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Proposal for a new COST Action

COST Action 734

Impacts of Climate Change and Variability on European Agriculture: CLIVAGRI

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DRAFT
MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action 734

"Impacts of CLImate change and Variability on European AGRIculture :CLIVAGRI"

The Signatories to this 'Memorandum of Understanding' declaring their common intention to participate in the concerted Action referred to above and described in the 'Technical Annex to the Memorandum', have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of the document COST 400/01 'Rules and Procedures for Implementing COST Actions', the contents of which the Signatories are fully aware of.

2. The main objective of the Action is the evaluation of possible impacts from climate change and variability on agriculture and the assessment of critical thresholds for various European areas.

3. The overall cost of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 15 million in 2005 prices.

4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.

5. The Memorandum of Understanding will remain in force for a period of four years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

TECHNICAL ANNEX

COST ACTION 734

"Impacts of CLImate change and Variability on European AGRIculture: CLIVAGRI"

A. Abstract

The main objective of the Action is the evaluation of possible impacts arising from climate change and variability on agriculture and the assessment of critical thresholds for various European areas. This goal will be achieved through the accomplishment of intermediate aims, in order to define the current and future levels of critical thresholds and hazards for agricultural activity and environmental resources. The Action will concentrate on four different tasks: agroclimatic indices and simulation models review and assessment of tools used to relate climate and agricultural processes; evaluation of the current trends of agroclimatic indices and simulation model outputs describing agricultural impacts and hazard levels; developing and assessing future regional and local scenarios of agroclimatic conditions; risk assessment and foreseen impacts on agriculture and the work will be carried out by four respective Working Groups. The activity of WGs has been structured like a matrix, presenting on the rows the methods of analysis and on the columns the phenomena and the hazards. Each intersection point describes the evaluation of past, present and future trends of climate and thus the impacts on agriculture. Based on these results, possible actions (specific recommendations, suggestions, warning systems) will be elaborated and proposed to the end-users, depending on their needs.

Keywords: climate change, climate scenarios, meteorological hazards, risk assessment

B. Background

Climate plays a fundamental role in agriculture because of its direct and indirect influence on production. Each physical, chemical and biological process determining agricultural activity is regulated by specific climatic requirements, and any deviation from these patterns may exert a negative influence. European agriculture, mainly oriented to production of high quality food, may be more susceptible to meteorological hazard impacts because it is based on highly developed farming techniques.

To define agricultural responses to climate, studies can be based on the application of agroclimatic indices and simulation models. They can be used to describe the effect of climatic conditions on key agricultural aspects, including production, protection, fertilisation, site selection, watering, etc. Their application requires data with different time-steps, depending on the processes. For pests and disease, hourly data are required, whereas growth, development and production responses can be derived from daily values.

The evaluation of climate impacts can be performed both on past and future data. There are different ways to analyse past climate, such as the use of historical data, remote sensing and re-analysis. Historical weather data are available from several meteorological services and institutes. Direct use of these data is not possible because of the need to apply time series analysis. Sometimes data validation takes a great deal of time, compromising the effective realisation of analysis. Remote sensing can be a valid alternative. In particular, Earth observation images show the world through a wide-enough frame so that complete large-scale phenomena can be observed. Finally, re-analysis projects reproduce historical global-scale atmospheric circulation over decades by analysing various meteorological observation data.

Scenarios are the best instruments by which to analyse future climate conditions. They are a simplified description of how the future may develop. Scenarios are neither predictions nor forecasts, but they are derived from projections. However, climatic effects can differ considerably in different regions. Thus, global average values are not adequate to quantify the potential hazard at the regional level. To simulate climatic variability and extreme events, depending on small-scale effects and influenced substantially by topography and geography, high-resolution downscaling techniques are of central importance. They are applied both on re-analysis and future scenarios and allow the users to obtain information at the meso-scale and local scale, where the impacts on agriculture are more evident and assessable. With this in mind, the use of numerical weather models can be very important because of their ability to simulate meteorological conditions on a small scale.

There is significant evidence that regional variation in climate, particularly the rise of temperature, have already affected agricultural systems in Europe, increasing hazard impacts. Examples of observed changes include the lengthening of the growing season, latitudinal and altitudinal shifts of plant range, earlier flowering, outbreak of plant diseases, acceleration in breakdown of organic matter in soils, and emergence of insects. With respect to the latter for instance, between 1964 and 2004 in England, a 1°C increase in temperatures is associated with a 16-day shift earlier in the first appearance of the peach-potato aphid and a 6-day advance in peak flight time of the orange tip butterfly. More frequent precipitation and more humid conditions favour the spread of diseases. The highest intensity of rainfall reduces the infiltration of water in the soil, decreasing the net available soil water content.

Sometimes climate variability can exceed a defined threshold determining an extreme event. The perceived severity of that event depends on the vulnerability of the natural environment and human society. These events cause very extensive or local hazards, always with high intensity: drought, frost, windstorm, heat wave, cold injury, fire, heavy precipitation, flood, snow, wind and hail. The importance of extreme events is due to their capacity to cause serious damage in very short time ranges. For example in the late 1990s, a drought that affected the central and the southern parts of Spain caused losses of more than EUR 800 million in the cereal, olive oil and livestock sectors (more than 50% of the total value of these fields). The impact of summer 2003 heatwave and drought on agriculture and forestry (potato, maize, wheat, fodder, poultry) caused EUR 4-5 billion losses in Italy, EUR 1.5 billion in Germany and EUR 4 billion in France. On this basis it is possible to show that variation in climate can affect the complex agriculture-climate system by influencing its main biological, chemical and physical elements. Therefore all management and planning aspects of agricultural activity have to be considered and adapted to climate change and variability with specific short- and long-term strategies with respect to crop protection, watering, fertilisation, plant breeding, production, site selection, etc.

