Report of the international workshop of the EU-concerted action of

AVEC

»Vulnerability of European ecosystems facing an increasing drought risk«

April 10-12, 2003 at the Doryssa Bay Hotel, in Samos,Greece

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1. Agenda

Session 1: Are there future risks? Predictions and scenarios using models and simulations

Chair: Christian Körner

Session 2: What evidence of drought do we have across Europe?

Chair: Hans-Jürgen Bolle, Wolfgang Cramer

Session 3: Biological implications

Chair: Rik Leemans

Session 4: Responses in agriculture and forestry to drought

Chair: Rik Leemans

Session 5: Social implications

Chair: Claus Beier

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3. Introduction

The question if there is an increasing drought risk within Europe has already been raised within many different research disciplines and it has been an issue of the latest IPCC report (2002). Although there have been several studies about this, there is no clear perception of the changes that will be expected within Europe. A special attention was paid to the Eastern Aegean region, where the workshop was held. The AVEC workshop aimed at contributing to the following questions:

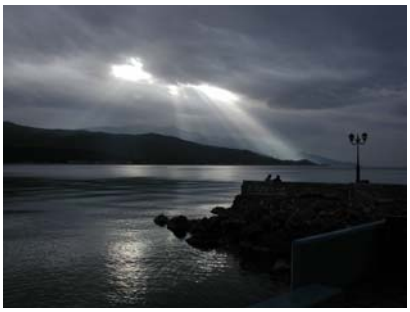
- Which areas will possibly be affected by an increasing drought risk in the future?
- What evidence of drought do we have across Europe?
- What are the biological implication?
- How do agriculture and forestry sectors react?
- What are the social implications?

The workshop carries the keyword »vulnerability« in its title because the concept of vulnerability assessment has become the key concept for interdisciplinary studies which are reported by the Intergovernmental Panel of Climate Change IPCC. The concept aims at generating an appropriate description of the possible damage occurring due to environmental change and the ability of society to adapt to damage. The goal of the workshop was to enlighten the issue of an increasing drought risk in Europe within this theoretical framework by finding answers to following questions:

- With global change do drought-prone areas increase?
- If so, will their ecosystems be damaged?
- If so, can users of the ecosystems adapt?

4. Workshop sessions

4.1. Session 1: Are there future risks? Predictions and scenarios using models and simulations



Although droughts are a normal summer phenomenon – especially in the Mediterranean area where the ecosystem services are well adapted – a change in its emergence pattern may cause a water scarcity over a certain period of time or within a certain region. To find an answer to the question if there is future increasing drought risk within Europe in the future three different views to the system were considered:

a) Measurements: The precipitation records of the last 100 years show prolonged periods of less and more rain, but there is no evidence of a clear long term trend. The 30 years of a climate period may bias the result of a trend calculation. Therefore a longer view is needed. For the temperature there is a clear trend which indicates an temperature increase in most parts of Europe.

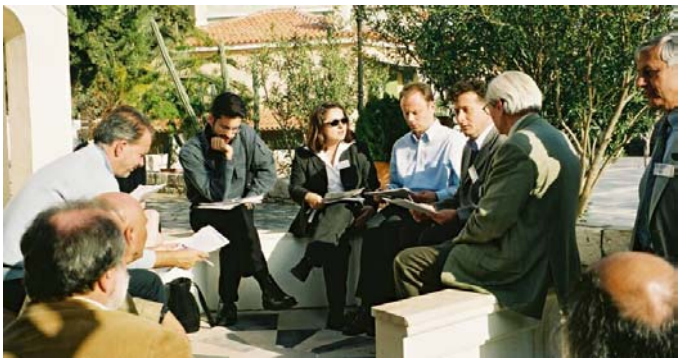
b) Satellite data: Since it is difficult to obtain a clear picture of spatial and

temporal extent of droughts on the basis of ground measured data only, from the 1990's on remote sensing data is used to assess the extent of droughts via measurements like the different vegetation indices which are derived from satellite images. Although satellite data support the climate change analysis via calculations of NDVI etc., due to its short record, currently deriving confirmed statements of a change in droughts pattern is not possible.

c) Model results: Calculations with global circulation models provide an understanding of possible expected large-scale changes in climate. Based on different greenhouse gas emission scenarios and initialized with different conditions, a variety of climate scenarios can be produced. Results of more than one of these scenarios show an expected change in temperature and precipitation for the period December – February. Still there is no detailed vision of the consequences of climate change in Europe.

Besides the climate aspect the human impact on the water resources is a major aspect of water availability. The results of an integrated water model »WaterGAP« show a change of drought frequencies in almost all areas of Europe. A decrease of drought frequency is expected for Northern Europe and the Alps. Southern Europe (Portugal, Spain, western France, Italy, southern Greece and western Turkey) and East-Central Europe (Belarus, Ukraine, and eastern Poland) will have to deal with an increase of droughts. The model results show an equivalent impact of anthropogenic influence and climate change.

