COMMISSION OF THE EUROPEAN COMMUNITIES

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Proposal for a
multiannual research programme in the
field of climatology (Indirect action -
1979-83)

(submitted by the Commission to the Council)

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CONTENTS

0. SUMMARY

0.1. Motivation

The present proposal concerns a EEC Research Programme in Climatology.

This programme proposal is motivated by two basic needs :

(i) To contribute to the understanding of the mechanism of climate and of the causes of climatic variability ;

(ii) To assess the impacts that climatic variability could have on basic European resources, as well as the role that man could be playing in that variability itself.

0.2. Climatic Variability and Man

The assumption of a constantly friendly climate is an unwarranted one, since the climatic variability observed in the past few centuries appears to represent the way in which climate normally behaves.

What is new with respect to past centuries is the great vulnerability characterizing the present society, due to our limited food and water reserves, which allow little or no safety margins to a steadily increasing world population and to our expanding industrial system.

The present society's strong dependence on technological means is also a factor to be taken into account. Technological progress could meet growing needs, but at the same time it would involve an increasingly large use of energy (i.e. an increasing depletion of resources) whilst causing a more intense pollution.

The latter can in its turn affect the natural ecosystems and have adverse effects both on those resources themselves and on climate (e.g. through direct energy input into the atmosphere and through accumulation of such pollutants as aerosols and carbon dioxide).

All this means that we might have to face a kind of climatic barrier to long-term energy growth.

0.3. Present state of knowledge

What we do and do not know about climatic variability can be summarized as follows :

(a) We know that climate is essentially changeable ; we do not know the precise causes of its changes.

(b) We know that climatic changes may occur at any time ; we also know that man might have a role in determining them ; we do not know when or where they could occur.

(c) We know that even relatively small changes might produce important effects ; we do not know the quantitative relationships linking climatic changes to the possible changes in the variables important to man's life and well-being.

0.4. Programme Outline

In order to take into account as many as possible of the main facets of a truly complex problem, and at the same time to concentrate on objectives which are of highest priority in Europe, the following items have been considered for inclusion in the programme. Two research areas have been defined, dealing with

(i) Climate's mechanism and behaviour ;

and

(ii) The interactions between climate and man.

In addition, two "spécial activities" have been proposed, to provide support and guidance to the whole research work to be performed within the present programme.

A. RESEARCH AREAS

I. "Understanding Climate"

The aim should be here to gain a deeper insight into the mechanism and behaviour of climate. Although to truly understand such a mechanism may be as yet a far-distant target, it is felt that efforts should be spent in this direction, in order that ultimately any climatologically-based planning may be put on a firmer basis than empirical guesswork.

I.1. Reconstruction of Past Climates

This should be achieved through the exploration and analysis of

a. Natural Records.

b. Observational and other Historical Records.

I.2. Climate Modelling and Prediction

Work in this area should help towards the ultimate goal of any climate modelling, viz. climate prediction. It is suggested that efforts should be spent to

a. Develop prediction methods based on a system-analysis approach.

b. Improve atmospheric circulation models.

c. Improve the simulation of the slowly varying components of the climatic system.

II. "Man-Climate Interactions"

The emphasis should be here on short-term variability and impacts, with the end in view of arriving at reliable diagnoses and projections.

II.1. Climatic Variability and European Resources

Three major focal points are here suggested :

a. Impacts on Land and Water Resources

b. Climatic Hazards Evaluation

c. Impacts on Energy Requirements, Use and Production

II.2. Man's Impacts on Climate

Chemical and thermal pollution of the atmosphere have been here selected :

a. Atmospheric chemical pollution, with a special emphasis on carbon dioxide accumulation

b. Release of Energy.

B. SPECIAL ACTIVITIES

These are meant to provide specific instruments in support of the previously mentioned research aims.

I. Establishment of an Interdisciplinary Group for the Study of Climatic Impacts

II. Inventory, Coordination and enrichment of European Climatic Data Sets

0.5. Implementation

The programme will be implemented as an indirect action by means of cost-sharing contracts with private and public research organizations in the Member States. This action shall be based on a preliminary effort to coordinate the ongoing research activities in the Member States, which will allow :

(a) to define precisely the projects, complementary to those research activities, which should be financed at Community level ;

(b) to avoid useless duplications ;

(c) to promote the cooperation of scientists active in the field of climatology in the member states.

0.6. Funding

The maximum contribution from the European Communities budget for the 5-year programme is estimated at 8.000.000 EUA to be used to fund research contracts and coordination activities.

0.7. Management

This programme will be managed by the Commission, counselled by an Advisory Committee on Programme Management.

1. INTRODUCTION

Natural climate variations are known to have had a major impact on human civilizations in the past, and their effects have been keenly felt in droughts, badharvests, floods and other extremes and catastrophes in recent years. There exists today no generally accepted explanation of these fluctuations, and there exists no reliable empirical or theoretical method for their prediction. The impact of man's expanding activities on climate also constitutes a potentially grave danger which cannot yet be properly assessed. The urgent need to improve our understanding of climate is widely recognized today and the problem is being addressed by a number of agencies, working groups and research programmes on the national and international level. However, a coordinated European research programme has so far been lacking. It is the view of the Commission that such a programme would encourage new efforts in Europe and provide a valuable contribution to climatic research in general. The motivation for such a programme is outlined in Section 3 of the present proposal.

In the context of this proposal climate is defined as various statistics of the weather averaged over periods of a month or more. It is thus seen that one must distinguish between climate (an averaged state) and weather (an instantaneous state).

The science of weather prediction attempts to predict the detailed state of the atmosphere for the future. Due to our limited knowledge of the state of the atmosphere at any given time (based on many kinds of atmospheric observations of wind, temperature, pressure, humidity, clouds, sea-surface temperatures, etc.) and due to our limited knowledge of the physics of all the atmospheric processes on many scales reaching from the micro-physics of clouds to the macro-physics of global weather phenomena, it is not possible to predict the weather in detail for long periods of time. At the moment, it is generally agreed that the weather, i.e. the detailed state of the atmosphere, cannot be predicted for more than about two weeks. It must also be stressed that one still needs to demonstrate that this goal can be reached.

