The sustainable management of resources in the mitigation of the risk of desertification in the Apulia region

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Abstract

Numerous studies at the international level have demonstrated that the possibility of climatic changes on a global scale could come true. The knowledge of the chronological tendency of the climatic parameters and the recognition of a character of extreme event in the manifestation of some meteorological phenomena allow the signals of change that are taking place to be defined and if there are tangible impacts on the territory, like the risk of desertification. According to the work of the UNCCD (United Nations Convention to Combat Desertification) the southern and insular regions of Italy are involved in a tendential process of environmental crisis essentially caused by some factors such as: tendential process of ‘tropicalization’ of the climate; qualitative depauperation of the resources; specific anthropic conditions of decay of the territory. The sensitivity of a land to desertification, in relation to natural causes, depends significantly on the climate, when its peculiar manifestations are aridity, drought and erosion of the rain; however the degradation of the soil, which leads to the loss of fertility, is also due to the not sustainable use of the natural resources, to the intensive exploitation of the agrarian lands and the water resources. This study, made at the basin scale in Apulian Tavoliere, tends to acquire specific information on the climatic, morphological, pedologic, geologic, hydrogeologic and the anthropic activity that causes a high risk of environmental decay in the territory, in order to create a sustainable management of the resources and the mitigation of the impacts of the productive processes.

Keywords: sustainable management, drought, aridity, desertification.
1 Introduction

In the last years the sequence of natural disasters together with atmospheric phenomena of particular intensity has brought serious consequences for the safety of the citizens and for the economy. Recent reports of the IPCC (International Panel for Climate Change) have focused on the elements that would induce the scientific community to examine the possibility of climatic changes on a global scale. Numerous studies at international level underline that the global average temperature is increasing. The OMM, in an official form (WMO statement on the status of the global climate) has declared that globally, the nineties represent the warmest decade ever registered. Various geological studies have reconstructed the climatology of the eras in which there wasn’t the presence of instrumental data; the nineties and XX century have been respectively the warmest decade and the century of the entire millennium. The warmest year ever registered is 1998 (mean +0.58° compared to datum Clino-61/90). That has lead the Meteorological Services of all countries to carry out studies on the climatic variability, also in order to characterize the objective parameters for the qualitative forecast of meteorological events that could be dangerous for the whole community [3]. The works of the International Conference on Mediterranean Desertification, Research Results and Policy, held in Creta in the autumn of 1996, have focused the attention on the typology and the entity of the desertification’s process of a territory owing to the co-existence of fragile echo-systems due to the intense anthropic pressure exercised. Different definitions have been given of the word “desertification”. In the circle of the Convention for the Fight to Desertification and Drought (UNCCD), come into force in 1996, desertification is regarded as a phenomenon of degradation of dry lands, half-dry damp and arid lands due to different reasons among which the most important ones are climatic changes and human activity.

![Map of Italy showing sensitive areas](image)

**Figure 1:** Official governmental map of the sensitive areas in Italy.
2 The risk of desertification in Apulia

In Apulia the existence of specific surrounding and social economic features exposes some areas to desertification; these areas are particularly exposed to stress because of the frequent conditions of aridity in some seasons, repeated episodes of drought, accentuated erosion of the grounds due to short and strong precipitations (but also because of an irrational exploitation of the layers made worse by the concentration of economic activities in the coast zones, and for a general anthropic pressure on the environment, often not sustainable).

An aspect to be carefully examined is the one related to the climatic changes, in order to point out possible negative trends, the distribution of dry periods, their magnitude and intensity. The pluviometric data nevertheless, alone, are not sufficient to highlight the aspects of sensitivity to desertification, but it is necessary to know also aspects concerning the agronomic practices (the working of the ground, irrigation and cultural alternations), the hydrogeologic aspects able to highlight the quantitative and the qualitative state of the layer. Other useful parameters are the intensity of the rain and its distribution during the year, tied to the definition of the erosive capability of the rain itself. In particular, between the areas vulnerable to the process of desertification the Tavoliere plain (Figure 1), is one of the most significant for the following reasons:

