecting the places where aquaculture will be established, the long-term environmental changes should be taken into account.

Suggestions for action to adapt to the changes

None.

Suggestions for follow-up

Research on the most suitable species which could be used in aquaculture under the environmental conditions expected as a consequence of climate change. Sites for mariculture should be selected on the basis of thorough check-up of their physical and hydrographic properties.

2.6.4 SILVICULTURE (M. Rukavina)

Past trends and present situation

The forest cover of the archipelago is represented by two climazonal associations. The northern part of the Cres Island, northward from the Sv. Blaz - Merag line, is covered by the deciduous forest. Southward from that line the archipelago is covered by evergreen oak forests. The latter was removed at the higher rate than the deciduous forest, and converted into pastures or agricultural land. At present 62 per cent of the Cres and Losinj islands surface is covered by forests; about one third of the forests are in private property.

In the past the forests were the main source of firewood and building material. The evergreen forests were cut at the base of the trunk in a special traditional way which allowed for quick natural reforestation. In deciduous forests trees were cut at the hight of 2 m in order to obtain firewood from new branches. However, this method of cutting caused degradation of the forest due to the development of fungal diseases on the cuttings.

Towards the end of the last century some areas were artificially reforested with conifers, initially to attract tourism (e.g. alepo pines on peninsula of Cikat). In the present century coniferous woods of black pine were planted on the plateau of the Cres island and on the Osorcica hill as a protection against soil erosion and strong winds. These woods are outside their natural habitats and never reached climax stage.

Until 1988 there was no systematic management of forests; they were managed by individual owners in traditional way. The first management plan for the northern part of Cres was adopted in 1988; the management plan for the Cikat forest area had been adopted in 1990.

Expected effects, and most vulnerable systems and activities

Climat change will particulary affect the forests outside of their natural habitats (e.g. chestnuts because of decreased soil humidity). Elevated average temperatures may lead to the expansion of evergreen oak forest and regression of the deciduous forests, resulting in more frequent forest fires. The planted pine forests will be also at higher risk from forest fires. Elevated temperatures may favour the occurrence of insects which may cause illness to trees or damage to the forest cover.

Suggestions for action to avoid or mitigate the effects

The risks from forest fires can be decreased by reintroduction of the evergreen oak into the planted cultures of alepo pines. The application of suitable technical forest management measures (e.g. firebreaks, clearing of the dry undergrowth, improved system of fire detection, etc.) would also contribute to the prevention of forest fires. Wider application of integrated pest control measures could decrease the danger from increased insect activities.

Suggestions for action to adapt to the changes

In order to ensure the optimal development and use of forest under the changed climatic conditions, contemporary management methods should replace, whenever necessary, the traditional methods.

Suggestions for follow-up

None.

2.7 ENERGY AND INDUSTRY (M. Mastrovic)

Past trends and present situation

Industries in the commune of Cres-Losinj include three shipyards (1.5 m above sea level), a fish canning factory (at sea level), seasonal olive oil production, textile factory, two marinas, and two petrol stations in the coastal area (one at sea level).

Electrical power, supplied from mainland through an underwater cable. is the main source of the energy on the archipelago. The present requirements of the archipelago are 15 MW; the requirements for the year 2015 are estimated as 75 MW.

Expected effects, and most vulnerable systems and activities

Temperature elevation is not expected to have a significant effect on the operation of the present industries. The total annual requirement for electric energy will probably remain the same, but with some decrease in winter (less heating) and increase in summer (a more intensive use of airconditioners).

Sea level changes will affect the fish canning factory, the shipyards, the petrol stations and the electric transformer stations situated in the coastal areas.

Suggestions for action to avoid or mitigate the effects

None.

Suggestions for action to adapt to the changes

The fish canning factory would have to be either protected by seawall, relocated, or closed. The shipyard, the marinas and the petrol stations will have to adapt their facilities by rising their operational working surfaces. The electric transformers will have to be either moved to a more appropriate location or raised.

The direct and indirect effects of expected climate change should be taken into account when elaborating the development plans of the archipelago.

Suggestions for follow-up

A detailed study of energy requirements should be carried out, taking into account the possible effects of expected climate change.

2.8 TOURISM (R. Cimerman and T. Knezic)

Past trends and present situation

Tourism in many diverse forms is one of the most important economic activity of the archipelago. It is strongly dependent on factors, such as climate, vegetation, water supply, historic sites, links with the mainland.

The total bearing capacity of the archipelago is about 40,000 tourist beds of which more than half are in camps. Most of them are around the cities of Cres, Osor, Mali and Veli Losinj which are valuable historic sites.

Expected effects, and most vulnerable systems and activities

With the increase in temperature the tourist season is expected to be prolonged and the year-round tourism may become more prominent. The more frequent and intense climate extremes (winds, storms, waves) might increase the dangers associated with nautical tourism.

The predicted sea level rise will have the most important effect on tourism, as it will lead to erosion of beaches. With a few exceptions, sea level rise will not affect the buildings used for tourism.

Historic centres of coastal cities will suffer because they are situated in low lying areas near the sea. The most vulnerable places are in Cres, Mali Losinj, Veli Losinj, Osor and Susak.

Suggestions for action to avoid or mitigate the effects

The direct impact of expected sea level rise could be countered by engineering works but the indirect effects (flooding of buildings' foundations, penetration of moisture) can not be easily avoided.

Suggestions for action to adapt to the changes

The expected impact of climate change should be taken into account in the preparation of future physical plans for the development of the archipelago.

Suggestions for follow-up

The changes of climate, and their direct and indirect effects, should be constantly followed, and the present planning and working designs should be reviewed and revised if necessary.

2.9 TRANSPORT AND SERVICES (R. Cimerman and T. Knezic)

Past trends and present situation

Maritime transport by ferries is the most important means of transport, enabling the connections with the mainland and between the small islands of the archipelago. There are 13 ports and ferry terminals for ships of local and long distance lines.

The network of roads is of relatively low standard. There are two draw-bridges on the archipelago at narrow sea channels (Osor, Mali Losinj).

On the island of Losinj there is an airport for smaller airplanes.

The telecommunication network is of good quality and covers the whole archipelago.

Expected effects, and most vulnerable systems and activities

The expected increase in frequency and intensity of winds and waves will have a negative effect on maritime transport. The number of days when some or even all ships and ferries will be unable to operate will probably increase. With the exception of new ports in Mali Losinj and Merag, all other harbours (length of 7,400 m) will be affected by sea level rise.