This state of affairs does not preclude the possibility that the averaged state of the atmosphere (that is climate) be predicted for periods longer than two weeks, although this represents at present an unsolved and very difficult problem. For periods beyond two weeks, the atmosphere can no longer be treated separately from the oceans, land and sea-ice, biosphere, chemical cycles and other components of the climatic system. Because of their large inertia, these components are generally regarded as given constants in routine weather prediction. However, for the longer time scales characteristic of climatic fluctuations the dynamical properties of the climatic system are largely governed by the components with large thermal and dynamical inertia. The proper understanding of the non-atmospheric components of the climatic system then becomes essential.

It should be emphasised that the gaps that exist in our present knowledge do not concern facts, but rather their causes and times of occurrence. Thus no scientist could possibly prove today that such and such disaster is awaiting us at a given date in the future. But science has gathered proofs enough that climate can cause disasters. It is therefore imperative that on one side we refine our means of investigation into the causes of climatic changes so as to reach a point where we can get early warnings of them ; on the other side we should improve our concept of "likelihood of occurrence" by giving it a precise and an as high as possible probability value for specified times and places.

In other words, we have to decide whether we can afford to remain unprepared for likely, serious climatic changes in a possibly near future, or whether we can go on polluting chemically and thermally our atmosphere without minding of the possible consequences on climate. Growing needs may be met by technological progress, but the latter involves a greater use of energy, meaning a greater chemical and thermal pollution of our environment. Should climate be adversely affected by those by-products of technological expansion, we might have to face a kind of climatic barrier to long-term energy growth.

2. PRESENT STATE OF THE ART

The present "state of the art" concerning climate and its relevance to human life may be conveniently treated under two headings :

1. Research activities underway, both world-wide and in Europe.
2. Present state of knowledge about climate and problems raised thereby.

2.1. RESEARCH ACTIVITIES WORLDWIDE AND IN EUROPE

2.1.1. International Projects

During the last decade there has been a significant increase in research on climate on a worldwide basis. The problems connected with the understanding of the present and past climates and the possibilities for predicting future climatic states have not only resulted in significant individual efforts but have also inspired national and international programmes dealing with various aspects of the climate problem.

A truly international programme, the Global Atmospheric Research Programme (GARP), sponsored jointly by the International Council of Scientific Unions (ICSU) and the World Meteorological Organisation (WMO), has among its objectives the study of those physical processes in the troposphere and stratosphere that are essential for an understanding of the factors that determine the statistical properties of the general circulation of the atmosphere which would lead to better understanding of the physical basis of climate.

A number of other climate programmes exist. These have to a large extent been created because of the renewed interest in climate modelling during the last decade induced partly by the possibility of man's impact on climate and partly by the implications of some of the early primitive climate models. A programme especially devoted to the assessment of man-climate interactive impacts is being organized by the WMO.

2.1.2. U.S.A. Projects

The scientific community in the USA has expressed its recognition of the need for climatic research by a well formulated plan for climatic studies during the next decades. The plan is summarised in the book "Understanding Climatic Change, A Program for Action", published by the U.S. National Academy of Sciences (1975).

This plan contains a wide spectrum of projects dealing with a Climatic Data Analysis Programme (CDAP), a Climatic Index Monitoring Programme (CIMP), and a Climatic Modelling and Applications Programme (CMAP). It is further recognised that these essentially national programmes must be seen in an international setting. To further the aims of the climatic part of the GARP programme, it was also recommended to create an International Climatic Research Programme (ICRP).

Another "U.S. Climate Program Plan" has been prepared by a Drafting Group of the Interdepartmental Committee for Atmospheric Sciences. It largely overlaps the former one by covering such topics as Climate Variability and National Activities, Diagnoses and Projections of Short-Term Climate Variability, Climate Data Management, Observations for Climate Research, etc.

An important plan for a Carbon Dioxide Effects Research and Assessment Program has been drawn by the Department of Energy. It aims at removing uncertainties from predicted future carbon dioxide concentration and at assessing its possible consequences, not only climatic, but also biological, social and economical.

There are in addition a number of more specialized programmes which are all closely related to some aspects of climatic research. Because the oceans dominate the climatic behaviour on a long time scale, it is important that the oceanographic community is engaged in those aspects of oceanography which are relevant to climate problems. Examples of such field studies are the Mid-ocean Dynamics Experiment (MODE), the North Pacific Experiment (NORPAX), and a POLYMODE experiment, jointly sponsored by the U.S.A. and the U.S.S.R. Other examples are the Climatic Impact Assessment Programme (CIAP) which was concerned with the impact on the climate by various air pollutants, and the Climate Dynamics Programme of the Advanced Research Programme (Department of Defence, U.S.A.).

2.1.3. U.S.S.R. Projects

Less detailed information is available from the U.S.S.R. about their programme for climatic research but it is known through the GARP planning meetings, that the U.S.S.R. scientists are keenly interested in climatic problems. Indeed, one of the first climatic models was presented by a Russian scientist (Budyko).

2.1.4. Projects in the EC Countries

(a) Climate modelling

It is convenient to separately consider the efforts in the modelling of climate which are made by use of general circulation models (GCMs) and those carried on with models where the weather systems are treated on a statistical basis.

At present, the only GCMs in Europe which can be used for climatic studies are those of the British Meteorological Office (BMO) and the ECMWF.* The BMO models have been applied to long-range prediction, and have been used for analyses of specific circulation anomalies and also for studies of man-made climatic changes. The GCMs at the ECMWF are closely related to and based on models developed in the U.S.A. and are used for medium-range predictions.

There are GCMs under development at the Deutscher Wetterdienst (Offenbach) and in France (Etablissement d'Etudes et de Recherches Météorologiques, Boulogne ; Laboratoire de Météorologie Dynamique, Palaiseau). The Joint Universities Group in Reading has made particular efforts in analysing the behaviour of GCMs which may prove fruitful for an assessment of the reliability of results obtained with GCMs. Ocean circulation models are under development in France (Laboratoire d'Océanographie Physique, Paris) England (DAMPT, Cambridge ; Joint Universities Modelling Group, Reading) and in Germany (Max-Planck Institute, Hamburg).

Some of the parametrized models presented so far in Europe exhibit a certain skill in the simulation and analysis of the present mean state of the atmosphere (Wiin-Nielsen, ECMWF). Some are concerned with the testing of a specific scheme for the parametrization of weather systems (e.g. Imperial College, London). The work at the Max-Planck Institute in Hamburg concentrates on studying the slowly varying parts of the climate system. Simplified models are in the stage of development in France and Belgium (e.g. Laboratoire de Météorologie Dynamique, Paris)

Some of these models concentrate on the study of selected mechanisms in the general circulation and the problem of seasonal prediction has been attacked.