- the condition of particular aridity of the climate; since the atmospheric perturbation coming from Nord-Ovest the Tavoliere by now deprived of dampness owing to its particular morphologic position, almost sunk between the reliefs of Gargano, Appennino Dauno and Murge;
- the presence of several tropical episodes, characterized the absence of precipitations, alternating to intense episodes of dampness and thunder-storms which help the impoverishment of the organic part of the ground because of the washing away and consequent erosion;
- the quantitative impoverishment of the layer, since the realization of the agriculture transformation Plan (1938) and the land transformation Plan (1948), there has been a great number of wells (100 thousand on average) that take water with a higher intensity as to the capacity of annual recharge of the layer. A clear picture of this quantitative depauperation can be deduced from the analysis of figure 2 that reports the values of the lowerings recorded since 1987 to 2001 in the piezometric control web of superficial layer contained in the alluvial part of Tavoliere composed in the circle of the studies for the definition of Basin’s Plan of the rivers Ofanto and Fortore. The wells’ position is reported in figure 2 where it is also possible to notice the state of the isophreatic lines in 1987. In fifteen years remarkable depressions have been recorded, especially if compared to the hydrogeologic character of the territory;
- the seawater intrusion, caused by depressions induced by massive withdrawals which happen not only in areas near to the coast. An important survey made in 2002 in the irriguous areas of the Fortore showed striking data. In the survey the data of 297 wells have been analyzed in order to point out the qualitative state of water. This study is important both for the suitable number of
the wells checked, both for the position of the same wells which are displaced in a vast and sufficiently indicative area. The results of these analysis show that the 97% of the examined samples taken from as many wells were unfit for irriguous uses. In figure 3 it is reported, on a digital cartographical support, in the territory interested by the inquiry, the distribution of the contamination obtained through a geostatistical elaboration of values of Ecw (electric conductivity Ecw) in checked wells. This elaboration has required the declustering of data, clearly evident in figure 3;

- the salinity of agricultural grounds, because of the use of brackish water which influences negatively their structural and nutritional properties, causing physiologic confusion on cultures, with the perspective of productive reductions;

- the intense agricultural exploitation, with the monoculture and the irrational agronomic practices which determine many problems of tenability of the productions with regard to protection and surrounding defense. Actually, despite the arid climatic features, it is often practiced an intensive agriculture, with fields that extend to a few metres from the coast. In the light of the above/said critic aspects, a new methodological integrated study has begun whose preliminary results are reported in Giasi’s work [5] useful for further investigation. The present work aims to test how climatic changes may have repercussion on the sensibility of the territory in comparison with the process of desertification in order to achieve a useful interpretation for every eventual contrast action.
3 Characters of the territory

The Apulian Tavoliere (fig. 4) is a level territory, with a surface of 4737 Km² on average; it borders to the SE on the river Ofanto, to the east on the Adriatic sea and it is closed on the other sides from the table-land of Murge, from the Appennino Dauno mountains and from the massif of Gargano from which the Apulian Tavoliere is separated by the river Candelaro. From a morphologic point of view in the south of the river Candelaro light valleys and broad esplanade are surveyed, bent weakly to the sea. The general slope towards east is the consequence of the pleistocenic recession and of the modeling of filling deposits in a phase of retreat of the sea. The inshore morphotype is typical of the alluvial plains, with not deep sandy beaches and strongly anthropic dunes; besides these dunes there are bogs and coast lakes partly reclaimed or transformed in salt pit.

Figure 3: Distribution of the contamination obtained through geostatistical elaboration (KRIGING) of the Ecw values (electric conductivity expressed in mS/cm) in the monitored wells.

