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INTEGRATED SYSTEM FOR THE MONITORING AND FORECASTING OF DROUGHT EVENTS AND DESERTIFICATION PHENOMENA, PROVIDING APPROPRIATE MEASURES FOR IMPACTS MITIGATION AND WATER RESOURCES USAGE PLANNING

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SUMMARY – APAT participates in the Community Initiative Programme INTERREG III B MEDOCC with the project SEDEMED “Sécheresse et désertification dans le Bassin Méditerranéen” whose aims are the definition of proper studies and mitigation strategies and the organization of an integrated information system supporting water resources planning in order to combat drought and desertification in the frame of an international collaboration. APAT has been involved in activities such as the implementation of a hydro-meteorological database, the extension of the water cycle analysis to the whole Western Mediterranean area, and the identification and application of new drought and desertification indices. It has also improved the existing observation networks and their better organization in pilot projects, and defined appropriate interventions against drought and desertification.

Keywords: drought and desertification

1. INTRODUCTION

The operative structures of the National Department of Technical Services in the Italian Prime Minister's Office, particularly those of the Italian Hydrographic and Mareographic Service, now merged with the National Geological Survey and ANPA into the National Agency for Environmental Protection and Technical Services (APAT) have collected for many years all the information relevant to the inner and coastal waters of Italy, in relation to the main meteorological phenomena. Recently they have also investigated some particular hydrological aspects connected with drought events, a natural hazard which has been occurring more frequently during the past years in the Mediterranean area. Such investigations have been carried out within Community initiatives of the European Commission such as INTERREG II C Programme “Territorial planning and coping with the effects of drought” in 1999-2000 and have been implemented during these last years in the frame of the Programme INTERREG III B with the project SEDEMED “Sécheresse et désertification dans le Bassin Méditerranéen” financed by the European Fund for Regional Development in the section dedicated to the spatial cohesion and integration of the EU Western Mediterranean area.

Twelve national and regional institutions coming from Italy, Spain, Portugal, Greece, Morocco and Tunisia participate with their technical or scientific competences in the activities of this project whose aim is to provide a better knowledge of this natural risk and find the most suitable strategies to mitigate the effects of an uncommon water shortage.

2. DROUGHT DEFINITION

In fact, drought is a normal, recurrent feature of climate, although it is erroneously considered as a rare and random event. It differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate. Drought should be considered relative to some long-term average conditions of the balance between precipitation and evapotranspiration (i.e., evaporation + transpiration) in a particular area. It is also related to the timing (principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages)

and the effectiveness (i.e., rainfall intensity, number of rainfall events) of the rains. However, these are only conceptual definitions that are unable to give an operational definition of drought.

In fact only an operational definition of drought helps hydrologists or water resources researchers and practitioners to identify the beginning, end, and degree of severity of a drought. This definition is usually made by comparing the current situation to the historical average, often based on a 30-year period of record (according to World Meteorological Organization recommendations). The following categories of drought are usually considered:

- Meteorological drought is usually defined on the basis of the degree of dryness (in comparison to some “normal” or average amount) and the duration of the dry period. Definitions of meteorological drought must be considered as specific to a region since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region.
- Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, reduced groundwater or reservoir levels, and so forth.
- Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., streamflow, reservoir and lake levels, groundwater). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale.

Although climate is a primary contributor to hydrological drought, other factors such as changes in land use (e.g., deforestation), land degradation, and the construction of dams all affect the hydrological characteristics of the basin.

3. SEDEMED PROJECT

Taking into account all these different aspects related to drought, the activities of the SEDEMED project have focused on the organization of an integrated information system supporting water resources planning in order to fight against drought and desertification in the frame of an international collaboration embracing six different countries of the Mediterranean Basin.

The following phases of work have been executed in order to develop a better updated knowledge of the concept of drought and its relationship to the downscaling analysis at finer spatial scales of

- the meteorological fields referred to a given hydrological basin;
- the implementation of a hydro-meteorological database;
- the extension of the water cycle analysis to the whole Western Mediterranean area;
- the identification and application of new drought and desertification indices;
- the application, check and development of forecast methodologies in order to reduce impacts through the availability of an early warning system;
- the definition of the role played in drought mitigation by unconventional resources like for instance sewage reuse;
- the exchange of information on drought and its possible mitigation measures;
- the definition of a decisional support system and the diffusion of the so-called “lesson learnt” to the other countries also affected by drought events.