* European Centre for Medium-range Weather Forecast, Bracknell, UK

(b) Reconstruction of Past Climates

Sporadic studies of climate in the historic past have been made in a number of European academic institutions and national meteorological services, and the results have been published in various scientific periodicals and weather service publications. Because the data and techniques for reconstruction of the past climatic record involve many branches of learning, this kind of research appears best done in the full interdisciplinary setting of academic institutions. The advanced computational facilities and expert staff in the laboratories of leading meteorological services, on the other hand, are ideally suited to pursue research of a theoretical nature, such as climate modelling, numerical predictions and the exploration of the potential effects of man's activities on the climate regime.

There is an obvious need for a large amount of co-operation between these two angles of climatic research which is at present (except in the United States) not fully met. Also, disproportionately less work and support has so far gone into the reconstruction of the climatic record : a record that shall be long enough to cover many times the evolution of long-term processes that may be important to prediction over the coming decades.

At present only a few groups and institutes exist in Europe where the observed record of climate beyond 100 years back is worked on by meteorologists. Small groups or individual scientists in the national Meteorological Services and Universities in Europe have recently published papers that indicate activity in this field. One European research unit, the Climatic Research Unit at the University of East Anglia, is almost totally committed to the reconstruction of past climates. The foremost objective of the work in this Unit is the reconstruction of past climates on a global scale with specific attention to the Atlantic/European sectors. The work is largely carried out by a team of atmospheric scientists in collaboration with other scientists at a full multi-interdisciplinary level.

2.2. PRESENT STATE OF KNOWLEDGE ABOUT CLIMATE AND PROBLEMS RAISED THEREBY

The following considerations apply in general to all climatological research throughout the world.

2.2.1. General Research on Climate

Climate is at present understood in its broad characteristics, but we have relatively little knowledge about the major processes of climatic change. In other words, the mechanism of climate is not understood in any detail sufficient for instance to allow climatologists to forecast climatic conditions.

It is therefore essential that the scientific community be allowed to increase substantially the amount of data available about the various components of the climatic system. Without these data, theories would remain largely unchecked and even the best model would be of little use.

Overall available data are so far only fragmentary and do not allow us to decide for example which are the most important causes of climatic variations, or which are the most sensitive of the many processes involved in the interactions of various components of the climatic system.

We also ignore how much of the long-term variations, so far known to have occurred, depends on cyclic regularities (of which the causes should be ascertained), and how much on purely random processes.

All these questions must clearly be answered before we even attempt to consider the ultimate question of climate predictability. This last and all-important problem will be solved only after :

(a) both theory and dynamical models have been further developed and applied ;

(b) the data bases now available have been greatly extended, both in space and in time.

2.2.2. Research on Man-Climate Interactions

When we come to consider the vast and hitherto largely inexplored field of man-climate interactions, the same situation of a poor or insufficient knowledge is encountered. In this case however it is not only a question of a lack of scientific evidence : climatic variability, either natural or man-indiced, may create serious problems for our present economic and social structure.

Our economic and social stability is strongly climate-dependent. The climates of our planet have always been changing, and without any doubt they will continue to do so in the future. What we do not know is how large these future changes will be, and how rapidly they will occur.

A major climatic change would bring about worldwide economic and social readjustments, since the evolution of the global patterns of food production and population has been so far largely controlled by climatic conditions.

At present, world grain reserves are only a few percent of annual consumption ; the occurrence of an unfavourable climatic period, coupled with the increasing food demands of an exploding population, could play havoc. We do not have therefore to wait for a new ice age in order to see our agricultural system devastated. A major social or economical disaster could be brought about by a relatively minor climatic change, such as one of those that have so often occurred, even in the recent past.

Similar considerations apply to water resources, whether we consider them from the standpoint of domestic use, or irrigation, or electric power generation, or industrial use. Here too population growth, the expansion of towns and industrial development are putting an increasing strain on a resource which is already becoming scarce. Thus while unfavourable climatic conditions could make that scarcity greater, one might on the contrary wish that they were favourable in order to cope with demands and build up reserves.

Although we know that water and food resources depend on climate, we ignore the precise relationships defining that dependence in a quantitative way. Hence an urgent need for well-planned scientific research.

The problem is made more serious by the possibility that climate changes may be the consequence of human activities. Man is steadily modifying many of the factors which are known to determine climate. Such modifications may be small, but for climate, in general, there is no *a priori* way of deciding the magnitude of the effect from that of the cause, since positive feedback mechanisms could act as amplifiers of seemingly small initial perturbations.

Man is for instance changing the chemical composition of the atmosphere by all kinds of pollutants, and in particular by burning fossil fuels that steadily increase the concentration of carbon dioxide. Man is destroying forests, which also increases the atmospheric carbon dioxide content while altering the surface albedo and thus affecting the earth's radiation balance. Man is also pouring large quantities of heat into the atmosphere, thus perturbing the planet's energy budget.

2.2.5. Summing up

All this points to a situation which in general terms can be briefly described as follows :

(a) We know that climate is essentially changeable ; we do not know the precise causes of its changes.

(b) We know that climatic changes may occur at any time ; we also know that man might have a role in determining them ; we do not know when or where they could occur.

(c) We know that even relatively small changes might produce important effects ; we do not know the quantitative relationships linking climatic changes to the possible changes in the variables important to man's life and being.

(d) We need therefore to concentrate our efforts towards the aim of eliminating as many as possible of our present uncertainties, so as to avoid as many as possible of the threats that climatic variability may have in store for us.

3. MOTIVATION FOR A CLIMATOLOGY PROGRAMME OF THE EUROPEAN COMMUNITIES

Climate has moved to the foreground of public interest during the recent years, when climatic events of an unusual character have convinced most people that there is no warranty for any assumption of climatic constancy over the span of time for which economic planning is undertaken.

The implications of climatic variability are serious : compared with recent decades, there continues to be a risk for adverse weather conditions, which are to be feared especially for their occurrence during sowing, growing and harvesting seasons.

Many climatic extremes have occurred during the 1960s and 1970s (see Appendix) and the economic and social impacts of some of these have been rather drastic : global grain reserves have dwindled to negligible amounts ; food markets and prices have been upset ; there is now a real threat of starvation to millions of people in developing countries.