The European agricultural community demands more evidence of climate change and variability. Consequently the assessment of meteorological hazard impacts on agriculture represents a fundamental goal for European researchers that require objective evaluation of current and future climatic conditions by using, harmonising and integrating all the available data, methods and technologies. Risk assessment, definition of warning systems and addressing specific recommendations and evaluations for policy makers, extension services, farmers and other users are crucial for Europe, considering the role of agriculture in the economy of the European Union (Agenda 2000). These activities also have to take into account other applications; for example increasing the quality of agricultural production, the development of sustainable agriculture and the protection of natural environmental resources.

The previous COST Action 718: Meteorological Applications for Agriculture (terminated in August 2005) highlighted some of the previous requirements and gaps to be filled. In particular, the conclusions during the last COST Action 718 meeting in Geneva, from 15 to 18 November 2004, jointly with the WMO-CAgM (World Meteorological Organisation-Commission for Agricultural Meteorology) expert team on Weather, Climate and Farmers, pointed out that agro-meteorologists should help users (policy makers, farmers, etc.) make the transition from 'passive acceptance' of climate change and variability by providing them with suitable information and know-how in order to make an active response. Moreover, both agro-meteorologists and users should realise as soon as possible that the past may no longer be a good guide to the future. The final recommendation emphasised the need to take into account modifications arising from climate change and variability.

This called for a new effort in analysing the impact of climate change and variability on European agriculture (focusing on the quality of crop production and including eco-environmental aspects) and it is necessary that the relevant scientists cooperate on a regular basis. It is thus evident that for such a multidisciplinary task, a COST Action provides the best framework to achieve an integrated approach and also exploit activities currently performed at national and international levels in this field. The wide-ranging participation of experts in the realisation of this MoU, and others expressing their interest in joining this COST Action, indicate a well-established European network which is critical in providing the users with internationally acknowledged hazard impact assessments of climate change and variability. The domain of COST Meteorology is also the most suitable because of the availability of relevant data, schemes and climate model outputs from national meteorological services and meteorological institutes as well having several previous Actions dealing with related issues.

It is also important to point out that many of these experts are also involved in some of the other activities described below. A COST Action will assure a fast and streamlined flow of information with regard to results of research activities from regions not directly involved in the project. Therefore, European efforts in this field will be valorised, providing a relevant and efficient way of information dissemination. Specific joint meetings (as indicated in Section G Dissemination plan) will be also organised between this COST Action and the other international activities to present the state-of-the-art and progress in the field of climate change and variability impacts on agriculture.

The European Union also supported other activities in this field within the last R&D Framework Programmes. For instance, projects (Seamless, Ensembles, Carboeurope, Amma, Quantify), networks (Claris) and Streps (Dynamite) are used to support research activities in Europe. Climate change is also one of the DG Environment priorities for 2005: "to contribute to the long term objective of stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (i.e. man-made) interference with the climate system". Therefore, considering the continuous interest demonstrated by European agricultural and environmental end-users, the commitment demonstrated by past and current COST Actions, the multiplicity of involved countries and the links with ongoing activities, the international platform to develop this COST Action and to fulfil its goals is ensured.

Finally, this COST Action will be connected with other projects, also exploiting the simultaneous participation of experts in these activities, organised in the frame of:

- EUMETSAT (the European Organisation for the Exploitation of Meteorological Satellites) with its SAF (Satellite Application Facilities) activities on climate monitoring, numerical weather prediction, and land surface analysis, as well as with GRAS (Global Navigation Satellite System Receiver for Atmospheric Sounding).
- WMO with the projects CLIPS (Climate Information and Prediction Services), WAMIS (World AgroMeteorological Information Service) and OPAG (Open Program Area Groups), as well as with the activation of INSAM (the International Society of Agricultural Meteorology).
- THORPEX, an international research programme to accelerate improvements in the accuracy of 1-day to 2-week high-impact weather forecasts.

C. Objectives and Benefits

C.1 Objectives

Main objective

The main objective of the Action is the evaluation of possible impacts from climate change and variability on agriculture and the assessment of critical thresholds for various European areas.

Particular attention will be devoted to the quality of production, which represents the main goal of European agricultural policy, but also to the eco-environmental impacts. The results will be made readily available in order to significantly enhance awareness in the agricultural sector of the current hazard level and the perspectives related to the next few decades. Risk maps, graphics, tables, etc. will be used to provide the requested information to end-users. The sensitivity, adaptive capacity and vulnerability of several European agriculture areas (chosen depending on climatic data availability, crop diffusion, etc.) will be evaluated to provide the users with all the information needed to adapt their strategies to current and future climatic conditions. This covers the fields of farmer activity, public and private extension services and especially policy-maker decisions on short- and long-term bases. Also, the insurance sector is interested in this analysis, in order to evaluate future aspects of insurance (e.g.. compulsory, social, etc.) and premium levels. Finally, plant-breeder activity will be oriented according to the evaluated hazard levels and their forecasted variations. Evaluations will be specified depending on the requirements of the target.

Secondary objectives

- The collection and review of existing agroclimatic indices and simulation models to assess hazard impacts on various European agricultural areas relating hazards to climatic conditions.
- Building climate scenarios for the next few decades.
- The definition of harmonised criteria to evaluate the impacts of climatic change and variability on agriculture.
- The definition of warning systems guidelines.

C.2 Benefits

Currently there is a need to integrate the knowledge and experience available at the European level concerning the analysis of climatic hazard impacts on agriculture. Extensive investigations have been performed to analyse this topic (both research projects and working group activity), but a wide variation in the results and uncertainty in the quality of future climate scenarios, make definite conclusions difficult to draw.

The activity planned in the frame of this COST Action is oriented to fill these gaps, collecting and integrating European activities in this field, providing the end-users (policy makers, extension services, farmers, etc.) with a reliable definition of current and future impacts for sustainable agriculture and conservation of the environment. Moreover, this COST Action allows the dissemination of information in areas not directly involved in other European activities in this field.