There are hints that the risk of droughts might have increased already by reduced precipitation and increased temperature in some regions of Europe. In drought prone regions most ecosystems and their services are able to adapt to the available amount of water until a certain threshold. In regions which have not been affected by drought events in the past, ecosystems and their services might be affected seriously, because they are not used to water stress at all. Besides the water quantity the annual precipitation pattern plays a major role. A shift in rain pattern in the annual circle might cause serious problems for agriculture and tourism.



The group agreed in the discussion that a clear definition of drought is essential. One suitable drought definition is the Palmer Index, which was developed by Wayne Palmer in the 1960s and uses temperature and rainfall information in a formula to determine dryness. It has become the semi-official drought index. The usage of vegetation parameters was seen as difficult since they depend besides of climatic conditions on land use management.

4.2. Session 2: What evidence of drought do we have across Europe?

In the Mediterranean area drought is mainly caused by low winter precipitation and/or high summer temperatures. Dry winters relate to weather conditions with high pressure, continental air advection and a high stability of anti-cyclones. The weather conditions of warm summers are linked to a blocking high over Europe and the entire Mediterranean area and stable weather situation. By analyzing historical climate data the answers to the question of an evidence of trends in drought frequency in this region can be investigated.

Based on the historical data from long instrumental series and written records, a statistical reconstruction of temperature for Europe provides a review for the last 500 years. The interannual to interdecade variability of the temperature during this period is high. Particularly cool winters and cool years were frequent during the time before 1900. The warmest summers occurred around 1800 and in the period starting from 1990. Significant increase of summer temperature emerge for the western and central parts of the Mediterranean area. The analysis of the Mediterranean area shows a trend towards increasing drought caused by warmer summers and dryer winters for the last decades during the last century.

The methodology of dendro-chronology enables the reconstruction of past climate conditions during the growing season (in large May-June). It can be used to assess the past spatio-temporal occurrence of drought episodes, because moisture is the key driver of tree growth in areas which do not have access to groundwater. In Turkey dendro-chronology analysis show a strong influence of the North Atlantic Oscillation on precipitation, streamflow and temperature. A period of the past 660 years tree ring records have been analysed using material from mountain habitats for *Cedus linbani, Juniperus excelsa, Pinus brutia* and *Pinus nigra* in Turkey. The results from Turkey illustrate a high variability of precipitation for this region, but no clear trend for the precipitation during the growing season. Dendrochronological investigations in *Pinus brutia* close to the sea level on the island of Samos indicate a significant decrease of trees growth during the last decades. The recent 1999–2000 drought led to the lowest rate of tree growth recorded during the last 150 years This tendency was confirmed by interviews with local villagers who calendared the dry out of several springs during the last decades. The abandonment of home gardens and vegetable crop land in this region was clearly influenced by the ceasing water availability. There is a high probability of similar conditions existing for the Aegean and the Eastern Mediterranean region.

4.3 Session 3: Biological Implications

The physiological reactions of ecosystems to drought include immediate control of vapor losses by stomata, short-term adjustments of structural investments (e.g. root growth), canopy as well as stand thinning and the replacement of species

assemblages toward more robust taxa. Water shortage leads to a reduced productivity, caused a blockade of the nutrient cycle. Within models stomata control of vapor loss, is sometimes overestimated and thus might underestimate forest ecosystems' susceptibility to drought. The consideration of the soil water conditions is essential for a realistic representation of the processes triggered by drought.

The ecological responses and the implications for assessment of drought risk for European shrublands during the growing season are assessed in the European project VULCAN. Artificial drought conditions are simulated as field studies in six different shrubland ecosystems across Europe, ranging from dry/warm to wet/cold conditions. The results show a reduction of the rate of most ecosystem processes and an increase of wildfire risk in the dry and warm sites. The opposite effect was observed on the cold and wet sites, where drought conditions promoted many ecosystem processes like soil respiration, decomposition and plant growth. The results are used and regionalized for an assessment of the potential risk for European shrublands to an increasing drought risk.

The impact of historic drought on humans, biodiversity and patch dynamics, plus their influence on ecosystem function and stability, were investigated in semi-aride Mediterranean steppes. As characterization of ecosystem functions and stability the processes erosion, infiltration and nutrient cycling were analysed. The results show that the patch characteristics like area occupied by late-successional shrubs, number and width of patches, biodiversity (species richness) have the highest impact on erosion, infiltration and nutrient cycling, while other determinants play only a secondary role.

4.4 Session 4: Responses in agriculture and forestry to drought

A study of soils in the agricultural area of the river Enipeus basin in Greece show increased drought risk as a consequence of increased water demand and an alteration in climate. Until 1992 the water table was stable as evidenced by boreholes for wells. Since then the groundwater level has fallen constantly, the general intensification of irrigation agriculture and the use of poor soils on marl and tertiary limestone deposits for water demanding crops like cotton and tomato have increased water consumption during the last decades. A series of dry years and overuse of water for irrigation caused by an intensification of the land use due to unemployment in urban centers added to the problem.