Sea level rise will also affect some parts of the road network (about 5 km), and the two bridges across the sea channels.

The airport is at 20 m above sea level and today it has extremely favourable microclimatic conditions. Therefore, it is not likely to be significantly affected by the expected climate change.

Suggestions for action to avoid or mitigate the effects

Gradual reconstructions will have to be carried out at ports and ferry terminals in several stages, taking into account the dynamics of expected sea level rise.

The parts of the road network, including the two bridges, vulnerable to sea level rise, will have to be raised.

Suggestions for action to adapt to the changes

The expected impact of climate change should be taken into account in the preparation of future physical plans for the development of the archipelago.

Suggestions for follow-up

The designs and decisions of planners should incorporate the concern about the possible impact of climate change on the transport systems and services of the archipelago.

2.10 HEALTH AND SANITATION (P. Vukelic and M. Mastrovic)

Past trends and present situation

The main health problems in the Cres-Losinj archipelago are similar to those in Croatia as a whole, namely: respiratory infections; nervous disorders; disorders of the heart and circulatory system, and urinary organs.

The water supply system of the Cres-Losinj municipality derives its potable water from the Vrana Lake. The current demand is approximately 70 litres per second, reaching 150 litres per second during the summer season. The maximum supply capacity of the lake has been estimated at around 300 litres per second throughout the year. The existing system supplies the town of Cres to the north and as far south as Mali and Veli Losinj.

Only a small part of the islands is covered with a sewerage system which is mostly combined with storm water disposal and is in a bad condition. There is a sewerage system with preliminary treatment and a submarine outfall 800 metres in length at Veli Losinj. Other places have temporary, short outfalls without treatment. The sewerage system in some coastal areas is already exposed to flooding and seawater penetrates the system. Coastal water pollution results from the direct discharge of untreated wastes.

There are two land fills in the commune; one is situated about five kilometres from Cres and the other is near Losinj. About 50 per cent of communal solid waste is disposed of on these land fill sites and the rest on uncontrolled sites.

Expected effects and most vulnerable systems and activities

In addition to the existing medical problems, the incidence of malignant neoplasms, cases of heat stroke and eye disease are all expected to increase under predicted climatic changes, placing an additional burden on health services in the Cres-Losinj archipelago. Extreme climatic conditions, exacerbated by increased air pollution, will cause an increase in heat stroke and respiratory problems (e.g. bronchial asthma, chronic bronchitis), particularly in children and elderly risk-group patients. In summer an increase in flies and mosquitoes could be expected. There might be also an increase in insect vectors which could cause an increase in virus-related illnesses, such as tick-borne encephalitis and papatachi fever. Stronger ultra-violet radiation may increase skin cancers and sight disorders, such as cataract.

Climate changes will cause flooding of the water supply network in the coastal areas as well as of the main distribution points. Corrosion effects are expected in the water supply installations while the rise of the sea level will cause a rise in the water level in wells located in the lower parts of the island, and will increase the salinity of this water. Lower rainfall in summer will cause water shortages in areas presently supplied by wells.

The rise of sea-level will also cause problems in the existing coastal sewage network. The increased rainfall (about 15 per cent in spring by 2050) will cause problems of excess water in combined sewage and stormwater systems. The direct impact will be to increase pumping costs and pollution of the sea caused by dilution of the waste waters. Flooding effects are expected in coastal areas on the unregulated solid waste disposal sites.

Suggestions for action to avoid, mitigate or adapt to the predicted effects

The water supply distribution points in coastal areas should be relocated inland. New installations of water supply systems should use corrosion (seawater) resistant materials. In areas supplied with well-water it may be necessary to find new sources of supply.

The existing sewage network in the coastal areas should be evaluated in the light of climate change predictions and redesigned in such a way as to minimise seawater penetration. This review should encompass current development plans, design criteria, and modes of and materials used in construction. Separation of the floodwater drainage system from the sewage system and improved capacity of the storm water system to handle higher volumes of flow.

Suggestions for follow-up

Due to the fact that existing landfills are not in satisfactory locations it is necessary to select sites with future environmental conditions in mind. Due to the current shortage of water and potential future problems due to climate change, serious consideration should be given to reuse and recycling of water.

2.11 POPULATION AND SETTLEMENT PATTERN (N. Karajic, R. Cimerman and T. Knezic)

Past trends and present situation

In 1991 the archipelago was inhabited by 12,000 people, living in 40 settlements. Twelve of these settlements, with 90 per cent of the archipelago's total population, are in the coastal belt. Mali and Veli Losinj (7,500 inhabitants) and Cres (2,200 inhabitants), both on the coast, are the largest settlements.

There is a constant trend in migration: within the archipelago from smaller to bigger settlements; and from the mainland to the coastal settlements of the archipelago.

Expected effects, and most vulnerable systems and activities

The predicted sea level rise will be the most important change felt by the settlements on the coast. It is estimated that seven settlements (central parts of Cres, Mali and Veli Losinj, Osor, Nerezine, Susak and Ilovik) will be particularly affected; the effect on five additional settlements might be of smaller consequences. About 35 hectares of urban area, carrying about 600 buildings and housing about 13 per cent of the archipelago's present population, will be affected in these twelve settlements.

Suggestions for action to avoid or mitigate the effects

Engineering solutions would have to be applied to protect the vulnerable costal settlements from flooding which might be caused by the predicted sea-level rise. Other actions may include dislocation of certain activities or the functional transformation of vulnerable areas (e.g. by filling the aquatory).

Suggestions for action to adapt to the changes

The predictions about the direct and indirect consequences of the expected climate change should be taken into account in future plans for the reconstruction (transformation) and development of coastal settlements. The reconstructions should be gradual and follow the dynamics of the climate changes, thus spreading the relevant costs over a longer time period.

Suggestions for follow-up

Detailed analysis of the vulnerable parts of the coastal settlements would have to be carried out, and the experience of other countries facing the same problems should be studied.