There will be a range of specific benefits, such as:

- Provision of an authoritative forum for the discussion of an adequate and reliable evaluation and assessment of climate change and variability impacts on European agriculture.
- Collection of historical climatic and hazard impacts data at the European level, for a reliable and homogeneous definition of the current impact on agriculture arising from climate change/variability and hazards.
- Identification of a series of indices and simulation models to evaluate the relationships between changed climate and agriculture.
- The assessment of past, present and future climatic impacts to provide farmers and the extension services with all the information needed to face the changes

and the increase in interannual variability, for the adaptation of the agronomical and technical aspects of production.
- Recommendations and assessments of critical thresholds to encourage European policy makers to implement suitable legislation in the field of climate change mitigation and adaptation to minimise impacts on agriculture and the environment.
- Provision of information on hazard impacts in the context of climate variability and change, so that users can base their short and long-term actions on the state-of-the-art and on harmonised information.
- Definition of early warning systems to provide recommendations for the future use of meteorological and hydrological information at different levels of agricultural decision making.

D. Scientific programme

The process of analysing the impacts of climate change and variability on agriculture will address the following issues:

- Determination of the possible change and variability of climate patterns in European regions with related uncertainties.
- Collection and review of agroclimatic indices and simulation models used to assess the impacts of climate and hazards on agriculture processes.
- Establishment of analysis methods (definition of frequency, intensity, trend, etc.).
- Assessment of required resolution (spatial and temporal) for practical agroclimatological applications.
- Analysis of trends of agroclimatic indices and simulation model outputs based on the application of past, present and future climatic conditions.
- Evaluation of the impacts on agriculture.
- Addressing the specific needs of decision makers, extension services, farmers and the other end-users to define the hazard impacts on agriculture, by defining recommendations, suggestions and also early-warning systems.

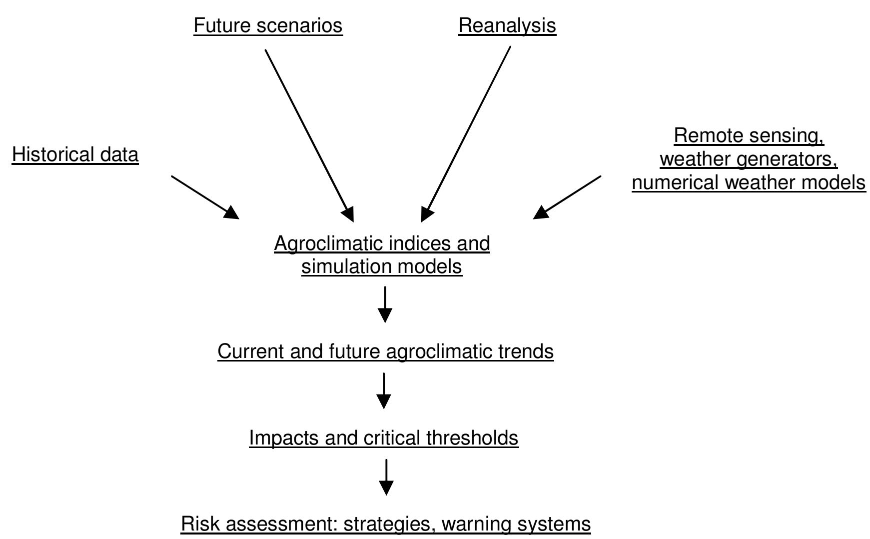

Figure 1. Scientific programme.

The complexity of the proposed activities is evident considering the range of meteorological hazards and climatic conditions, the multidisciplinarity of the cause-effect relationships, the wide range of analysis methods, the possible impacts on various aspects of European agriculture and the host of reduction tools. Accordingly, the above-listed topics will be addressed by four Working Groups (WG):

WG1 - Agroclimatic Indices and Simulation Models: this WG will review and assess the tools used to relate climate with agricultural processes.
WG2 – Evaluation of the Current Trends of Agroclimatic Indices and Simulation Model Outputs describing Agricultural Impacts and Hazard Levels.
WG3 – Developing and Assessing Future Regional and Local Scenarios of Agroclimatic Conditions.
WG4 – Risk Assessment and Foreseen Impacts on Agriculture.

The activities of the WGs have been structured like a matrix, presenting on the rows the methods of analysis and on the columns the phenomenon and the hazards (see Table 1 as an example). Each intersection point describes the evaluation of past, present and future trends of climate and thus the impacts on agriculture. Based on these results, possible actions (specific recommendations, suggestions, warning systems, etc.) will be elaborated and proposed to the end-users, depending on their needs.

Table 1. Example of a Working Group activity

	Seasonal shift	*Frost risk*	*Drought*	*Etc.*
Time series analysis	Anticipation of budbreak	Delay of late frost and increasing of its temperature	Reduction of water storage in the soil at the end of winter	
Remote sensing	Modification of NDVI patterns		Determination of drought risk areas	
Future climate scenarios	Latitudinal and altitudinal plant shift	Increase of risk due to the simultaneous anticipation of budbreak and delay of frost event	Widening of areas subjected to dry conditions during spring and summer	
Etc.				

WG1: Agroclimatic Indices and Simulation Models

Agricultural activity is strongly related to climatic variables that are the main causes of the year to year variation of quantity and quality of production. Physiological processes (respiration, photosynthesis, transpiration), as well as growth and development are influenced by the patterns of each climatic variable and their combination diurnally, monthly, seasonally and annually. The direct consequence is differences in the success of cultivation, and profit for the growers.

To determine the relationships between climatic conditions and agricultural systems, several indices and simulation models can be used. In this way information can be obtained concerning the chemical, biological and physical relationships among the system components. At the same time this knowledge can be applied to manage the system with respect to irrigation, crop protection, harvesting, fertilisation, etc.