In particular the most significant activities of APAT in the SEDEMED project have focused on the phase of studies concerning the analysis of the hydrological cycle, the exchange of experiences, the section devoted to the realization of a computerized network and that dedicated to training and information.

The Department of Physics in Rome University “La Sapienza” had already outlined in the frame of the European Programme INTERREG II C a prototype of monthly bulletin for monitoring drought in Italy and on the occasion of the renewed cooperation with APAT in the activities of the SEDEMED project it has developed the extension of this drought analysis on a large scale to the MEDOCC (Western Mediterranean) area using the Standardized Precipitation Index (SPI) and the Average Percentage. The possibility of elaborating a statistical forecast of drought in short time has also been evaluated. Furthermore the pluviometric data observed by the Hydrographic Office of Genua and transmitted to the National Hydrographical and Tidal Service now in APAT have been analysed in

order to select the historical series useful for the drought evaluation, i.e. enough long lasting series with very few missing data for applying the drought indices to them. The results have contributed to the implementation of the analysis at regional scale foreseen in the bulletin prototype. In this case the climate variability of Liguria Region, which has no operating partner in SEDEMED, has been analysed in order to elaborate homogeneous information in the MEDOCC area also with reference to other Italian regions not involved in the SEDEMED project. Finally, using the ERA-40 precipitation data available from the European Weather Centre, the analysis of drought at large scale in the Western Mediterranean area has been executed through the SPI application. The results have been compared with those obtained through the utilisation of NCEP/NCAR data. This comparison has highlighted considerable differences which need to be verified and analysed more deeply.

The Department of Civil and Environmental Engineering of the University of Catania has defined a methodology for the evaluation of the times of drought occurrence on the basis of hydrological series. This methodology applied to the Sicilian territory has allowed SEDEMED partners to derive the time of occurrence of drought events with severity and duration higher or equal to fixed values.

Furthermore the Department has elaborated some criteria to be adopted in order to create a reliable network of hydro-meteorological stations for the monitoring of drought events. These criteria should take into account both the quality and quantity aspects of the available historical observations and also the network suitability for describing the spatial variability of the drought phenomenon in a proper way.

The Department of Mathematics and Informatics of the University of Camerino has defined some techniques enabling the researchers to calculate the capability of the pluviometrical network from the point of view of the atmospheric precipitations concerning the non homogenous Italian territory. Then it has provided basic scientific criteria for the definition of a reliable pluviometrical network for the monitoring of weather precipitations.

The Department of Soil Protection of the University of Calabria has continued all its service activities (evaluation of the hydrological variables and their WEB publication) already undertaken during the previous operational programme when it had realized a model of water budget in the Italian regions of Calabria and Basilicata. This model allows the evaluation at monthly scale and in a distributive manner on regular cells with a side of 5 km of the principal elements of the hydrological cycle, i.e. potential and real evapotranspiration, soil moisture, deficit, surface flow and groundwater flow. These elements have been evaluated since January 1999 and are available on monthly updated digital maps till June 2001. This Department has also carried out on-site campaigns for directly measuring hydrological variables to be compared with those evaluated by the water budget model through the check of new sensors. It has also extended through WEB-GIS procedures the functionality of the WEB page INTERREG in order to enable Internet users to obtain information concerning the historical and present situation of the main elements contributing to the definition of hydrological budget in a selected geographical area. Finally this Department has performed a training course for the dissemination of the expertise developed in the field of water resources management and in the forecast of water scarcity due to drought.

APAT has taken upon itself the publishing of the meeting acts of Villasimius which had concluded the INTERREG II C project and also the distribution of this publication which contributes to the diffusion of the results. APAT has also taken care of the realization of the Hydro-geological map of Southern Italy at the scale 1:250.000 which contains homogenous bibliographic information on groundwater resources of Southern Italy and therefore represents a very important tool for the study of all questions regarding water supplies in an interregional perspective.

4. APAT DROUGHT BULLETIN

As already mentioned, the Hydrological Service in the Department for Inland and Sea Waters Conservation of APAT has been monitoring drought phenomena eventually affecting our national territory by means of a monthly drought bulletin published on its web site. The analysis of the climatic conditions in Italy is available from the first days of every month and can be freely consulted.

The bulletin is aimed at providing information of diagnostic character on the state of drought in the entire country. The state of drought is documented by some significant indices, among which the Standard Precipitation Index and the Palmer Drought Severity Index.

Because there is no single definition for drought, its onset and termination are difficult to determine. We can, however, identify various indicators of drought, and tracking these indicators provides us with a crucial means of monitoring drought.