Hence, where agriculture is moisture-limited, as in eastern and southern Europe, a reduction of water availability will affect the agricultural production. Responses and adaptations to an increasing drought risk will increase the use of external inputs such as fertilizer, pesticides, growth regulators etc., and practices to conserve moisture. Suitable crop types which are resistant to heat water-, weed-, pest- or disease stresses will be needed, the irrigation systems will be improved and maybe the farming systems will be modified from mixed to specialized arable and livestock systems or

vice versa. These responses will be influenced by flexible policy measures at European level.

The attitudes towards risk will influence conservation policies on production choices. An example of irrigation water quota in Cyprus shows different risk levels for producers of vegetables, citrus and cereal products. The producers exhibit a strong aversion against risk. The results of the study show that the impact of conservation policies on agricultural revenue should not be assessed in terms of expected profit from production alone, but it should also include the change of the revenue as the consequence of hedging against a modified risk. The variation of revenue originates from modified insurance behavior. Conservation policy should include agricultural subsidy schemes for accounting for a changed risk.

The responses in agriculture are very difficult to asses, because agricultural behavior is highly managed and therefore overlaid by strong political and management changes.

4.5 Session 5: Social implications

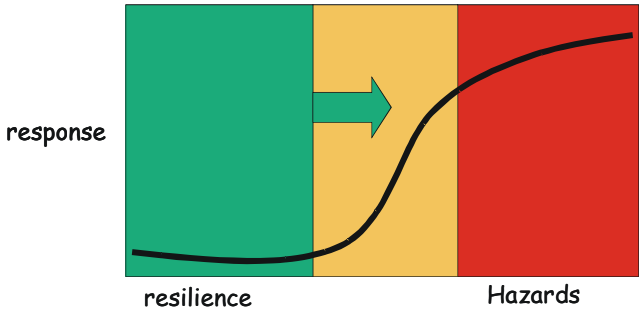
Since tourism in Southern Europe has the highest water demand during summer when the availability is very low and the water consumption of the tourists are up to four times higher than the demand by local people, water shortage and increases in the frequency or severity of episodic drought could be a limiting factor for this sector. A survey in Ibiza indicated that there is only little knowledge and awareness of water stress among the tourists. Comprehensive adaptation strategies with high-tech solutions like desalination plants, water grids, water re-use and water harvesting are applied already in the Mediterranean. At the other extreme it is shown that it might be necessary to severely restrict tourist growth in some areas. Both tourist managers and stakeholders have to find solutions for water shortage situations for a sustainable tourism. The involvement of different stakeholders aims at responding to drought with anticipatory measures and at evaluating the value of incorporating climate forecasts information into specific action. Effective adaptation measures have to be derived which fulfill the criteria of high effectiveness, good rate of adoption and constraints of these measures including the risk.

For islands of the Mediterranean three aspects of vulnerability have been identified as major components/aspects/facets:

- Physical aspect of water supply: decrease of precipitation and an increase of evapo-transpiration, which leads to reduced recharge rates for the aquifers and an over-pumping of the near shore aquifers.
- Economic dimension of water use: irrigation still accounts for the most extensive consumption of water in the islands.
- Societal/ political issues of water use: institutional/administrative procedures and traditions/customs of water use as well as the stakeholders perception.

There are many technological and behavioural response options to cope with global change and its impacts, because there are assessment treatments like environmental impact analysis, benefit cost analysis, etc. to analyse the consequences of these options. But there is no silver bullet solution, because responses are regional and context specific and have to be linked to vulnerability through modeling, stakeholder involvement and bottom-up approaches. However, there are possible win-win situations, but also tradeoffs and synergies within and across regions. Still there is a lack of systemic approach to define the transition of responses from resilience to hazard situation of different sectors and systems in different time, spatial and organizational scales (see Figure 1).

Figure 1: Transition of responses from resilience to hazard situation (Leemans)



5. Conclusions of the workshop

1) Climate models indicate a drier future climate in the Mediterranean.
2) This is supported by long term data series that integrate over the whole area
   Evaluation of regional data series show that the picture has to be diversified and that trends in many regions are statistically not significant in view of the large variability.
3) With respect to impacts not only inter-annual variability matters but also changes in the annual cycle (seasonality).
4) The observed changes and intensities of annual cycles at some stations may as well be an indicator of climate change as a trend within the range of normal periodicities (trends up to 25 years may be doubtful).
5) From tree-ring analysis together with solid independent climate information the integrative impact of climate variability on biota can be estimated.
6) The impact of climate variability on agriculture can be estimated by relating yield to climate variability but this leads to wrong conclusions when yields from increasing irrigation and greenhouse cultures are included.
7) Tools exist to predict impacts of economy on ecology an to advice farmers to mitigate affects of droughts. Unfortunately reaction of individuals to climate as well as economical forcing is difficult to predict.

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