ANNEX IV

PRELIMINARY STUDIES OF THE SUBSTANTIVE SECTIONS OF THE KASTELA BAY TASK TEAM REPORT

2.1 CLIMATE CONDITIONS (M. Gacic)

Past trends and present situation

Three decades of meteorological (atmospheric pressure, air temperature, relative humidity, wind) and oceanographic data (sea level and sea surface temperature) show that mean monthly temperatures range from 7.6oC in January to 25.5oC in July. The annual mean maximum is 28.8oC and the minimum 20.0oC. Average annual precipitation is 820.6 mm with a minimum of 613 and maximum of 1101 mm.

In general these data display no significant trends, although atmospheric pressure and relative humidity display a respective increase and decrease. The present data are insufficient to determine whether these are trends, or a reflection of longer-term variability. Rainfall data from two localities within Kastela Bay demonstrate that existing differences over very short distances are greater than the changes predicted to occur as a consequence of global warming.

Expected effects and most vulnerable systems and activities

The predicted increase in rainfall is smaller than existing spatial and inter-annual variations, thus changes in this parameter are not expected to result in significant overall effects. Predicted changes in temperature are also considered to have little effect. One of the important aspects of the climate prevailing in the Adriatic is the passage of mid-latitude cyclones and anticyclonic conditions over the area. Climatic conditions (winds, rainfall, air temperature) are thus determined as an average of all such events. It is important to know whether there will be any changes in the paths of cyclonic events due to climate change. Either a decrease or an increase in the frequency of these transient atmospheric perturbations could appreciably affect winds, rainfall and temperature, and present data are inadequate for this purpose.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

None

Suggestions for follow-up

A more detailed study of the long-time series of wind data is needed. A specific analysis of the rainfall data which takes into account spatial variability is also needed.

2.2. LITHOSPHERE (B. Milos)

Past Trends and present situation

The wide spatial variability in natural factors of soil formation (geology, geomorphology, hydrology and living organisms) combined with a long history of intense use by man has resulted in a great variability in the types and distribution of soils in the area.

Geologically the Kastela Bay area is composed of marine limestones and dolomites, Palaeocene flysch sediments and quaternary sediments. In this area are found: lithosols, calco-melanosols, calco-cambisols and Terra Rosa soils on the mesozoic sediments; calcaric-regosols and calco-rendzinas on the flysch and anthropogenic soils. The basic factors limiting reforestation of the natural soils based on limestones are soil depth, low water retention capacity, slope and stoniness. Limiting factors for agricultural use of the anthropogenic soils are physiographic and lithological combined with their actual use. The abandoned terrace soils are limited by low water retention capacity, physical degradation and erosion. The small plot size, fragmentation of holdings, slope and limited possibilities for use of agricultural machinery all limit production.

The arable, agricultural soils on typical Adriatic coastal flat lands are highly productive. However a large proportion of these areas are densely populated and present trends are for further expansion of populations and transformation to non-agricultural use. In other areas chemical degradation of the soils resulting from over-use of pesticides and fertilisers is a problem.

Expected effects and most vulnerable systems and activities

With the predicted increase in air temperatures and a decrease in precipitation at least during the autumn it is anticipated that potential evapo-transpiration will increase from 511 to 536 mm in the period May to September and that the soil moisture deficit will increase from 375 to 394 mm.

Physical degradation and soil erosion through increased rainfall will occur on steep slopes with impermeable flysch substrates. Total content and quality of soil humus will not change in these soils because the dominant form of humus is resistant to degradation processes.

With a rise the predicted rise in sea level alluvial soils in the Jadro and Zrnovica estuaries will be exposed to salinisation and rising ground water; saline marshland near Pantana spring will be flooded. Higher sea level will not cause extensive coastal erosion since much of the coastline is already artificial.

Accumulation of nutrients and pesticides due to intensive use of fertilisers and deposition of airborne contaminants will continue to be a problem and may increase due to reduced leaching under the new climatic conditions. Transfer of such contaminants to the sea through soil erosion is possible.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

On the Flysch terrains recultivation of the anthropogenic terraced soils should be carried out only with adequate soil conservation actions. Soils should be protected from erosion by surface run-off and stream flows should be controlled.

Suggestions for follow-up

Evaluation of the soils and land areas of Kastela Bay for different types of use. Continuous monitoring of soil conditions is required in order to achieve a better understanding of the effects of expected climatic changes on soils and agriculture.

2.3. HYDROSPHERE (J. Margeta)

Past Trends and present situation

Kastela Bay is relatively well supplied with freshwater resources. The average annual precipitation is 820 mm. Seasonal variation is typical for the Mediterranean with a wet winter and dry summer. There are two rivers the Jadro and Zrnovica with watershed areas extending outside the study area. These rivers are typical karst springs. As a result of the flysch formations a barrier runs parallel to the coast behind which is formed an inland aquifer, having a watershed area of 260 km2 in the hinterland. The average annual discharge of the Jadro is 9.5 m3/sec with an average summer minimum discharge of 4.0m3/sec and an average winter maximum of 66 m3/sec. Similar variations in seasonal flows are shown by the Zrnovica but the average annual flow is much lower around 1 m3/sec.

The local aquifer for Kastela Bay is small and in contact with the sea. The annual discharge rate is 101 m3, via diffuse seepage and submarine springs. The region is highly developed such that the natural processes in Kastela Bay have less influence on the local water budget than do human activities. Sewerage outputs to the bay have more influence than natural local freshwater sources, particularly during the summer when sewage discharge is around 1.5 m3/sec.

Expected effects and most vulnerable systems and activities

Three elements of climate change will influence local water resources: increasing temperature; increasing annual precipitation and sea level rise.

Increased air temperature will increase the sea surface temperature and hence enhance surface evapouration. On land evapo-transpiration will also increase and relative humidity is expected to increase throughout the year. It is not possible to predict accurately the effects of these changes on the water balance. Increased evaporation and evapotranspiration losses from the system and increased precipitation inputs may possibly balance resulting in no significant change to surface run-off. There will be no significant change in river and groundwater flows and the freshwater table.

Sea level rise will have a significant influence on local water resources resulting in movement of salt water upwards and landward. This will have an effect on coastal aquifers, coastal springs and river estuaries. Aquifers will change position and be reduced in capacity; coastal springs will be relocated at higher elevations and flow rates will be altered; estuaries will suffer saline intrusion further inland with consequent changes to river bank aquifers. In addition upward and landward movement of the sea will result in contamination of freshwater resources and flooding.