Drought indices assimilate thousands of bits of data on rainfall, snowpack, streamflow, and other water supply indicators into a comprehensible big picture. A drought index value is typically a single number, far more useful than raw data for decision making.

There are several indices that measure how much precipitation for a given period of time has deviated from historically established norms. Although none of the major indices is inherently superior to the rest in all circumstances, some indices are better suited than others for certain uses.

The choice of the indices to be inserted is based on various considerations. The state of drought of a particular region depends on a considerable number of elementary data on the state of many environmental parameters. Consequently it is of great use to develop some indices which are capable of summarizing the general picture of the climatic situation. An index is therefore a single number, whose usefulness is decidedly greater than the information of which it is synthesis.

This notion acquires an even greater meaning whenever a drought analysis is distributed in the form of a service. In such case, the necessity of also reaching a public not necessarily specialized, makes the use of indices which are easily comprehensible indispensable.

Another important characteristic of an index is its ability to describe the phenomenon on different time scales, so that the types of drought previously listed are correctly diagnosed.

Various drought indices have been developed and applied in international publications. The SPI is among one of the most used indices by international drought monitoring centres, therefore its effectiveness in capturing the nature of the phenomenon has been tested on many climatic realities.

The bulletin that has been developed is a prototype product still under review and expansion.

In particular, the analyses of the drought phenomena on large scale are currently available utilizing the data of the NCEP/NCAR re-analysis, while the analyses on regional scale utilizing the recorded pluviometric data fall within the objectives of a future extension of the bulletin.

5. REUSE OF WASTEWATER

The experience of Region Sardinia. Within the sphere of the INTERREG IIC community project the complete implementation was foreseen of the intervention named "Connection of the urban wastewater treatment plant of the Cagliari area and neighbouring municipalities (Arenas Is) to the Simbirizzi basin".

The implementation of the intervention has ended the pouring into the sea, although purified, of the wastewater from Cagliari and neighbouring municipalities. The wastewater is now totally used for irrigation purposes. The idea of implementing the intervention was backed by a study of non conventional techniques for the treatment of wastewater through pilot plants, within the sphere of a convention between the Ente Autonomo del Flumendosa, activator of the intervention, and the Institute of the Environment of the joint centre of Research ISPRA.

With financing of the European Community within the sphere of the Envireg programme for the protection of the environment in the sub-programme Propenv 1 and with a co-financing of the Council for the final arrangement of the distribution network and the activation of the service, the Villasimius (CA) council implemented a project of a system of reuse of treated water. The overall system is made up of a biological treatment plant using activated sludges with final disinfection and discharge into the Foxi River (prior to the reuse project) and a refinement plant made up of: pumping section, pressure filter, ozonization and final disinfection with PAA or sodium hypochlorite.

The works, commenced in 1995 and completed in 1999, have permitted the implementation of a treatment plant capable of regenerating 6.000 cu. m. of purified water a day and a distribution network capable of serving 250 hectares of agricultural land and about 150 hectares in tourist areas.

The reuse system came into operation in the summer of 1999 and distributed, in two months, 40,000 cu. m. of treated water for the watering of the green areas of two hotel infrastructures. In 2000, following the comforting results obtained in the experimental stage, distribution began on all the areas served by the network, creating significant interest on the part of users.

These activities have been carried on in the frame of the SEDEMED project.

6. ABOUT DESERTIFICATION

In 1999 the Italian Committee to Combat Desertification (ICCD) carried out the guidelines for the National Action Plan and in this context, the *National preliminary map of Italian areas prone to desertification* was realized by a working group coordinated by the Italian Hydrographic and Mareographic Service.

The map of the index of sensitivity to desertification has been obtained with a Geographic Information System (GIS) combining four different indices reflecting specific processes related to desertification: aridity index, soil characteristics index, land use index and demographic variation index. The data for the aridity index go back to the period 1960-1990.

APAT is now working on the SIDES project aiming at the implementation of an Information System for the monitoring, the evaluation and the mitigation of desertification phenomena. The tasks of this project are: the analysis of the main international and European indices and methodologies; a comparison of the methodologies and the analysis of the data used for the indices; the checking of the existing available data in Italy and the acquisition of data necessary for the elaboration of the new map of the Italian areas prone to desertification. The main goal of the SIDES project is to enhance the Italian methodology and, at the same time, to update the map drawn up in 1999 with the data of the last decade in order to assess the phenomenon trend.