The superficial draining system of the Tavoliere is constituted by several rivers, between whom the most important are the Candelaro, the Cervaro, the Carapelle, the Ofanto and a series of tributary rivers that have often seasonal downflow and a prevailing torrent-like regime. The geologic picture is characterized by a Mesozoic calcareous-dolomitic basement of the Apulian platform on which there are transgressing plioquaternary deposits of the Bradanic cycle whose thickness is the highest in the zones near the Appennino and the lowest near the Adriatic coast, where it does not exceed 200m [2]. In the west zone, the plio-quaternary and holocenic clastic sediments are in contact with the Pelitico-fliscioidi unities of the Appenninic chain, which form the orographic
system of Daunia mountains. The whole surface of Tavoliere is covered by after-calabrian deposits, prevailing of alluvial facies, leaning in discordance on the underlying marine deposits. In the central part of Tavoliere there is a bank of marly clay, probably of lagoon origin, as proved by overhanging little layers of evaporite limestone. The hydrogeology of Tavoliere is characterized by a multi-nappe system in which one can individuate: a superficial aquifer, in marine sand-conglomeratic and alluvial pleistocenic deposits, delimited below from an impermeable substratum represented by grey-blue clays of the sedimentary plio-pleistocenic cycle: more in the depth, an intermediate aquifer, in sandy lenses contained in the grey-blue clays, withdrawn for irriguous uses: a deep aquifer in Mesozoic limestone confined from grey-blue clays. The last one is correspondent to the important Apulian Karst layer floating on the salty sea water and with levels of piezometric burdens determined by the confining of the blue clays.

Figure 4: Schematic geologic map of the Tavoliere delle Puglie (Caldara and Pennetta 1990). Legend: 1– mesozoic limestone; 2– eocenic calcarenites; 3– geologic apennine formations of different age and nature; 4– miocenic calcarenites; 5– pliopleistocenic soils of Bradanic forethrough; 6– terraced marine sediments; 7– terraced alluvial deposits of superior pleistocene; 8– debris deposits and eluvial olocenic deposits; 9– alluvion, lacustrine and olocenic lagoon sediments; 10– shores and present coastal dunes.

4 The aridity of the climate

The area of Tavoliere is one of the warmest and less rainy zones of the whole national territory. The climate is Mediterranean, with rains in autumn and winter. In this area, in order to define the intrinsic sensibility to Desertification, the climatic factor is regarded as the most significant natural factor. For this reason a short analysis of climatic data has been conduced, in order to obtain objective checks useful to the definition of the climate of the area under examination and
of its changes in the last years. In particular the first survey described below aimed to research characteristic signals of the drought phenomenon.

Considered the nature of the study, the analysis conducted regarded representative stations of climatic behaviour typical of the captaincy and such as to have a period of observation of fifty years. The considered data are those pertinent to the station of Foggia Observatory, Cerignola and Barletta. From a quick observation of data it appears that, from all the stations the annual precipitations are as a general rule gathered in winter months, the annual mean values of rains are equal to 469.8 mm. For Foggia, to 561 mm. For Barletta and 564 mm. For Cerignola. The annual potential evapotranspiration, owing to the high summer temperatures can exceed the 1200 mm. with the highest points of 200 mm. in the month of July. Taking into consideration the historical series and in particular analyzing the mobile thirty-years means of the annual rains, it is evident a decrease for all the stations (fig. 5) and this is evident also from the observation of the state of annual percentage of rainy days. This means that precipitations are more and more concentrated; the decrease of rainy days is more evident above all in fifteen years included from 1980 to 1995.

![Figure 5: Thirty year mobile mean of the precipitation for the stations of Foggia, Barletta and Cerignola. The evaluation is referred to the period 1980-2000.](image)

As already reminded, the drought is a phenomenon which takes place when precipitations are sensibly lower of the normal recorded levels; its impact on physical reality results from the interaction between the natural phenomenon (reduction of meteoric contributions) and the request. In the area examined, in order to evaluate the existence of critic droughty events [10] the historic annual series have been considered and the mean of the same as the level of the request has been observed. Figure 6 reports the results of this analysis for the considered stations. In fig. 7 it is shown in the histograms the temporal series of annual precipitations (Pi) for the considered years of sample, relating to the average value of precipitations (Po). In this representation an event is droughty if the relative annual precipitation is lower of the average value (Pi<Po). Fixed a value
of duration correspondent to a critic drought (for instance two years), all the shortest episodes are considered common, those longer, are considered critic. Figure 8 synthesizes clearly the three considered stations, the frequency of dry spells occurred in the years of observation. It is evident that for all the stations the episodes are frequent. The results, reported in figure 9 are particularly significant since they are based on the observations of fifty-years and thus they show the variable nature of precipitations.