The expected effects on the biological component of the hydrological changes are very difficult to predict because of the complexity of the interacting factors and the extent of human interference including urbanisation and other activities on the land surface. The Jadro, Zrnovica

and Pantana are important freshwater resources for this area but their watershed is not unfortunately included in the area covered by the present study.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

Due to the extent of urbanisatiopn it is very difficult to distinguish between the effects which result from climatological changes and those resulting from anthropogenic activities. Consequently it is difficult to suggest mitigation measures for the effects of climate change on water resources. The hydrology of the Kastela Bay area has been constantly modified by man and will continue to be changed in the future. Human influence is likely to dominate other influences except for the effects of sea level rise effects. As a result it will be necesary to study changes in the macroeconomics of water resources.

Appropriate authorities should take into consideration these changes and through the planning process suggest appropriate measures which should include necessary flood prevention action and actions designed to mitigate the impacts of vertical changes in the water table and saline intrusion up-river. Authorities and city planning institutions should suggest possible mitigation measures which might be either active or passive. Active measures might include zoning, insurance, or education while passive measures might include all kinds of civil engineering work such as increasing the height of coastal sea defenses, mechanical prevention of sea water intrusion; or reduction of the level of the water table in the coastal aquifer through pumping. The most suitable measures could only be recommended following a more detailed evaluation of their relative costs and benefits in the light of expected changes in water resources.

To avoid the negative effects and adapt to predicted changes a more precise analysis of the effects is needed including the necessity to study how changes in the biosphere influence changes in water resources and how changes in evaporation and evapo-transpiration relate to changes in rainfall.

Suggestions for follow-up

To be able to advise on suitable policy options and measures to avoid the negative effects of climatic changes it is necessary to have an adequate database and models of the freshwater resources. In this regard it is necessary to further study the influence of the expected changes on the catchments of the Jadro Zrnovica and Pantana springs.

It is also necessary to develop monitoring programmes which will enable the early detection of the effects of climatological changes and sea level rise on the freshwater resources of the region; and to develop methodologies for the study of climatological changes in the predominantly urbanised areas.

2.3.1 SOCIO-ECONOMIC CONSEQUENCES OF CHANGES IN WATER RESOURCES (J. Margeta)

Past Trends and present situation

Sea level rise is an on-going process that has occurred over the last century as a result of which many old building and historical sites have been flooded. With increased sea level rise, flooding will be intensified both directly by the sea and indirectly by changes in water tables. Other changes in water resources will not have significant effects in the socio-economic sectors.

Expected effects and most vulnerable systems and activities

Sea level rise will result in flooding of estuaries, natural and artificial coastlines. Estuaries will experience increased effects from bank overtopping and upstream flooding which will occur in the Jadro and Zrnovica river estuaries. Flooding along natural coastlines will not be important since the coast is largely steep and rocky so effects are localised in the coastal belt 0.5-1 m wide. The strongest effects will be felt along developed coastlines and will include effects on coastal services, infrastructure and construction. Present coastal service infrastructure in low-lying areas will become unsuitable in the future. Infrastructure such as sewers, water supply, electricity and other services could be flooded and corrosion of pipes and intrusion of seawater into pipes and sewage systems will occur.

With a rise in the water table the foundations and basements of coastal buildings will be flooded causing destabilisation of these structures. These effects will be particularly serious for the older buildings already at low elevations due to past sea level rise such as those in the old town of Trogir the old centre of Kastela and Diocletian's Palace in Split.

Sea level rise will influence all water and sewage discharge to the sea as a result of intrusion into the pipes resulting in changes to discharge rates and increases in water level in the sewage network with the possibility of upstream sewage flooding.

Sea level rise will result in salinisation of freshwater resources and indirectly change their availability. Pollution with effluents and increased water temperature will reduce the oxygen capacity since it will increase the speed of decomposition. Together with chemical pollution this will adversely affect biological processes. Unfortunately man-made pollution is dominant and will mask climatological effects.

A sea level rise of 30 cm would result in direct flooding of around 15 Ha around Panatana spring and 10 Ha each in the Jadro and Zrnovica estuaries. In contrast a rise of 60 cm would flood: the shipyard; the western portion of the port of Split; the old centres of Split, Trogir and Kastela; all 6 existing marinas; and, a coastal belt of approximately 6 km length to a distance of 15m inland.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

Firstly it is necessary to detail all the effects and to immediately anticipate all expected changes in use, and to take into account the results of this evaluation in future design and construction. City planning authorities should immediately review plans for city development in the light of these findings. It is possible to take immediate action in terms of public information, seminars and awareness raising and through the provision of detailed information to policy makers and local and national authorities.

Mitigation of the anticipated negative impacts of flooding should include both regulatory measures and civil construction work. The latter should include: construction to prevent surface flooding; prevention measures against saline water intrusion; lowering of the water table; relocation of structures and infrastructure as appropriate. Regulatory measures might include zoning, revision of long-term development plans, and actions in the fields of information and education.

Negative impacts on infrastructure could be mitigated or avoided by: relocation; use of appropriate corrosion resistant materials; adopting new design criteria; and altering construction techniques. Different services will require adoption of different mitigation measures depending on the nature of the services such as transport, sewage, water and electricity suplly, housing and others.

Suggestions for follow-up

Detailed survey of all the effects of sea level rise especially on historic monuments and sites and development of regulatory measures which will anticipate the changes. Provision of information to the general public and special groups including city planning authorities.

2.4. ATMOSPHERE (B. Grbec)

Past Trends and present situation

At present all air pollutants exceed the upper permissible limits. The concentrations of settling particles exceed these limits by five times; airborne particles by a factor of two while SO2 concentrations are about two and a half times the permissible limits.

More than ten years of data on SO2, smoke, settling and airborne particulates are available which demonstrate that concentrations depend on the intensity of local sources, wind and thermal conditions. Wind contributes to the lowering of air pollution through dispersion. It was not possible to conclude whether the strong year to year variations are due to changes in the sources or to varying climatic conditions.

Expected effects and most vulnerable systems and activities

The most important factor affecting air pollution in the Kastela Bay area is wind. Therefore any appreciable alteration to the wind regime will strongly alter air pollution levels, the possible increases in wind speed will lower the general level of air pollution. In contrast the thermal regime is less important in determining the level of air pollution.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

Improve technology and use filters.

Suggestions for follow-up

Study the dependence of pollution levels in various parts of the area as a function of different weather conditions. Establish appropriate monitoring of critical pollutants.