7. THE POTENTIAL EROSION MAP

In the frame of the Programme INTERREG III B Medocc –“Sécheresse et désertification dans le bassin Méditerranéen « a research has focused on the editing of a map entitled “Potential Erosion of the Sicilian Territory and its GIS”. In particular, this activity has concerned the updating of the database used for the tracking of the isoerosion lines map with recourse to the daily precipitation data, the calculation of rain aggressiveness indices, the study of the spatial variability of the rain aggressiveness index, the sampling plan for the evaluation of the soil erosion potential, the GIS project and the implementation of the SEDD model in a basin underneath a Sicilian reservoir.

The research activities have produced a series of themes which will compose the information basis of a specific GIS.

8. CHECKING OF NEW SENSORS

SEDEMED project has also foreseen the development of hydrometric station networks in some areas of Southern Italy and the promotion of innovative actions even from the point of view of new instrumental techniques.

The most difficult parameter to be evaluated in the water budget calculation is the evapotranspiration which has required the utilization of a portable instrument able to produce very good results in research activities and give expectations of functionalities on active service. The technique of eddy correlations is represented by the use of sophisticate sensors able to measure the real evapotranspiration of a given surface whose extension has a variable radius between 200-300 meters to 1 km. This technique is considered the most reliable in the measurement of the atmospheric flows.

The eddy correlations system is a modular structure because it is composed by many instruments. That used in this case is formed by a supply system, a datalogger, an anemometer, a rapid acquisition hygrometer and a thermocouple, a sharp radiometer, a tester for temperature and heat flows at ground level and by a traditional instrumentation for the measurement of wind direction and speed, air temperature and humidity.

9. CONCLUSIONS

The impacts of drought, like those of other natural hazards, can be reduced through mitigation and preparedness (risk management). Planning ahead to mitigate drought gives decision makers the chance to relieve the most suffering at the least expense. Reacting to drought in “crisis mode” decreases self-reliance and increases dependence on government and donors.

Planning for drought is essential, but it may not come easily. There are many constraints to planning:

- Politicians, policy makers, and the general public may lack an understanding of drought.
- In areas where drought occurs infrequently, governments may ignore drought planning, or give it low priority.
- Governments may have inadequate financial resources.
- No single definition of drought applies to all regions.
- Responsibilities are divided among many governmental jurisdictions.
- Most countries lack a unified philosophy for managing natural resources, including water.
- Policies such as disaster relief and outdated water allocation practices may actually deter good long-term natural resource management.

One of the major impediments to drought planning is its cost. Officials may find it difficult to justify the costs of a plan, which are immediate and fixed, against the unknown costs of some future drought. (These unknown costs of drought are not entirely economic; they also include human suffering, damage to biological resources, and the degradation of the physical environment, items whose values are inherently difficult to estimate.) But studies have shown that crisis-oriented drought response efforts have been largely ineffective, poorly coordinated, untimely, and inefficient in terms of the resources allocated.

Moreover, drought planning efforts can use existing political and institutional structures, and plans can (and should) be incorporated into general natural disaster or water management plans, thus reducing the cost of the planning effort.

Mitigating drought—taking actions in advance of drought to reduce its long-term risk—can involve a wide range of tools. These tools include policies, activities, plans, and programmes.

A European Drought Preparedness Network could provide the opportunity for nations and regions to share experiences and lessons learned (successes and failures) through a virtual network of regional networks; for example, information on drought policies, emergency response measures, mitigation actions, planning methodologies, stakeholders involvement, early warning systems, automated meteorological networks, the use of climate indices for assessment and triggers for mitigation and response, impact assessment methodologies, reduction of demand/water supply augmentation programmes and technologies, and procedures for addressing environmental conflicts.

Working individually, many nations and regions will be unable to improve drought coping capacity. Collectively, working through global and regional partnerships, we can achieve the goal of reducing the magnitude of economic, environmental, and social impacts associated with drought.

The project SEDEMED II, started last September and lasting till end of December 2006, intends to improve the water resources management in drought conditions through the checking of the SEDEMED methodologies and the realization and setting up of a quality network for a homogeneous databank.

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(NDMC) National Drought Mitigation Center – University of Nebraska – Lincoln
www.drought.unl.edu

MEDEA – monitoraggio della siccità
<http://romatm13.phys.uniroma1.it/siccita/index.html>
www.ambientediritto.it

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www.itacon.it

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<http://uirsiciliana.it/indez.php>

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<http://www.idrocz.it>