Simulation models and indices describe the effect of climate on a specific crop and a specific process (phenological development, growth, damage on production, disease development, water balance). Concerning climatic impacts, the activity of this WG will mainly address the following hazards, directly or indirectly arising from atmospheric conditions: rainfall, flood, frost, drought, hail, heatwave, seasonal shift (length of growing season, budbreak), change in pest and disease, fire, wind and snow. Their evaluation will be done according to the characteristics of each crop in terms of seasonal development, characteristics of production, cultivation methods, etc. General descriptions can also be obtained, such as the number of frost days during the year, total precipitation, length of dry period, etc.

Deliverables

Key deliverables of WG1 will be:

- a review and assessment of agroclimatic indices and simulation models relevant for various European agricultural activities;
- a collection of agroclimatic indices and simulation models and their relationships with specific crop responses;
- the identification of model outputs and index thresholds relevant to evaluate the responses of crops to climate change and variability.

WG2: Evaluation of the Current Trends of Agroclimatic Indices and Simulation Model Outputs describing Agricultural Impacts and Hazard Levels

The last few decades have been characterised by a variation of climatic conditions. Both mean values and statistical variability have been affected. Current trends can be described using both re-analysis data and collecting historical series of ground-level data. A specification of data requirement will be provided by WG1 and WG4, from the perspective of defining the responses of specific crops and characterising the underlying biological, chemical or physical processes. Spatial and temporal resolution of data will be assessed in order to evaluate possible application on the local or global scale.

Agroclimatic indices and simulation models will be applied and the results will be analysed to define past and present trends of climate in various European agricultural regions. Probability levels will be determined in order to evaluate the statistical significance. Available data will be analysed for the whole series, but also sub-periods (decade) will be taken into account to evaluate the presence of trends during shorter periods. Statistical analysis will be carried out to precisely quantify the probable variation of agroclimatic conditions and critical thresholds and to determine their significance. At the same time, the modification of interannual variability will be analysed. In this case the whole series will be divided into shorter periods (decade, five-year period), also using the moving average method, and the mean and deviation patterns will be calculated. Thus, the trend of these patterns during the whole series will be considered in order to evaluate increasing or decreasing trends of hazards.

Time-series statistical analysis will be also performed to evaluate the homogeneity of the historical data and to precisely separate the climate change effect from other sources of variability (cyclical variation of climate patterns etc.). Numerical weather models can be used to provide small-scale data, according to the geo-topographical conditions of studied agricultural areas. The possible application of weather generators and the support of remote sensing techniques, such as atmospheric temperature observed by satellite, vegetation cover/indices, will be also taken into account in order to develop and complete WG2 planned activity.

Deliverables

Key deliverables of WG2 will be:

- a collection of climatic data for several European regions according to agroclimatic indices, simulation models and hazards;
- verification of data and solving of problems arising from missing, non-homogeneous and erroneous data;
- assessment of required resolution for practical agroclimatological applications as a function of variables, areas and agricultural aspects;
- definition of statistical protocols to analyse the climatic series, in order to evaluate mean and variability patterns;
- determination of current trend of agroclimatic indices, simulation model outputs and hazards;

- determination of interannual variability of agroclimatic conditions.

WG3: Developing and Assessing Future Regional and Local Scenarios of Agroclimatic Conditions

Climate modelling continues to be a rapidly growing field of science. Although useful attempts with simple climate models were made with early computers, it is only during the last two decades or so that computers have been powerful enough for coupled atmosphere-ocean models to be employed for climate prediction. Their results have been sufficiently comprehensive and credible to be taken seriously by policy makers. Climate models that have been developed are probably the most elaborate and sophisticated of computer software developed in any area of natural science. As the power of computers increases it becomes possible to investigate the sensitivity of models by running a variety of ensembles that include different initial conditions, model parameterisation and formulations.

Climate projections are now available based on several variables, such as emission/concentration/radiative forcing, which themselves depend on assumptions concerning, for example, future socio-economic and technological developments, population number, deforestation, land use, etc. On this basis several climate scenarios have been proposed, representing a plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that have been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models.

WG3 activity will be developed on this outline, collecting the future scenarios over European regions according to WG1 and WG4 output. The analysis will be centred on the available scenarios, also depending on their spatial and temporal resolution. Agroclimatic indices and simulation models will then be applied to available data, in order to obtain a description of future change (frequency, intensity, trend) in climatic and hazard impacts on agricultural activities (crop protection, watering, site selection, etc.). The forecasts will be limited to the next few decades, with the aim of increasing the reliability of the simulations.

Deliverables

Key deliverables of WG3 will be:

- collection of future climate scenarios for various European regions according to agroclimatic index and simulation model characteristics;
- assessment of future trends of climatic conditions and hazards;
- evaluation of climate scenario reliability according to the current situation.

WG4: Risk Assessment and Foreseen Impacts on Agriculture

At the beginning of this COST Action activity, WG4 will focus on the harmonisation of criteria to evaluate the possible impacts from climate change and variability on agricultural activity. These criteria will be disseminated to the other WGs. Afterwards, on the basis of the results obtained by WG2 and WG3 the current and future trends of agroclimatic indices and simulation model outputs will be analysed in order to evaluate the hazard levels for agriculture and the possible consequences for natural resources. Consequences in terms of production quality and quantity, biological and physical damages and seasonal changes will be mainly considered. Risk assessment will be carried out bearing in mind that European agriculture is based on highly developed farming techniques, where the sensitivity to climatic hazards is greater than in traditional farming. Critical thresholds will be determined according to the characteristics of agriculture in European agricultural areas.

Based on this, possible modification of crop protection methods, irrigation programmes, cultivation techniques, harvesting, storage and commercialisation strategies will be evaluated. Economic aspects will also be considered. Appropriate links and interfaces will be established with agronomists, plant pathologists, economists, etc. and related international scientific societies to better assess the required adaptations.