2.5.2. FRESHWATER ECOSYSTEMS (A. Baric)

Past Trends and present situation

There are two springs in the study area, Jadro and Zrnovica. Both are typical karst springs and their water flow depends on precipitation in the immediate hinterland. The minimum water flow has been increased by construction of several dams on the river Cetina indicating that there is a common system of under-ground channels connecting these systems.

Along their upper course (500 metres from their sources) the banks of both rivers are natural while for the remainder of their course the banks are artificial. Houses and industries have been constructed along the rivers which have become recipients of waste waters. Water quality decreases from source to river mouth.

The Jadro is famous for its endemic trout species which is endangered due to pollution in the lower reaches and poaching in the headqaters. The Zrnovica estuary which was an important feeding ground for migratory birds some 20 years ago has been devasted and is no longer visited by birds.

Expected effects and most vulnerable systems and activities

The anticipated climatic changes will not directly affect the Jadro and Zrnovica rivers. Sea level rise will presumably cause significant changes in river estuaries. A large part of the Zrnovica estuary will be flooded. Seawater will penetrate deep into the Jadro River since its lowest flows are very small and the saltwater wedge can be expected to intrude along the river bed to around 500 metres further inland. This will change the present freshwater ecosystems to a saline system and similar changes are expected in the mouth of the Zrnovica.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

There is no reason to introduce any action to avoid or mitigate the expected negative impacts of climate change. Measures to eliminate all types of pollution (domestic and industrial waste water, run-off) of both rivers should be planned and implemented, in order to reduce oxygen depletion due to biodegradation of organic waste matter.

Suggestions for follow-up

A detailed study of the ecosystem of both rivers should be implemented.

2.5.3. MARINE ECOSYSTEMS (A. Baric)

Past Trends and present situation

It is not possible to estimate the impacts of expected climatic changes on the marine ecosystems of Kastela Bay despite the availability of some 50 years of data. This is due to the considerable changes which have occurred to primary productivity over the last 30 years as a consequence of pollution, primarily from urban and industrial waste waters. Primary production in the Bay has increased and the phytoplankton community has been changed. Red Tides caused by blooms of dinoflagellate species have occurred since 1980 and this is now a regular phenomenon in summer when the water temperature exceeds 20oC. Changes in the zooplankton as well as bacterial populations have also been noted.

The benthic communities have been severely affected by pollution and significant changes have occurred at the species and community level with green algae dominating in a number of areas.

Expected effects and most vulnerable systems and activities

It may be assumed that the present pollution by urban and industrial waste waters will be considerably decreased in a comparatively short time through construction of an appropriate sewerage system for the collection, treatment and submarine disposal.

The global increase in surface air temperature will cause an increase in the sea surface temperature although this may not be as great a rise as in the case of air temperature. These

changes are likely to intensify the daily wind patterns of on-shore and off-shore winds in the summer season and on a synoptic time scale. This will intensify surface currents and increase vertical mixing in the Bay and in the channels, decreasing the salinity gradient and increasing nutrient exchange between the bottom and surface waters.

Primary production will therefore be increased but this effect will be countered by the reduction in nutrient inputs from waste waters. Red tides will consequently be reduced in frequency. Although changes in primary production are likely to occur it is impossible to predict how these will be reflected further up the food chain and in particular affect the availability of important fish species.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

Since the ecosystem is in urgent need of restoration no suggested actions to counter the impacts of climate change can be made. Construction of the proposed sewerage system would have beneficial effects on the marine ecosystems of the bay.

Suggestions for follow-up

Detailed study of the impacts of various pollutants on marine communities in order to distinguish between climate change and other anthropogenic impacts.

2.6.1. AGRICULTURE (B. Milos)

Past Trends and present situation

The total area covers around 16000 ha. of which natural forest soils cover 450 ha and anthropogenic, mainly terraced soils cover 10,000 Ha, 3,500 ha are abandoned terraced soils. 1,900 ha has been deforested for urban development of Split, the airport and industrial developmenst in Kastela and Solin. The area between the coast and the steep slopes of the foothills (5,500 ha) are covered by high quality anthropogenic soils. The greater part of this area is heavily populated and current trends indicate a further expansion and transformation of valuable agricultural land to non-agricultural purposes including housing, industry and tourism.

Many of the present crops were grown in ancient times and include vines, olives and cereals. Dryland farming was and is the predominant practice in most areas. The main irrigated crops include citrus, kiwi and a wide variety of vegetables and flowers produced under controlled environments (greenhouses) and in the open.

Problems of agricultural development include: the private ownership of land in Kastela Bay resulting in thousands of small and fragmented agricultural holdings; water shortages; and low rainfall in the main growing season of May - September.

Expected effects and most vulnerable systems and activities

The predicted increase in air temperature will be generally favourable for agricultural crop production extending the growing period. Decreased soil moisture will however further decrease the agricultural potential and the extent of this reduction will depend on the differing soil properties particularly the soil water retention capacity.

Suggestions for action to avoid, mitigate or adapt to the preicted effects

Agricultural development should be geared towards enhanced winter vegetable production. The suitability of the Kastela Bay area for different future agricultural uses should be fully evaluated. Control of the excessive use of fertilisers and pesticides should be enforced and the most appropriate crop varieties and systems of irrigation for future climatic conditions should be identified.

Suggestions for follow-up

None.

2.6.2. FISHERIES (A. Baric)

Past Trends and present situation

The area of Kastela Bay including the Brac and Split Channels are not very important from a commercial fisheries standpoint. Pollution of the bay over the past decades has resulted in prohibition of any fishing activity. Fishing is permitted only in the channels and then with closed seasons from time to time. Quantities of demersal fish are low and quality considerably impaired compared with 30 years ago when the catch was estimated at 600 kg/Km2. This decline has been primarily ascribed to over-fishing and pollution by urban and industrial effluents. Small pelagic fish catch (sardines & anchovy) varies around 1500 t/yr of which between 300 and 500 tonnes are caught in the bay. Some 15 years ago Sardinella aurita was first captured in the bay. A normal inhabitant of waters off the North African coast catches of this species increase year by year.

Expected effects and most vulnerable systems and activities

Over-fishing and pollution are the two major factors which will continue to affect demersal fish stocks for the foreseeable future. It seems improbable that anticipated climate changes (increased temperature and precipitation) will have any direct effect on fish stocks. Changes in primary production (phytoplankton) as well as changes in the food chain would have some indirect effect, but it is impossible on the basis of present knowledge to predict these changes.