Climatic change is therefore not only a subject of theoretical interest : the most compelling reasons for its study are in fact the growing awareness that our economic and social structures are deeply influenced by climate, while man's activities themselves may be able to contribute to climate's instability, possibly in an undesirable direction.

This is true in particular for the EC Countries which are closely interrelated both economically and socially, and which share regional climates extending across political boundaries. Thus any major impact, whether of climatic variability on natural resources or of human activities on climate, could never be limited to any one European country. In this respect it may also be observed that the EC Countries cover an area which has the ideal dimensions for the study of regional impacts, as distinguished from local or microclimatic, and global effects.

Water is one of the most important resources to be considered at Community level. Its replenishment depend on the hydrological cycle, and the latter is one of the main components of the climatic system. The Community's attention is already focussed on water resources, the need having been realised of a much stricter planning and control in view of the economic growth, urban concentration and even deficiency of water in certain areas, threatening to hinder general development, especially of agriculture and industry. The necessity has therefore been recognized of taking account of the interdependence of the various environmental factors, which cannot be managed separately (1).

The Community is also concerned with the protection of particular areas, such as the mountain regions, whose fragility (soil and climate) makes them particularly subject to erosion and various natural disasters like avalanches, landslides and flooding of streams (2). Here again climate comes to the foreground.

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(1) European Community Action Programme on the Environment (1977-1981), Council Resolution of 17 May 1977, OJ N°. C 139, pp. 29-30.

(2) OJ N°. C 139, p. 25

As regards general criteria, the present programme proposal meets the four general objectives of the Community Science and technology policy (1) which are :

(i) the long-term supply of resources ;

(ii) the promotion of internationally competitive economic development ;

(iii) the improvement of the living and working conditions ;

(iv) the protection of the environment and nature.

General criteria (1) are also met : effectiveness (greater efficiency at Community level ; this as regards in particular interdisciplinary studies and data management), transnational nature and common requirements (the satisfaction of needs common to all EC Countries, e.g. as regards environment, resource planning, pollution control, data acquisition, etc.).

Climate research is going on already at the national level in most EC Countries. But, for the reasons explained above, climatology is a field of endeavour where coordinated efforts are most needed. European competences are unevenly distributed, and an EC programme would bring together the best specialists available in each discipline, thus making the best use of their knowledge and experience, besides encouraging present efforts and stimulating new research in a field of growing interest.

It is however understood that, due to the global nature of climate variations, an EC climate programme should be regarded as a contribution to worldwide efforts such as the Global Atmospheric Research Programme (GARP) sponsored by the World Meteorological Organization and the International Council of Scientific Unions, or the World Climate Programme, which is now being planned by the World Meteorological Organisation in collaboration with other international organisations. The first of these two programmes correspond to Research Area I of the present proposal ; the second to Research Area II.

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(1) Common Policy in the field of Science and Technology, "Guidelines", COM(77)283 ; R/1659/77(RECH 16).

4. DETAILED DESCRIPTION OF THE PROGRAMME

4.1. GENERAL REMARKS

Climate may be considered both (i) by itself as one of the many facets of the natural world and (ii) as a part of man's environment, and as such in interactive relationships with man's activities.

On these grounds two research areas have been naturally considered for the present programme, the first having its main emphasis on climate's mechanism, the second on the interactions between man and climate.

In dealing with climate mechanism, under Research Area 1, explicit mention has been made of mathematical models as an obvious means of dealing with the problem. Elsewhere more experimental methods may have been stressed.

It should be understood however that no constraint is put in general on the means whereby a given problem could be solved. Various methodological approaches are in principle applicable to the several research items described later on. They include for instance :

(a) Experimental research ; measurements and monitoring activities ;

(b) Statistical evaluations of climatological records ;

(c) Simulation, diagnosis and projection studies, as regards both long- and short-term climatic variability and impacts.

To properly implement the programme, it has be found advisable to also suggest the establishment of :

(i) a group of climatic experts especially appointed to study the possible impacts due to the interactive relationships between man and climate ;

(ii) a system of data storage, enrichment and management, whereby up-to-date climatic data may be freely and rapidly accessible to all researchworkers concerned

4.2. RESEARCH AREAS

4.2.1. Research Area I : "Understanding Climate"

4.2.1.1. Objectives

The general objective of this research area is that of gaining a deeper insight into the mechanism and therefore the behaviour of climate, the ultimate goal being climate prediction, especially on a usefully short-term (weeks to decades) scale. To achieve that goal it is necessary :

(i) To reconstruct the past record of climate in as much detail, over as much of the Earth and as far back in time as data and interpretative techniques permit ;

(ii) To analyse that record so as to be able to determine the causes of the changes observed ;

(iii) To improve theoretical understanding and knowledge of the development of climate, the circulation processes in the atmosphere and oceans and the interactions involved, and the nature of the impact of external influences.

Clearly these observational and theoretical attacks are closely interlinked and need to be pursued hand in hand, by also taking advantage of data obtainable through research work in Research Area II.

4.2.1.2. Research Themes under Research Area I

I.1. Reconstruction of Past Climates

The past variability of climate on long time scales can provide valuable information on the dynamics of the climate system. Furthermore, in order to obtain reliable statistics, the sampling period of a continuous statistical process should be considerably longer than the fluctuation periods of interest. There is a convincing evidence that climatic changes and variability have been significantly better in the past than in the short period of instrumental observation on a global scale (ca. 100 years). There is also a growing evidence of quite abrupt climatic changes which would be really catastrophic to mankind if they would repeat. For these reasons the analysis of past climates should be an important contribution to the present Programme.

There exists a wealth of unexplored historical information on climate in Europe which should be collected and organized. These include both (a) Natural Records and (b) Observational and other Historical Records.

(a) includes for example fossil types of data such as tree-rings ; year-layers in lake sediments, river estuaries and ice-sheets ; concentrations of stable isotopes of oxygen, carbon, nitrogen etc. in the wood substance of tree-rings and in the ice of ice-sheets ; pollen analysis ; analysis of insects and marine microfaunes in the sedimentary records, etc.

(b) includes for example records of measurements made in the past about meteorological parameters, as well as reported data about floods, frosts, harvests, disastres caused by weather, etc.

Such records should be explored and analysed in such a way as to bring to light the circulation processes in the atmosphere and the oceans, and any external influences (solar, tidal, volcanic or other) which underlied the changes made evident by the records themselves.