Results will be analysed with a view of implementing support systems based on information technologies to disseminate advice and early warnings to the potential users: policy makers, extension services, farmers, plant breeders. Insurance companies are interested in the results of these analyses and they will be involved in the evaluation of future perspectives of agricultural risk insurance. Risk maps and other methods (graphics, tables, etc.) will be produced to provide end-users with a detailed description of current and future impacts.

Deliverables

Key deliverables of WG4 will be:

- standardisation and harmonisation of criteria to evaluate the impact of climate change and variability on agricultural activity;
- determination of the current and future impacts on various European agricultural areas;
- determination of critical thresholds;
- formulation of specific recommendations and assessments for policy makers, extension services, farmers and other end-users;
- definition of warning systems.

E. Organisation

This Action deals with a multidisciplinary issue being performed at national and regional meteorological and hydrological services (NMHS), research centres and universities in Europe that will require a sufficient period to establish procedures for cooperation and to identify and prioritise the various activities and needs.

The planned activity will be structured in four separate WGs, but three main phases can be identified for all of them. The overall time plan will be as follows:

Phase A: Planning, operational arrangements, establishment of WGs and inventory (first part of Year 1)
Phase B: Main scientific work to be conducted by each WG (end of Year 1 to end of Year 3)
Phase C: WGs activities to be concluded with emphasis on disseminations, reports and final publications (Year 4)

During the first year, the Management Committee (MC) will supervise the establishment of the WGs. The participants will specify their contributions and goals through the Expression of Commitment scheme developed by the Technical Committee for Meteorology. Four WGs will be established, broadly developing the research areas described in Section C.

During Year 2, the detailed work programme for the Action will be established by the participants. The opinions of the wider community will be sought through its participation in the first workshop to set up the detailed work programme. At this stage the preliminary results and plans will be discussed and the activities and membership of WGs will be finalised. Over the main period of work, interactions between the WGs will be firmly established so that they will work in synergy rather than independently, eventually coming together in the final phase (last year) during which the research will be completed, integrated, peer reviewed and published. Aspects of the activity will be also presented in workshops, meetings, etc. and published at national and international level during the intermediate period. During the final phase, joint recommendations of the WGs will be published as a final report for wide dissemination. Particular attention will be paid to the dissemination of the results, in order to reach policy makers, farmers and technicians through technical and professional publications.

The MC and WGs will meet twice a year, usually in conjunction with each other. An observer from the TC will be appointed to monitor the planned activities and outputs. WG and expert meetings may be organised on different occasions, according to specific aims. Each WG will be coordinated by a chairperson who will report back to the MC. Coordinators will also be allocated for each sub-area of the WGs. When required, external experts will be invited to MC and WGs meetings to seek advice and/or enlarge the application basis of the Action. Each WG will have between 8 and 10 members, which is suitable for efficient management. The MC will supervise the overall progress of work, link and coordinate WG activities in a way that the information, the needs and the results of each WG will serve as input to the others, and will ensure wide dissemination of results. The MC and the four chairpersons of the WGs will constitute the leading structure of the action. Short-Term Scientific Missions (STSMs) will be used to maximise the exchange of experience among the participants.

A Website will be created as soon as possible after the start of the Action and be updated in a timely and continuous manner to serve as an information management tool, act as a focus for information exchange and as a medium for disseminating the results of the Action.

The three phases of the Action with the main milestones of the planned WG activities are described below. However each phase will probably overlap with others.

Phase A: Inventory (Year 1,, 9 months)

MC	Establish initial WGs and membership and define initial work
	Identification of end-user needs
	finition of European agricultural areas as the focus of this COST Action activity depending on data availability, crop diffusion, etc.
WG1	Critical review of agroclimatic indices and simulation models and assessment of the new needs
WG2	Inventory and collection of current climatic information from European regions
WG3	Inventory and collection of future climatic scenarios
WG4	Definition of standard criteria for the evaluation of hazard impacts on agriculture in Europe
All WGs	Report to MC

Phase B: Development, Assessment, Applications and Evaluation (end of[1] Year 1, all Year 2 and Year 3, 27 months)

	First workshop with proceedings with the presentation of the preliminary work programme of the Action
	Establish final WGs and preparation of detailed plan of work based on outcomes of Phase A
All WGs	Regular WG meetings for planning, implementing, reviewing and synthesising the work
	Report to the MC every 6 months on the progress of work
MC	Short-Term Scientific Missions as appropriate
	Preparation of final workshop
	Monitoring of WG activities and advances in the field outside the Action
	Dissemination of results through publications and participation in international conferences
	Preliminary definition of final report structure

Phase C: Synthesis and Dissemination of Action results (Year 4, 12 months)

WG4	Risk assessment and climate hazard impact evaluation on various European agriculture areas, and specific recommendations to policy makers, extension services, farmers and other end-users
All WGs	Finalisation of the expected outputs
All WGs	Contributions to the final report
MC	Final workshop with the proceedings, and presentation of the conclusions of the Action, especially to end-users

MC Completion of the final report

MC Dissemination of results through publications and participation in international conferences

F. Timetable

The overall duration of the Action is 4 years, as described in Table 1.

Table 1. Overall timetable

	Year 1				*Year 2*				*Year 3*				*Year 4*			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Phases	A	A	A	B	B	B	B	B	B	B	B	B	C	C	C	C
MC meetings	X		X		X		X		X		X		X		X	
WG meetings			X		X		X		X		X		X		X	
WG reports					X		X		X		X		X		X	
Reports to TC				X				X				X				X
Final report																X
Workshops							X								X	
Website	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

G. Economic dimension

The following countries have actively participated in the preparation of the Action or have otherwise indicated their interest: Bulgaria, Czech Republic, Cyprus, Denmark, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Romania, Slovenia, Spain, United Kingdom. Also the World Meteorological Organization (WMO) and the Food Agricultural Organisation (FAO) have expressed their interest in participating and collaborating in this COST Action. On the basis of national estimates provided by the representatives of these countries, the economic dimension of the activities to be carried out under the Action has been estimated, in 2005 prices, at roughly EUR 15 million.