Pelagic species such as the sardines and anchovy could be affected by temperature increases, approaching coastal areas earlier and remaining longer than under present conditions. This would lengthen the traditional fishing season which is based on the use of nets under artificial light on moonless nights.

Changes in water mass circulation could also impact migrations of some fish species but such impacts cannot be predicted at the present time.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

On the basis of present knowledge it is impossible to suggest appropriate action.

Suggestions for follow-up

To avoid or mitigate the negative effects of expected climatic changes it would be necessary to establish a proper monitoring system and employ appropriate measures to avoid over-fishing.

In order to undertake the necessary actitivities it would be necessary to obtain more informationm on the biology of important fish species especially on their spawning patterns and feeding ecology. Special attention should be given to the recently arrived Sardinella aurita.

2.6.3. AQUACULTURE (A. Baric)

Past Trends and present situation

There are presently no marine fish farms nor plans for their construction in the area due to the current levels of pollution. Freshwater aquaculture (rainbow trout) farms are located at the Pantana spring and in the delta of the Jadro river. In the initial stages fish are cultured in the Jadro hatchery and then transferred to Pantana. Total annual production is around 400 tonnes.

Expected effects and most vulnerable systems and activities

Anticipated temperature rise will not significantly affect the present temperature regime of the Jadro River and Pantana spring thus no direct impacts are anticipated on present activities. Temperature increase would have an indirect effect on the Jadro hatchery since higher temperatures would accelerate decomposition of organic matter which will decrease oxygen concentration in the river water.

The anticipated sea level rise may adversely affect the Pantana hatchery since part of the area may be flooded. Sea level rise will significantly affect the spring itself and salinity will increase.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

Reduction of pollution by organic matter of the Jadro River in order to reduce oxygen depletion. The area of the Pantana hatchery could be protected by embankment of the site. There is no information as to how the existing aquaculture could be adapted to the predicted changes.

Suggestions for follow-up

Sites suitable for mariculture should be selected on the basis of a thorough examination of their physical and hydrographic properties.

2.6.4. SYLVICULTURE (I. Onofri)

Past Trends and present situation

There is no forest on the study area.

2.7. ENERGY AND INDUSTRY (A. Baric)

Past Trends and present situation

Industry in the area includes: shipbuilding, chemical plants, cement works, steel production and production of alloys, cloth making, footwear, and the beverage industries. Industry employs 38,500 people and the energy consumption for the area totals 1,026,000 MW/yr of electricity; 235,000 tonnes/yr of coal; 178,500 t/y of fuel oil; and, 17,000 t/yr of liquified gas.

Expected effects and most vulnerable systems and activities

Existing industry should be re-structured regardless of the expected climate changes since it is the greatest energy consumer and at the same time a significant source of pollution within the Bay. Industrial development should concentrate on light industry, services, agriculture and tourism.

Temperature increases may favour the consumption of soft drinks and consequently increase demands for the products of the existing soft drink and beer industries. It is also likely to affect cloth production and the footwear industry. Sea level rise is likely to directly affect the shipyards, chemical plants and the ferro-alloy plant.

The temperature increase will reduce the need for heating in winter but increase demand for airconditioning in the summer hence changing the seasonal patterns of demand for different energy sources. The increased demand for airconditioning may encourage the establishment of airconditioning manufacture and servicing in the area.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

Predicted effects should be taken into account in the preparation of future development plans for the coastal region, particularly in future use of the areas where the chemical plant, cement works and ferro-alloy plant are presently located. The shipyards should undertake appropriate modification of their facilities to cope with the anticipated sea level rise.

Suggestions for follow-up

A detailed analysis of future energy requirements should be undertaken in order to plan for future needs in the light of expected climatic changes, particularly a rise in temperature.

2.8. TOURISM (M. Veldic)

Past Trends and present situation

Tourism is not a major economic activity in Kastela Bay, although the area has high potential as one of the most attractive destinations in Croatia.

At present coastal tourism is the main pattern of tourist development in the region with tourist infrastructure located in a narrow coastal belt that is already under strong pressures for space. Practically all coastal land is developed, mostly by settlements and industry.

The capacity of tourist accommodation in the region is relatively small. At present there are around 25,700 beds of which 6,500 are in hotels and guest houses, the remaining 19,200 being in camps, private and other accommodation. The number of visitors has declined over the last twenty years. The average number of overnight stays over this period has been between 1.5 and 2 million.

Kastela Bay Region: Numbers of visitors and overnight stays, 1989.

	Visitors			Overnight Stays		
Municipality	National	Overseas	Total	National	Overseas	Total
Split	121553	118728	240228	504179	418521	929700
Kastela	27079	22192	49269	162682	184552	347189
Trogir	35094	61675	96769	166712	455469	622181
Total	183726	202595	386321	833573	1058542	1892115

Expected effects and most vulnerable systems and activities

It is recognised that the changing climate conditions and particularly the impact of sea level rise will not have a major impact on tourism development in the region, since it will not result in the loss of sites or land considered as suitable tourist areas. In addition the rugged relief and erosion resistant substrate of the shore-line means that beach loss within the area is unlikely. However accelerated deterioration of coastal and low-lying historic sites may occur, and improved infrastructure and drainage for the population of low-lying areas will be necessary.

The increase in temperature and changed weather conditions are unlikely to alter the level of human comfort. However the increase in temperature may extend the summer season which would be a positive benefit.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

Adoption of an expected safe elevation for tourist establishments, industries, urbanisation, drainage and sewage systems taking into account the scenarios of climate change.

Development of educational programmes about coastal environments thus alerting the population, planners and decision makers to the possible consequences of climatic changes and sea level rise and enabling them to be taken into account on an individual and collective basis.

Suggestions for follow-up

In order to avoid generalisations of the problems relating to the protection of the coastal areas as well as to support planners decision making concerning land use the preferred follow-up would be a detailed assessment of the vulnerability of the Kastela Bay coastline to sea level rise and climate change.

2.9. TRANSPORT AND SERVICES (M. Veldic/A. Baric)

Past Trends and present situation

The study area represents a very important traffic crossing point on the Adriatic coast. Roads run along the coast and towards the hinterland, while the town of Split is the terminal station for two rail lines into the hinterland. The passenger port is the single connection point for the mid-Adriatic Islands to the mainland, as well as with other Adriatic towns in Croatia and Italy. Split airport is located towards the town of Trogir.