I.2. Climate modelling and prediction

The ultimate goal of climate modelling is climate prediction, and it is obvious that society is interested in climatic predictions of time scales from the limit of detailed weather predictions (say, two weeks) to many years. Apart from the immediate relevance to society, this time scale interval is also more promising for theoretical studies than the longer time scales because of the better availability of data.

Studies aimed more specifically at the problem of forecasting climate should therefore be encouraged, and in this context three main possible growth points can be identified :

(a) A System-Analysis Approach

The techniques of system analysis should be used in order to provide extrapolation techniques useful for periods of the order of magnitude of one month.
A technique currently used at present consists in selecting a so-called "historical antecedent" to a present situation from climatic archives.
Assuming the two situations to be identical, they should have an identical evolution. The problem is here to identify and correctly select those parameters that can act as useful predictors of climatic change. The technique of system analysis should be used for the selection of such predictors, with the advantage that the choice would be guided by synoptic as well as by dynamical criteria.

(b) Atmospheric Circulation Models

An attempt should be made at developing numerical models of the atmospheric circulation directed specifically at the problem of climate prediction. Appropriate simplifications of the detailed general circulation models could be guided by the use of special analyses of global atmospheric data and by the existing General Circulation Models. One would in this way develop and test numerical models with relatively few degrees of freedom compared to the detailed GCMs, and perform analyses of atmospheric data relevant to the design of such models. Test cases should include not only "normal" climatic conditions, but also spectacular excursions like the drought in north-western Europe during 1976. Care should be taken to include in such models a proper treatment of the physical processes at the air-land and air-ocean interfaces, a hydrological cycle and a treatment of the upper mixed layer of the ocean.

(c) Slowly varying elements

As the periods of the prediction of the atmosphere become longer, it is almost certain that the detailed atmospheric description will play a lesser role, while the oceans and the other slow-response parts of the climatic system will play a greater role. It has thus been realised recently that prediction models for the longest time scale must concentrate on the evolution of the slowest-response parts. Models of this nature are in their infancy, but give great promise for further development.

One should therefore try to develop models for climate predictions concentrating on the parts of the climatic system with the slowest response (continental ice sheet, deep circulations of the oceans, changes in vegetation and snow cover over land and of drifting sea ice). It will be required to include the physics of the slowly-varying components, their interactions and the specification of the statistical representations of the faster-response components of the system. The models should be tested and attempts should made to make experimental forecasts for 100 years.

4.2.2. Research Area II : "Research on Man-Climate Interactions"

4.2.2.1. Objectives

If one considers short-term needs and impacts, the present one is probably the most important field of research. Recent problems concerning the availability and distribution of food, water and energy have raised the general level of concern about the impacts of climate on man's resources, as well as about the possible impacts of human activities on climate.

The objective of the research work to be performed in this area should therefore be that of assessing in an as precise and quantitative way as possible (1) the relationships between climate variability and the availability, spacewise and timewise, of important resources, and (2) the impacts that certain human activities could have on climate.

The assessment of such relationships and impacts will be typically the result of an interdisciplinary study. For this reason, besides the implementation of specific research projects within the present Research Area, the establishment of an Interdisciplinary Group is proposed (see below under "Special Activities").

4.2.2.2. Research Themes under Research Area II

Since man-climate interactions can be considered both ways, Research Area II includes naturally the following two research themes.

II.1. Climatic Variability and European Resources

(a) Impacts on Land and Water Resources

Climatic variability affects land and water resources in manyfold ways. This clearly applies to such natural hazards as droughts and floods, as well as to surface and ground water demands for energy, domestic and agricultural purposes.

Proper land and water resources management, especially in view of hazard reduction, requires therefore that one is able to obtain a knowledge of the frequency and magnitudes of past and present climatic changes.

Water resource planning is based at present on statistical and probability predictions. Therefore the extension of the historical records concerning run off should allow improved estimates of the probability of future streamflow magnitudes. This kind of information is important in forecasting the availability of domestic water, irrigation water and hydroelectric power.

Research should therefore be focussed on the quantitative relationships between specific changes in climatic variables and the occurrence and availability of surface and ground water. Recharge processes, which are known to be sensitive to climatic conditions, should be investigated in this respect.

Soil moisture and vegetation are mutually linked : the effects of changes in either of these should be studied in relationship to specified climatic conditions.

Rainfall outlooks, limited at present to one month ahead, should also be improved upon and cast in terms of probability or ranges of expected values in order to be properly used. Spatial and temporal correlations, known as teleconnections, should be systematically explored to these purposes.

The agricultural community needs monthly or seasonal rainfall and temperature predictions for the growing season several months in advance, in order to plan crop types, seed varieties and fertilizer needs. Suppliers may need longer times, and government planners and policy makers may want even longer periods, possibly one year in advance.

Extensive new observations of the relevant parameters should be gathered and diagnostically analysed in order to help the construction of new statistical prediction formulas and the generation of further hypotheses for testing with proper models. The highest priority should be given to research aimed at developing yearly projection techniques.

(b) Climatic Hazards Evaluation

A special field of endeavour is the evaluation of the probability of occurrence of such extraordinary yet economically and socially important events as disasters, like floods and droughts, caused by climatic conditions.

Flood hazard planning could be improved by the extension of our knowledge about past flood recurrence, using evidence from the geological records, coupled with the evaluation of changes in the surface run off characteristics.

Similar considerations apply to snow hazards, such as snow avalanches in mountain regions and snow hazards to buildings and communications in regions where snowfalls are normally light or infrequent.

Droughts are also a kind of hazard that properly oriented climatic research could help predicting and being prepared against, especially in view of a proper management of water resources.

(c) Impacts on Energy Requirements, Use and Production

Climate has a profound influence on the amount of power required, and even on the means whereby power is generated (for instance electrical energy from water reservoirs, solar energy in sunny regions). Conversely, power generation and use may affect climate, through thermal or chemical pollution of the atmosphere.

Apart from general climatic effects, a knowledge of the climatic conditions likely to be experienced by any given region is necessary for planning both site selection and plant design and operation. Especially needed is a better capability of relating the dispersion of airborne pollutants, especially those of a toxic kind, with ambient climate conditions. Such information is particularly lacking for irregular zones such as mountain-valley complexes, coastal regions and forest areas.

Besides their relevance to hydroelectric power production, water flow forecasts and precipitation outlooks are important for cooling plants necessary to nuclear and fossil power plants, since about 60% of the energy produced is dissipated as heat. For this reason the rainfall and run off prospects of any given region have a marked influence on energy production.