This estimate is valid on the assumption that all the countries mentioned above, but no other countries, will participate in the Action. Any departure from this will change the total cost accordingly.

H. Dissemination plan

One of the main aims of the Action is the dissemination of the results in order to provide the end-users (policy makers, extension services, farmers, etc.) with consistent risk assessment based on harmonised data for European agricultural areas, therefore the results of the Action will be disseminated using a wide range of methods. These will include a dedicated Website, COST reports, conference presentations, peer-reviewed publications and advanced training schools for users. Particular attention will be paid to informing decision makers and to transmitting results to the scientific community. This will apply to both those using these methods and those who might have an application for these methods. In the way dissemination will not be limited to the presentation of what has been achieved during the COST Action, but will focus rather on the precise evaluation of climate change and variability impacts on agriculture and environment, and consequently on a definition of current and future hazard levels and critical thresholds.

Publication of the results of the Action will be of two types: scientific papers and technical manuals. The first should be promoted and encouraged by the MC in terms of co-authored papers in international journals and reviews. This will acknowledge the scientific value and justify COST support. The second will be a very useful mechanism to disseminate the results to the recipients and particularly the NHMSs, the agriculture research institutes, the agricultural extension services and public administrations responsible for land planning. This will allow these users to put into practice the procedures and protocols established by the Action through specific well-organised guides.

Direct links will be established with the European Union (relevant DGs, e.g., Research, Environment, Agriculture), existing European networks (Eumetnet – the network of European Meteorological Services), projects (MARS project) and bodies, and also with WMO and FAO. Links will also be established with national and international societies interested in problems of agriculture and climate change and variability (European Society of Agronomy, International Society of Biometeorology, European Meteorological Society, etc.). Every year, during the meeting of the MC and WGs, international agencies involved in the fields of the COST activity, and representatives of the users, will be invited to exchange information and to coordinate and develop synergies and collaborations.

Organised workshops will also be a means for disseminating the results especially among potential users and for promoting COST activities in Europe and worldwide. Special efforts will be made to invite external keynote speakers and to publicise the workshop outside the Action. Wherever possible the Action will host workshops jointly with other international meetings. These will include:

- European Meteorological Society annual meeting
- European Conference on Applied Meteorology
- European Conference on Applied Climatology
- International Congress on Biometeorology
- European Society of Agronomy congress and workshop.

COST Action 734

“Impacts of Climate Change and Variability on European Agriculture: (CLIVAGRI)”

ADDITIONAL INFORMATION
NOT PART OF THE MoU

List of project acronyms
SEAMLESS: System for environmental and agricultural modelling; linking European science and society
ENSEMBLES: Ensemble-based predictions of climate changes and their impacts.
CARBOEUROPE: Assessment of European terrestrial carbon balance
AMMA: African monsoon multidisciplinary analysis
QUANTIFY: Quantifying the climate impact of global and European transport systems
CLARIS: A Europe-South America network for climate change assessment and impact studies
DYNAMITE: Understanding the dynamics of coupled climate system

History of the proposal
Current and past COST Actions deal with the topic of meteorology and climatology and their relationships with agricultural activities and land management. In particular, COST-718 (Meteorological applications for agriculture), COST-719 (The use of geographic information systems in climatology and meteorology), COST-725 (Establishing a European phenological data platform for climatological applications) are now in progress. Earlier, COST-77 (The application of remote sensing in agrometeorology), COST-79 (Integration of data and methods in agroclimatology) and COST-711 (Operational applications of meteorology to agriculture) dealt with related topics.

Preliminary working plan
The activity of the Action will be structured in the following three main phases: Phase A: Inventory (First part of 1st Year); Phase B: Development, Assessment, Applications and Evaluation (End of 1st Year to end of 3rd Year); Phase C: Synthesis and Dissemination of Action results (4th Year). However, it is supposable that each phase will probably overlap with the others. The four WGs will start simultaneously at the beginning of the action under the supervision of MC. Then during the four years of the Action, WG activity will be evaluated by MC, also considering annual reports. A leading structure, including the four chairpersons of the WGs will constitute the leading structure of the action. In order to assure the dissemination of information, a WEB site will be created as soon as possible after the start-up of the Action and be updated in a timely and continuous manner. Dissemination of the results is one the main aim of the action. COST reports, conference presentations, peer-reviewed publications and advanced training schools for users will be used.

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Related publications

Alexandrov, V.A., Hoogenboom, G., 2000. The impact of climate variability and change on crop yield in Bulgaria. Agricultural and Forest Meteorology, 104, 315-327.
Antle, J.M., 1996. Methodological issues in assessing potential impacts of climate change on agriculture. Agricultural and Forest Meteorology, 80, 67-85.
Bindi, M., Olesen, J.E., 2002. Agricoltura e cambiamenti globali, estratto delle Problematiche dell'agricoltura italiana. Scenari possibili n°6. Agricoltura e salvaguardia dell'ambiente: analisi e proposte per un'agricoltura sostenibile. Accademia Nazionale di Agricoltura, Consiglio Nazionale delle Ricerche, Bologna.
Bindi, M., Fibbi, L., Gozzini, B., Orlandini, S., Miglietta F., 1995. Mini Free Air Carbon Dioxide Enrichment (FACE) experiment on grapevine. In: "Climate change and agriculture in Europe: Assessment of impacts and adaptations", a cura di HARRISON P. A.,