Expected effects and most vulnerable systems and activities

The airport will not be directly affected by the anticipated rise in sea level nor by the predicted meteorological changes. Anticipated climatic changes may however indirectly affect transportation via measures that may be introduced to reduce the emission of greenhouse gases, although such measures would not be introduced at a local level.

Climatic changes will have no significant implications for Port facilities and navigation. Very serious problems will be created in the western part of the city harbour, where the coast level is very low and an increase of 50 cm in sea level will flood this part of the port. Sea level rise will also affect the existing railway in the city of Solin where railway tracks and the bridge crossing the Jadro river are located at low elevations.

Increases in precipitation, manifested as a larger number of rainy days, particularly in spring and summer, will cause an increase in the number of traffic accidents, particularly at the beginning of rains when the thin film of oil and water makes the roads extremely slippery.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

In the planning of infrastructure along the coast the expected sea level rise should be taken into account. The necessary measures should be undertaken to protect the railway tracks in the Solin area.

Suggestions for follow-up

A detailed study of possible impacts of sea level rise (including changes in wave conditions) and wave induced erosion should be prepared.

2.10. SANITATION (J. Margeta)

Past Trends and present situation

The Jadro has been used as a water supply since the third century and its use will continue in the future. The spring originates 27 m above mean sea level and the capacity of the water supply system is 2.5 m3/sec. The water is of good quality. The sewage system is incomplete, with some direct discharge to the river systems and all sewage presently passes to the sea without treatment. A single solid waste disposal site is located within the area at a distance of around 2 kilometers from the coast.

Expected effects and most vulnerable systems and activities

Expected climatic changes may influence sanitation in the region through affecting water supply from the Jadro spring. Sea level rise will influence the water supply network through corrosion from sea water intrusion into ground water.

Corrosion problems in the sewage system may lead to contamination of ground and drinking water supplies. Changes in the pattern and intensity of rainfall will severely tax the existing storm water drainage system and flooding will increase. Increased risks of flooding of the sewerage system will increase the risks from contamined flood water. The increased water levels in the sewage system will affect the operation of the system and future treatment plants. Increased temperatures may speed up the rate of anaerobic decomposition in the sewage system leading to dangerous levels of methane build-up.

Increased rainfall will increase leaching of the landfill site.

Suggestions for action to avoid, mitigate and adapt to the predicted effects

For components of the water supply system affected by saltwater corrosion, replacement with resistant materials will be necessary. Similar action should be taken in the case of the sewerage system which should also be better ventilated to reduce methane build-up. All outflows should be designed and constructed in a manner appropriate for the new environmental conditions.

New design criteria should be developed and adopted taking into account the conditions which will prevail under changing climate and sea level.

Suggestions for follow-up

Further investigate the water balance of the Jadro, Zrnovica and Pantana and eliminate direct sewage discharges to them. Develop plans and new design criteria for the storm water disposal system.

2.11. POPULATION AND SETTLEMENT PATTERN (M. Veldic)

Past Trends and present situation

The Kastela Bay region has been experiencing intense population growth since the early 1950's during the period 1953-1981 the regions population grew from 144,000 to 2500,000 (2.31% per annum). This rapid growth can be attributed to a net rural to urban migration resulting from the process of industrialisation and urbanisation throughout Croatia.

Nowadays around 90% of the population (267,000 - 1991) is concentrated along a narrow coastal belt as a result of favourable natural conditions and past development policies which have favoured coastal settlements such as Split, Solin, Kastela and Trogir.

Expected effects and most vulnerable systems and activities

It is not anticipated that the expected climatic changes will have any direct effect on human demographic characteristics such as life expectancy at birth, fertility or health. From the perspective of population growth and distribution the indirect consequences of climate change

are likely to be more important. These effects include the implications of climate change and sea level rise for agricultural land use, coastal mariculture, infrastructure such as drainage systems and the maintenance of water supply and sewerage services which are likely to have increased maintenance costs.

Suggestions for action to avoid, mitigate or adapt to the predicted effects

Adoption of an expected safe elevation for infrastructure construction including hotels, industries, urbanisation, drainage and sewage systems taking into account the scenarios of climate change.

Development of educational programmes about coastal environments thus alerting the population, planners and decision makers to the possible consequences of climatic changes and sea level rise and enabling them to be taken into account on an individual and collective basis.

Suggestions for follow-up

Assess the vulnerability of the Kastela Bay coastline to sea level rise in order to support planners decisions concerning land use and population distribution.

TABLE 1

SCENARIOS FOR THE PREDICTED CLIMATE CHANGE IN KASTELA BAY DEDUCED FROM SCENARIOS PRODUCED BY THE IPCC AND THE UNIVERSITY OF EAST ANGLIA

SCENARIOS	TIME HORIZON		
	2030	2050	2100
IPCC GLOBAL			
Temperature	+1.8 EC	-	+2 to +5 EC
Sea level	+ 18 cm +/- 12 cm	-	+ 65 cm +/- 35 cm
IPCC Southern Europe			
Temperature	+2 EC winter +2 to + 3 EC summer	-	-
Rainfall	+ 0 to + 10% winter - 5 to + 15% summer	-	-
Soil moisture	- 15 to - 25% summer	-	-
Univ. East Anglia Med	for each EC Global		
Rainfall	+ 3% winter - 3% summer		
UNEP Task Teams			
Temperature	-	+ 1.5 to + 3 EC	-
Sea level	-	+ 24 to 52 cm	-
Univ. East Anglia* for Kastela Bay			
Temperature			
Annual	+ 0.8 to + 0.9 EC		
Winter	+ 0.9 to + 1.0 EC		
Spring	+ 0.8 to + 0.9 EC	as for 2030	as for 2030
Summer	+ 0.9 to + 1.0 EC		
Autumn	+ 0.8 to + 1.0 EC		
Rainfall			
Annual	- 5 to + 2%		
Winter	+ 1 to + 2%		
Spring	+ 4 to + 6%	as for 2030	as for 2030
Summer	+ 10 to + 19%		
Autumn	0 to - 2%		

* Percentage change in rainfall should be related to present values.