Finally, climatic forecasts or outlooks have an obvious relevance to the planning of energy production in view of heating and cooling needs.

II.2. Man's Impacts on Climate

It has been recognized that man's activities can affect the climate of the earth, possibly in an unfavourable way. Inadvertent climate modifications are here meant, and among the various possible research fields the following have been selected.

(a) Atmospheric Chemical Pollution, with a special emphasis on Carbon Dioxide release

Direct contamination of the atmosphere is one of the most obvious of man's influences on his environment, one moreover that can have direct effects on climate.

Particles and certain trace gases influence the heat balance of the atmosphere by changing the flux of solar and infrared radiation. Particles are also involved in the initiation of condensation and freezing in clouds.

Among gaseous products, by far the most important for its possible impacts on climate is carbon dioxide, which man has been pouring into the atmosphere since the beginning of the industrial era. Thus CO_2 concentration has increased from about 290 ppm by the year 1860 to about 320 ppm by 1970, that is about a 10% increase in 110 years. But since CO_2 concentration is growing exponentially, the next 10% increase would only take 20 years, and a 100% increase would occur after 50 years, that is by 2020.

Such a doubling of the CO_2 global concentration could effect an increase of the temperature near the earth's surface by about 2°C. Such a warming would constitute a serious climatic modification which could lead to irreversible effects, such as the destruction of the Arctic Sea ice with a drastic shift of all climatic belts northwards. While a disappearance of the floating Arctic sea ice would have no immediate effect on sea level, the possibility of a large-scale surge of Antarctic shelf-ice has been suggested, which would cause a danger of inundations over low coastal regions.

Various hypotheses have to be tested in this connection ; for instance, the earlier assumption of a permanent 50% storage in the ocean and the biosphere of the released fossil CO_2 may be untenable. Increased deforestation may prevent the biological storage of important quantities of CO_2, while the storage in the oceanic upper mixing layer could only last a few decades, because of the low mixing rate with the cold layers below the thermocline. Large amounts of CO_2 could therefore be released by the oceans sooner or later and this process would be intensified by a slow acidification (due to pollution) and warming (due to the "greenhouse effect" of CO_2 itself) of the upper mixing layer. On this basis a fivefold increase in the CO_2 concentration after 100 years cannot be excluded if the use of fossil fuels were to continue unchecked at the present growth rate.

On the other hand, scientists are not unanimous as regards the temperature impact of such an increase. Estimates of the mean temperature rise due to CO_2 vary, and the net temperature change which could result against the observed cooling trend since 1940 is not certain.

It appears therefore that one of the highest priorities in the present Programme should be assigned to the CO_2 accumulation problem in order to assess precisely :

(i) past and present CO_2 concentrations ;

(ii) sources and sinks of CO_2, and their evolution in time ;

(iii) exchange rates between the various compartments of the climatic system ;

(iv) climatic and other environmental impacts.

The assessment of such factors should be arrived at through both applied research and proper modelling. Monitoring should be provided by a number of stations suitably chosen or possibly established to the present purpose.

(b) Release of Energy

Thermal pollution is also a cause for concern, since man is thereby significantly contributing to the energy budget of the earth by burning fossil fuels : coal, gas and petroleum products. The rapidly increasing contribution from nuclear power plants must also to be included in any future projections. For 1970 the global energy production has been estimated at about 6 x 10^{19} cal/year. Distributed evenly over all continents this energy amount corresponds to a small fraction of the net solar radiation at the earth's surface ; but the annual growth rate of energy production has been gradually rising, with an average global increase of about 4-5% annually, according to UN data. This is equivalent to a rise by a factor of 3 to 4 in 30 years. There will be therefore many areas in the world in which the additional energy input will approach the order of magnitude of the natural net radiation. The EC energy output for 1976 can be calculated from EC data (1) to have been 7.5 x 10^{15} Kcal, which corresponds to about 0.6 Wm^{-2}. An assumed growth of 3% per year would bring the average energy output to about 1.2 Wm^{-2} by the year 2000 and to about 5.2 Wm^{-2} by the year 2050, the solar radiation at the earth's surface being about 100 Wm^{-2}. Those being average values, clearly urban and industrial areas would add much more to the natural radiation input. For instance, the value for West Berlin has been about 21 Wm^{-2} during the years 1965 to 1968, and it was already 19 Wm^{-2} for Sheffield in 1952 (2)

The effects of urban and regional heat sources on continental and global climate are however uncertain ; we can speculate that there is a possibility that such areas may sooner or later trigger some changes in the local or large-scale weather patterns. A certain amount of research work should be directed towards the assessment of the possibility and the magnitude of such changes.

4.3. SPECIAL ACTIVITIES

4.3.1. Objectives

The objectives of the work to be performed under "Special Activities" correspond to four basic needs, namely :

(i) to correlate in a panoramic and synthetic view the data collected under Research Areas I and II ;

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(1) Overall Energy Balance Sheets (1963-1976), Statistical Office of the European Communities, Luxembourg, December 1977.

(2) Inadvertent Climate Modifications, SMIC Report, MIT (1971)

(ii) to provide suitable diagnoses and projections concerning climatic variability and impacts ;

(iii) to provide suitable instruments and services for climatological research.

4.3.2. Specific Instruments and Services

(a) A European Interdisciplinary Group for the Study of Climatic Impacts

Scientific disciplines applied to climatological research may be or become so highly specialized that the necessary comprehensive view of the whole may be lost in individual efforts. Yet, due to the highly interactive nature of all climatic or climate-related factors, climatological research is typically one where a panoramic view has to be maintained at all costs. Hence the necessity of establishing an Interdisciplinary Group whose task should be to take care of needs (i) and (ii) stated above. The Group should include a number of European Experts in various disciplines selected on the basis of their relevance to and complementarity in climatological research.

(b) Inventory, coordination and enrichment of European Climatic Data Sets

Climatological research in general and projection studies in particular will require extensive data collections. Various centres in Europe possess or are building up such data collections either from modern observations or from natural or historical records. To make the best possible use of such a work in the frame of the present Programme, it appears essential

(i) that an inventory of the existing European data sets, sources and formats be established and regularly updated ;

(ii) that practical means be devised to favour the exchange of data between the various centres, and their general availability to the scientific community ;

(iii) that new, useful data sets from outside the EEC Member States be acquired.