BUTTERFIELD R. E., DOWNING T. E. Research Report N°9 to the Commission of the European Union, Contract EV5V-CT93-0294, 125-137.
Bindi, M., Fibbi, L., Gozzini, B., Orlandini, S., Miglietta F., 1995. Effects on grapevine. In: "Climate change and agriculture in Europe: Assessment of impacts and adaptations", a cura di HARRISON P. A., BUTTERFIELD R. E., DOWNING T. E. Research Report N°9 to the Commission of the European Union, Contract EV5V-CT93-0294, 206-220.
Bindi, M., Fibbi, L., Gozzini, B., Orlandini, S., Miglietta, F., 1996. Modelling the impact of climate scenarios on yield and yield variability of grapevine. Climate Research, 7, 213-224.
Bindi, M., Fibbi, L., Gozzini, B., Orlandini, S., Seghi, L., 1996. The effect of elevated CO2 concentration on grapevine growth and yield under field conditions. ACTA Horticulturae, 427, 325-330.
Bindi, M., Gozzini, B., Orlandini, S., 1995. The combined effects of climate changes and increases in atmospheric CO2 concentration on the potential growth of three grapevine varieties. Acta Horticulturae N° 388, 43-52.
Caprio, J.M., Quamme, H.A., 2002. Weather conditions associated with grape production in the Okanagan Valley of British Columbia and potential impact of climate change. Canadian Journal of Plant Science, 82, 755-763.
CEH, Centre for Ecology & Hydrology, 2003. Indicators of Climate Change in the UK. www.edinburgh.ceh.ac.uk/iccuk
Climate Change: Draft UK Programme, 2000. Department for Environment, Food & Rural Affairs, England.
Copa Cogeca, 2004. Assesment of the impact of the heat wave and drought of the summer 2003 on agriculture and forestry. www.cogeca.be
Cossu, A., Battaglini, A., Bindi, M., 2004. Cambiamenti Climatici e caratteristiche produttive di un'area ad alta vocazione viticola in Sardegna. L'Informatore Agrario, 33, 85-88.
Cubasch, U., Mehl, G.A., 2001. Projections of future climate change. Chapter 9 in: Climate Change 2001: The Scientific Basis. Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Camebridge, U.K., 525–582, 2001.
Déqué, M., Marquet, P., Jones, R.G., 1998. Simulation of climate change over Europe using a global variable resolution general circulation model, Climate Dyn., 14, 173–189.
EEA Report n.2, 2004. Impacts of Europe's changing climate. An indicator-based assessment.
EEAa, European Environmental Agency, 2003. Mapping the impacts of recent natural disasters and technological accidents in Europe. Environmental issue report n.35, Scanprint a/s, Denmark.
EEAb, European Environmental Agency, 2003. Europe's environment: the third assessment. Environmental assessment report n.10, Scanprint a/s, Denmark.
Enea, 2003, La risposta al cambiamento climatico in Italia, Roma.
EPA, Environmental Protection Agency, 2002. Climate change: indicators for Ireland (2000-LS-5.2.2-M1), Final Report, EPA, Ireland
Fregoni, M., 2002. Adattamento della vite ai cambiamenti climatici futuri. L'Informatore Agrario, 45, 29-30.
Giorgi, F., Hewitson, B., 2001: Regional climate information -evaluation and projections. Chapter 10 in: Climate Change 2001: The Scientific Basis. Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Camebridge, U.K., 583–638, 2001.
Gozzini, B., Bindi, M., Orlandini, S., 1996. Los effectos combinados de los cambios climaticos y del aumento en la concentracion de CO2 atmosferico sobre el crecimento potencial de tres variedad de vid. Viticultura y Enologia Professional, 46, 32-40.
Grifoni, D., Mancini, M., Orlandini S., 2004. Analisi dell'impatto dei cambiamenti climatici sulla qualità del Brunello di Montalcino. In: atti del Convegno AIAM 2004 "Gli agroecosistema di fronte al cambiamento climatico" (quaderno degli abstract). Matera, 22-23 aprile 2004, 42.
Gruza, G., Rankova, E., Razuvaev, V., Bulygina, O., 1999. Indicators of climate change for the Russian Federation. Climatic Change, 42, 219-242.