SCENARIOS	TIME HORIZON		
	2030	2050	2100
Operative Scenarios for Kastela Bay			
Temperature			
Annual	+1.44 to +1.62 EC	+1.2 to +2.7 EC	+ 1.6 to + 4.5 EC
Winter	+1.62 to + 1.80 EC	+1.35 to +3.0 EC	+ 1.8 to + 5.0 EC
Spring	+1.44 to + 1.62 EC	+1.2 to +2.7 EC	+ 1.6 to + 4.5 EC
Summer	+1.62 to + 1.80 EC	+1.35 to +3.0 EC	+ 1.8 to + 5.0 EC
Autumn	+1.44 to + 1.80 EC	+1.2 to +3.0 EC	+ 1.6 to + 5.0 EC
Sea Level	+ 18 +/- 12 cm	+ 38 +/- 14 cm	+ 65 +/- 35 cm
Rainfall			
Annual	- 9.0 to + 3.6%	-1.5 to 6.0%	- 10.0 to + 10.0%
Winter	+ 1.8 to + 3.6%	+1.5 to +6.0%	+ 2.0 to + 10.0%
Spring	+ 7.2 to + 10.8%	+6.0 to +18%	+ 8.0 to + 30.0%
Summer	+18.0 to + 34.2%	+15% to +57%	+ 20.0 to + 95.0%
Autum	0 to - 3.6%	0 to -6.0%	0 to - 10.0%

TABLE 2

SCENARIOS FOR THE PREDICTED CLIMATE CHANGE IN THE CRES/LOSINJ ISLANDS DEDUCED FROM SCENARIOS PRODUCED BY THE IPCC AND THE UNIVERSITY OF EAST ANGLIA

SCENARIOS	TIME HORIZON		
	2030	2050	2100
IPCC GLOBAL			
Temperature	+1.8 EC	-	+2 to +5 EC
Sea level	+ 18 cm +/- 12 cm	-	+ 65 cm +/- 35 cm
IPCC Southern Europe			
Temperature	+2 EC winter +2 to + 3 EC summer	-	-
Rainfall	+ 0 to + 10% winter - 5 to + 15% summer	-	-
Soil moisture	- 15 to - 25% summer	-	-
Univ. East Anglia Med	for each EC Global		
Rainfall	+ 3% winter - 3% summer		
UNEP Task Teams			
Temperature	-	+ 1.5 to + 3 EC	-
Sea level	-	+ 24 to 52 cm	-
Univ. East Anglia* for Mali Losinj			
Temperature			
Annual	+ 0.9 to + 1.0 EC		
Winter	+ 0.8 to + 1.0 EC		
Spring	+ 1.0 to + 1.1 EC	as for 2030	as for 2030
Summer	+ 1.0 to + 1.1 EC		
Autumn	+ 1.0 to + 1.1 EC		
Rainfall			
Annual	0 to - 3%		
Winter	+ 3 to + 6%		
Spring	- 1 to + 4%	as for 2030	as for 2030
Summer	- 4 to - 7%		
Autumn	0 to + 4%		

*Percentage change in rainfall should be related to present values.

SCENARIOS	TIME HORIZON		
	2030	2050	2100
Univ. East Anglia* for Cres			
Temperature			
Annual	+ 1.0 to + 1.1 EC	as for 2030	as for 2030
Winter	+ 0.8 to + 1.0 EC		
Spring	+ 1.0 to + 1.1 EC		
Summer	+ 1.0 to + 1.3 EC		
Autum	+ 1.1 to + 1.2 EC		
Rainfall			
Annual	0 to + 3%	as for 2030	as for 2030
Winter	+ 3 to + 6%		
Spring	+ 8 to + 10%		
Summer	- 4 to - 7%		
Autumn	0 to - 7%		
Operative Scenario for Mali Losinj			
Temperature			
Annual	+ 1.6 to + 1.8 EC	+ 1.4 to + 3.0 EC	+1.8 to + 5.0 EC
Winter	+ 1.4 to + 1.8 EC	+ 1.2 to + 3.0 EC	+1.6 to + 5.0 EC
Spring	+ 1.8 to + 2.0 EC	+ 1.5 to + 3.3 EC	+2.0 to + 5.5 EC
Summer	+ 1.8 to + 2.0 EC	+ 1.5 to + 3.3 EC	+2.0 to + 5.5 EC
Autumn	+ 1.8 to + 2.0 EC	+ 1.5 to + 3.3 EC	+2.0 to + 5.5 EC
Sea Level	+ 18 +/- 12cm	+ 38 +/- 14 cm	+ 65 +/- 35 cm
Rainfall			
Annual	0 to - 5%	0 to - 5%	0 to - 15%
Winter	+ 5 to + 13%	+ 5 to + 18%	+ 6 to + 30%
Spring	- 2 to + 7%	- 2 to + 12%	- 2 to + 20%
Summer	- 7 to - 13%	- 6 to - 21%	- 8 to - 35%
Autumn	0 to + 2%	0 to + 12%	0 to + 20%

* Local values are related to each degree of global warming

SCENARIOS	TIME HORIZON		
	2030	2050	2100
Operative Scenario for Cres			
Temperature			
Annual	+ 1.8 to + 2.0 EC	+ 1.5 to + 3.3 EC	+ 2.0 to + 5.5 EC
Winter	+ 1.4 to + 1.8 EC	+ 1.2 to + 3.0 EC	+ 1.6 to + 5.0 EC
Spring	+ 1.8 to + 2.0 EC	+ 1.5 to + 3.3 EC	+ 2.0 to + 5.5 EC
Summer	+ 1.8 to + 2.3 EC	+ 1.7 to + 3.9 EC	+ 2.0 to + 6.5 EC
Autumn	+ 2.0 to + 2.2 EC	+ 1.7 to + 3.6 EC	+ 2.2 to + 6.0 EC
Sea Level	+ 18 +/- 12 cm	+ 38 +/- 14 cm	+ 65 +/- 35 cm
Rainfall			
Annual			
Winter	0 to + 3%	0 to + 9%	0 to + 15%
Spring	+ 5 to + 13%	+ 5 to + 18%	+ 6 to + 30%
Summer	+ 14 to +17%	+ 14 to + 30%	+ 16 to + 50%
Autum	- 7 to - 13%	- 6 to - 21%	- 8 to - 35%
	0 to - 13%	0 to - 21%	0 to - 35%

* Local values are related to each degree of global warming