5. IMPLEMENTATION, FUNDING AND MANAGEMENT OF THE PROGRAMME

This programme will be implemented as an indirect action by means of cost-sharing contracts with private and public research institutions in the Member States. It will be managed by the Commission Services, assisted by an Advisory Committee on Programme Management.

The indirect action should be coupled to an effort to coordinate the ongoing research activities in the Member States, which will allow :

(a) to define precisely the projects, complementary to those research activities, which should be financed at Community level ;

(b) to avoid useless duplication ;

(c) to promote the cooperation of scientists active in the field of climatology in the Member States.

The maximum contribution by the Commission of the European Communities for the entire 5-year period (1979-1983) is estimated at 8.000.000 EUA. The relative distribution of funds between the various parts of the programme will be decided by the Commission and the Advisory Committee after definition of the internal priorities of the programme and examination of all research proposals submitted.

Tentatively the relative distribution of funds could be approximately the following :

Research Area I	: 40%
Research Area II	: 40%
Special Activities	: 20%

The programme will be submitted after two years to review and possible revision on the basis of results achieved and new research needs. Consequently, initial contracts will be limited to a period of 2 or 3 years, subject to extension if warranted. Moreover, considering the transfrontier character of climatic problems, provisions will be made to offer to COST countries to participate in the research programme.

A P P E N D I X

SOME NOTEWORTHY WEATHER EXTREMES SINCE 1960
(courtesy by Dr. T.H. Mörth)

1961	Extraordinary yield of the equatorial rains in east Africa ; the great lakes there rose in a few months to above all twentieth century records.
1962-63	Coldest winter in England since 1740.
1962-65	Driest 4-year period in the eastern United States since records began in 1738.
1963-64	Driest winter in England and Wales since 1743. Coldest winter over an area from the lower Volga basin to the Persian Gulf since 1745.
1964-65	Supposedly ice-free port of Murmansk, on the south coast of the Barents Sea, blocked by the Arctic pack-ice for the first time known.
1964	Snow covered all the uplands of South Africa and South-West Africa in June, the heaviest and most widespread snowfall there since 1895, causing many deaths.
1965-66	Baltic Sea completely ice-covered.
1968	Ice half-surrounded Iceland and stopped shipping for the first time for 80 years, since 1888.
1968-73	Severest phase of the prolonged drought in the Cape Verde Islands, the African Sahel and Ethiopia, surpassing all twentieth century records for length and severity combined.
1968 and 1969	Slow-moving cyclones produced on 4 occasions 2-day rainfalls exceeding the once-in-50-years expectation in several low-land districts of England and Ireland.
1960-69	Driest decade in central Chile since the 1790s.
1969	Lowest frequency of Westerly wind days in Britain for over 109 years, possibly since 1785.
1971	Barometric pressure map for the month of September showed anomalies in three areas (North America, North Atlantic and Siberia) amounting to 5 standard deviations from the average values for the earlier part of the century.

1971-72	Coldest winter of record in parts of eastern Russia and Turkey : River Tigris frozen over in eastern Turkey.
1972	Highest summer temperatures ever observed in northern Russia and Finland : 33°C in Lapland. Greatest drought for many years caused general shortfall of the harvests in Russia and Soviet Asia.
	Number of icebergs (1,587) on the western Atlantic south of 48°N exceeded (by 250) any previous year since records began in 1880.
1973	Great Lakes of North America and Mississippi River at highest level since 1844, following several notably wet years.
	Mexico sharing the drought affecting Africa at the same latitude : the severest drought in central America for many years.
	Snow again in South Africa. First ever report of snow on high ground in Queensland, northeast Australia.
1973-74	Floods beyond all previous reported experience in January, stretching across the central Australian desert to the northwest and east of the continent, ended succession of great drought summers.
1974-75	Mildest winter in England since 1834. Virtually no ice on the Baltic Sea, least ice since perhaps 1652.
1975	Great heat-wave in western Europe about 4-11th August, mean temperatures for the week in the Netherlands and Denmark (about 24°C) exceeding previous highest by over 2°C.
	The Arctic sea ice returned to Iceland for the first time in July in the twentieth century.
1975-76	Great drought in western and central-northern Europe, especially England, where rainfall from May 1975 onwards for 16 months were the lowest since the beginning of the record in 1727.
1976	Great heat in June-early July in western Europe : temperatures over a 24-day period in England exceeding by about 4°C the highest monthly mean in the 300-year record.
	Very cold, wet summer in Russia and parts of Canada.
	Droughts between April and August in a large number of tropical and subtropical areas including Sri Lanka, West Africa and northern Chile, followed by large rainfall excesses in October.
	Similar large rainfall excesses during September and October following the drought in northwestern Europe.
	Tropical cyclones (hurricanes) of extreme severity affecting Madagascar (January-March) and Mexico (October).

PROPOSAL
FOR A
COUNCIL DECISION

adopting a multiannual research programme for the European Economic Community in the field of Climatology (indirect action, (1979-1983)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 235 thereof,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Parliament (1),

Having regard to the opinion of the Economic and Social Committee (2),

Whereas, pursuant to Article 2 of the Treaty, the Community has the task of promoting throughout the Community a harmonious development of economic activities, a continuous and balanced expansion and an accelerated raising of the standard of living ;

Whereas, in its resolution of 14 January 1974 on a first action programme of the European Communities in the field of science and technology (3), the Council stated that the whole range of available ways and means should be used as appropriate, including indirect action ;

Whereas man's economic and social structures are largely dependent on climate ; whereas especially such vital resources as water and food can be seriously impaired by possible adverse climatic conditions ; whereas man himself could contribute by his own activities, and especially by polluting the atmosphere, to climatic instability and even to drastic climatic changes; whereas it is therefore in the Community's interest to promote a better knowledge of the mechanism and behaviour of climate, as well as of the possible impacts of climatic variability in view of a sound planning as far as European resources are concerned ;

Whereas a Community research programme in the field of Climatology is likely to contribute effectively to the achievement of the abovementioned objectives ;

Whereas the Treaty does not provide the specific powers necessary for this purpose ;

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(1) O.J. N°
(2) O.J. N°
(3) O.J. N° C 7 of 29.1.1974

Whereas the Scientific and Technical Research Committee (CREST) has given its opinion concerning the proposal from the Commission,

HAS DECIDED AS FOLLOWS:

Article 1

For a five-year period from 1 January 1979, the Community shall carry out a research programme in the field of Climatology as described in the Annex hereto.