Hanssen-Bauer, I., E.J. Førland 1998. Long-term trends in precipitation and temperature in the Norwegian Arctic: can they be explained by changes in atmospheric circulation patterns? Clim. Res., 10, 143–153.
IPCC 1996a, Climate change 1995. The science of climate change: Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K.
IPCC 1996b, Climate change 1995. Impacts, Adaptations and Mitigation of climate change: Scientific-technical analyses: Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K.
IPCC 2001, Climate change 2001. The scientific basis, in Houghton J.T., Ding Y., Griggs D.J., Noguer M. et al., Cambridge University Press, Cambridge, U.K.
Jacobeit, J., Beck, C., Philipp, A., 1998. Annual to decadal variability in climate in Europe - objectives and results of the German contribution to the European climate research project ADVICE. - Würzburger Geographische Manuskripte 43, 163 pp.
Kenny, G.J., Harrison, P.A., Parry, M.L. (Eds.), 1993, The effect of climate change on agricultural and horticultural potential in Europe, Environmental Change Unit, University of Oxford, Oxford, U.K.
Komuscu, A.U., Erkan, A., Oz, S., 1998. Possible impacts of climate change on soil moisture availability in the southeast Anatolia development project region (GAP): an analysis from an agricultural drought perspective, Climatic Change, 40, 519-545.
Maracchi G., 2000. Effetto dei cambiamenti climatici sull'agricoltura. L'Informatore Agrario, 30, 31-37.
Maracchi, G., Crisci, A., Orlandini, S., 2004. Il cambiamento climatico e le prospettive di una agricoltura moderna, Il Tabacco italiano, 39, 8-13.
Maracchi, G., Orlandini, S., 2000. Cambiamenti climatici: problemi e prospettive. In: atti del convegno Clima e salute, 9 novembre 2000, Firenze (Italia), 1-12.
Maracchi, G., Orlandini, S., 2003. Cambiamenti climatici ed impatto sull'agricoltura ed il territorio. Coltivare insieme, XIII, 3, 24-26.
Mehrotra, R., 1999. Sensitivity of runoff, soil moisture and reservoir design to climate change in central Indian river basins, Climatic Change, 42, 725-757.
Middelkoop, H., Daamen, K., Gellens, D., Grabs, W., Kwadijk, J.C.J., Lang, H., Parmet, B.W.A.H., Schädler, B., Schulla, J., Wilke, K., 2001. Impact of climate change on hydrological regimes and water resources management in the Rhine basin, Climatic Change, 49, 105-128.
Moen, T.N., Kaiser, H.M., Riha, S.J., 1994. Regional yield estimation using a crop simulation model: concepts, methods and validation, Agricultural System, 46, 79-92.
Moonen, A.C., Ercoli, L., Mariotti, M., Masoni, A., 2002. Climate change in Italy indicated by agrometeorological indices over 122 years. Agricultural and Forest Meteorology, 111, 13-27.
National Research Council, 1982. Carbon dioxide and climate: A second assessment. Report of the CO2/Climate Review Panel. National Academy Press, Washington, DC.
Nemani R.R., White M.A. Cayan D.R., Jones G.V., Running S.W., Coughlan J.C., Peterson D., 2001. Asymmetric warming over coastal California and its impact on the premium wine industry. Climate Research, 19, 25-34.
OcCC, Organe consultative sur les Changements Climatiques, 2003. Exteme events and Climate Change. 88 pp.
Olesen, J.E., Bindi, M., 2002. Consequences of climate change for European agricultural productivity, land use and policy. European Journal of Agronomy, 16, 239-262.
Orlandini, S., Bindi, M., Gozzini, B., 1993. Effect of CO2-induced climatic change on viticultural environments of cool climate regions of Italy. Viticultural and Enological Sciences, 48, 81-85.
Orlandini, S., Dalla Marta, A., Mancini, M., Maracchi, G., 2004. Il cambiamento climatico e le prospettive di una agricoltura moderna. In atti convegno "L'agricoltura umbra di fronte ai cambiamenti climatici. Marciano, 13 ottobre 2003, 9-24.

Orlandini, S., Grifoni, D., Mancini, M., Barcaioli, G., Crisci, A., 2004. Analisi degli effetti della variabilità meteo-climatica sulla qualità del brunello di montalcino. Rivista Italiana di Agrometeorologia.

Parry, M.L., 1990. Climate change and world agriculture, chapter 4. London, Earthscan Publications.

Plummer, N., Salinger, M.J., Nicholls, N., Suppiah, R., Hennessy, K.J., Leighton, R.M., Trewin, B., Page, C.M., Lough, J.M., 1999. Changes in climate extremes over the Australian region and New Zealand during the twentieth century. Climatic Change, 42, 183-202.

Puglisi, A., Dalla Marta, A., Mancini, M., Orlandini, S., 2004. Analisi degli impatti della variabilità climatica sul Sangiovese. Atti del secondo convegno internazionale sul Sangiovese. Firenze, 17-19 novembre 2004.

Puglisi, A., Mancini, M., Orlandini, S., 2004. La risorsa acqua difronte ai cambiamenti climatici. In: atti del convegno "Acqua – strategie per un impiego ottimale in agricoltura" (CD-ROM). Chiesuol del Fosso (Italia), 12 gennaio 2004, 19-30.

Ragab, R., Prudhomme, C., 2002. Climate change and water resources management in arid and semi-arid regions: prospective and challenges for the 21st century, Biosystems Engineering, 81 (1), 3-34.

Schär, C., Davies, T.D., Frei, C., Wanner, H., Widmann, M., Wild, M., Davies, H.C., 1998. Current Alpine climate. In: Cebon P., U. Dahinden, H. C. Davies, D. M. Imboden, and C. Jäger [Eds.], Views from the Alps: Regional perspectives on climate change. MIT Press, Boston, 21–72.

Schultz, H.R., 2000. Climate change and viticulture: a European perspective on climatology, carbon dioxide and UV-B effects. Australian Journal of Grape and Wine Research, 6, 2-12.

Thomas, A., 2000. Climatic changes in yield index and soil water deficit trends in China, Agricultural and Forest Meteorology, 102, 71-81.

Tiefu, P., 1993. The impacts of climate change on agricultural production in the north-east China, in Deng Genyun (ed.). The impact of Climate Change on Agriculture in China, Beijing Science and Technology Press.

Türkeş, M., 1996. Spatial and temporal analysis of annual rainfall variations in Turkey. International Journal of Climatology, 16, 1057-1076.

Viglizzo, E.F., Roberto, Z.E., Filippin, M.C., Pordomingo, A.J., 1995. Climate variability and agroecological change in the central Pampas of Argentina. Agricultural Ecosystem and Environment, 55, 7-16.

Wanner, H., Gyalistras, D., Luterbacher, J., Rickli, R., Salvisberg, E., Schmutz C., 2000. Klimawandel im Schweizer Alpen-raum, vdf, Zürich, 283 pp.

Wild, M., Dümenil, L., Schulz, J.P., 1996. Regional climate simulation with a high resolution GCM: surface hydrology, Climate Dyn., 12, 755–774.

Yang, Y., Watanabe, M., Wang, Z., Sakura, Y., Tang, C., 2003. Prediction of changes in soil moisture associated with climatic changes and their implications for vegetation changes: waves model simulation on Taihang Mountain, China, Climatic Change, 57, 163-183.

Zinoni, F., 2004. Cosa possiamo aspettarci per agricoltura e ambiente?. Dossier Cambiamento Climatico. Agricoltura, anno 32°, n.3, Marzo 2004, 64-66.