Article 2

The upper limit of expenditure commitments necessary for the implementation of this programme is estimated at 8.000.000 European units of account, the European unit of account being defined by the Financial Regulations applicable, and the number of staff is set at three.

Article 3

The Commission shall be responsible for implementing the programme. It shall be assisted in this task by an Advisory Committee on Programme Management, the terms of reference and composition of which shall be defined in accordance with the Council resolution of 18 July 1977 on advisory committees on research programme management (1).

Article 4

During the third year the programme shall be reviewed ; this review may result in a revision of the programme in accordance with the appropriate procedures after the Advisory Committee on Programme Management has been consulted. The European Parliament shall be informed of the results of that review.

Article 5

The European Parliament shall be informed of the results achieved and the funds used.

Article 6

(1) In accordance with Article 228 of the Treaty, the Community may conclude agreements with other States involved in European

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(1) O.J. N° C 192, 11.8.1977, p. 1.

Cooperation in the field of Scientific and Technical Research (COST) with a view to extending the coordination which is the subject of this Decision to research undertaken in those States.

(2) The Commission is hereby authorised to negotiate the agreements referred to in paragraph 1.

Article 7

The information resulting from the execution of the programme shall be disseminated in accordance with Council Regulation (EEC) N° 2380/74 of 17 September 1974 adopting provisions for the dissemination of information relating to research programmes for the European Economic Community (1).

Done at Brussels,

For the Council

The President

(1) O.J. N° L 255, 20.9.1974, p. 1

ANNEX

A. RESEARCH AREAS

I. "Understanding Climate"

I.1. Reconstruction of Past Climates

Exploration and analysis of :

a. Natural Records.

b. Observational and other Historical Records.

I.2. Climate Modelling and Prediction

a. Development of prediction methods based on a system-analysis approach

b. Improvement of atmospheric circulation models

c. Improvement of the simulation of the slowly varying components of the climatic system.

II. "Man-Climate Interactions"

II.1. Climatic Variability and European Resources

a. Impacts on Land and Water Resources

b. Climatic Hazards Evaluation

c. Impacts on Energy Requirements, Use and Production

II.2. Man's Impacts on Climate

a. Atmospheric chemical pollution, with a special emphasis on carbon dioxide accumulation

b. Release of Energy.

B. SPECIAL ACTIVITIES AND SERVICES

I. Establishment of an Interdisciplinary Group for the Study of Climatic Impacts

II. Inventory, Coordination and enrichment of European Climatic Data Sets

Research work will be carried out by way of contracts.

FINANCIAL DATA

1. BUDGET CHAPTER : 3366

2. HEADING OF THE BUDGET TITLE : Multi-annual R & D programme of the European Communities in the field of climatology (indirect action 1979-83)

3. JURIDICAL BASIS : Article 235 of the EEC Treaty
   Council Decision

4. DESCRIPTION, OBJECTIVES AND JUSTIFICATION OF ACTION

4.1. Description : Research programme on climatic processes and variation, to be carried out by means of shared-cost contracts to be conducted with research institutes in the Member States in the following fields :

Topic 1 : Studies of climatic processes and reconstruction of previous climatic conditions.

Topic 2 : Studies of the effects of climatic variation on certain resources, especially water resources, and on energy requirements.

Topic 3 : Studies of the effects of certain human activities, especially the pollution resulting therefrom, on the climate

Topic 4 : Creation of an interdisciplinary group of experts of the European Community to study climatic impact.

4.2. Objectives :

To establish a greater understanding of climatic processes and solve the problems caused, for major resources, by climatic variations. To help eliminate the risks created by the human exploitation of the environment and by environmental pollution.

4.3. Justification :

There is an urgent need for improved techniques of forecasting the potential effects of climatic variations, especially on water resources and on agricultural productivity. It is also important to evaluate the extent to which climatic change can be induced by human activities.

5. TOTAL FINANCIAL INCIDENCE OF ACTION (in EUA)

5.0. Incidence on expenditure

5.0.0. Total cost during the term envisaged

- on Community budget	8.000.000
- by national administrations	(
- by other sectors at national level	(7.030.900
Total	15.030.900

5.0.1. Multiannual schedule

Commitment

	1979	1980	1981	1982	1983	
Staff	87.100	160.700	169.700	180.200	201.300	
Manag.	30.000	32.100	33.900	36.000	38.100	
Techn.						
Contracts	2.000.000	2.932.500	2.098.400	-	-	
Total	2.117.100	3.125.300	2.302.000	216.200	239.400	

Payment

	1979	1980	1981	1982	1983	1984
Staff	87.100	160.700	169.700	180.200	201.300	
Manag.	30.000	32.100	33.900	36.000	38.100	
Techn.						
Contracts	600.000	2.000.000	2.078.700	1.524.300	609.400	286.000
Total	717.100	2.192.800	2.282.300	1.740.500	848.800	286.000

5.0.2. Method of calculation

a) Personnel expenditure

Needs were assessed on the basis of the officials required for the programme

1979	1 Category A official 1 Category C official	1980 to 1983	2 Category A official(s) Category B official(s) 1 Category C official(s)

Apart from these posts the calculations take account of the parameters set for the purpose of drawing up the preliminary draft budget for the financial year 1979. No increase in purchasing power has been provided for. A change in the weighting applicable to remuneration was the only alteration introduced to take account of the general trend in prices within the Community.

b) Expenditure for administrative and technical operations

They cover travel, mission and meeting expenses as well as the cost of scientific and technical assistance whenever it proves necessary for the implementation of the programme.

c) Expenditure in respect of contracts

Since the nature of the work and the qualifications of the contracting parties vary, it is impossible to introduce a standard method of calculation.

However, the Advisory Committee on Programme Management (ACPM) will always be consulted on the allocation of funds.

d) Multiannual forecasts

The rates fixed for calculating estimates are :
1980-1,07 1981-1,13 1982-1,20 1983-1,26

5.1. Implications in respect of revenue

6. Type of control to be applied

Scientific controls : Management Committees
ACPM
Officials appointed by DG XII

Administrative controls :

Budget implementation : Financial Control

Regularity of expenditure : Financial Control
Contracts Division DGXII

7. FUNDING ACTION

7.0.

7.1.

7.2.

7.3. Funds to be included in future (s) budget (s)