Figure 6: Salas method for the evaluation of dry events for the three stations.

Figure 7: Temporal series of the annual precipitations considering the origin coinciding with the main value of the considered period for each of the three stations.
In order to define the sensibility to desertification of this territory [3],[5], besides elaborating data pertinent to the rains, it has been also characterized the climate through a bio-climatic index which analyze also the temperature.

The Index regarded as convenient is the Drought Index suggested by the UNEP and adopted in 1998 for the Italian territory by CNLD [4], defined by the relation between the annual average precipitation and the annual average potential evaporation. The analysis conducted taking into consideration the monthly average values of the potential evaporation as average monthly values on the historic series considered under the method Penman-Monteith provides a classification of semi-arid climate. An improvement of this index is the Index De Martonne-Gottmann more suitable to point out the climatic zones characterized by strongly dry seasons. The elaboration for this last index has been conducted on annual scale for the three considered stations and makes it possible to define the climate as drought for all the station.

![Figure 8: Duration of the critical dry events.](image)

In order to consider the aptitude to a greater erosion of the climate, it has been determined the CSEP [7] which is a climatic index developed to represent the potential soil’s erosion starting from a model based on the quantification of the capacity of erosion of the superficial downflow. The index is calculated on monthly base to include the effects of the different seasons. The application of the model on the Tavoliere’s territory has been conducted on the data of the station of Foggia and relatively to the period 1987-1994, a particularly dry spell. On the basis of a simplified hydrologic budget, it is possible to obtain an index both of the seasonal rains both of its main erosive effects. The conducted elaboration is reported in figure 10, in which it is possible to point out the different aliquots of the monthly hydrologic budget. It is necessary to highlight
that the kind of considered culture (cereals) leads to consider a lower quantity of water necessary to soak the ground and then to consider lower the relative volume in this balance.

Figure 9: Histogram relating to the application of the SAI to the historical series of the total annual precipitations and to the three considered stations.

Nevertheless, it appears evident that the aliquots relative to the recharge of the layer and to the superficial downflow are very low. In a hydrogeologic budget, the aliquot relative to the layer’s recharge should be compared with the condition of “extraction” in act in order to quantify the consequent deficit.

Figure 10: Annual rates of the hydrologic budget calculated with the CSEP methodology for the station of Foggia. The annual values of the different rates are obtained by summing up the monthly values.
Another aspect connected to the variations of the climate is that of its tropicalization. For tropicalization of the climate are to be meant the sharp meteorological variations, in which also sudden and consistent thermic variations take place, the alternation of extremely dry spells with even flood events, the violent and sudden atmospheric disturbances after periods of stability.

The damages caused by those climatic variations are at least as serious as the ones produced by the aridity and the demonstration of that is given by the consequences caused by the flood due to the 65mm of rain fallen in 26 hours in the days from the 24 to the 26 January 2003 in the Tavoliere. The analysis of this event, exposed in the following shows features that make it possible to define it ‘extreme’.

5 Mitigation of the risk

From what has been said up to here, the area of Tavoliere appears a very fragile ecosystem, particularly sensitive to desertification because it is susceptible to undergo phenomena of decay in function of its intrinsic characteristics and of the intensity of the anthropic exploitation. In this area, the perspectives of a sustainable development could come true only if the socio economical development is linked to a correct management of the natural resources.

A fundamental aspect for the sustainability of the territory is the implementation of an integrated water management, that is to say a qualitative and quantitative recovery of the groundwater resource and the stability of the territory.

New perspectives of sustainability could be achieved only if the character of the climatic change that is taking place is fully taken into account and if the management of the territory is conformed to it. The consequent interventions are numerous and intensely widespread over the territory. They should include:

- New modalities of water storage in order to guarantee availability of the water resource during periods of crisis;
- Interventions of rationalization of the irrigation systems for the saving of water;
- Utilization of streaming water in order to create new water supply;
- Control of the phenomenon of seawater contamination and predisposition of appropriate groundwater recharges in order to recover the quality in coastal as well as in internal areas;
- Application of telematic techniques of continuous monitoring for the management and the control in real time of the water systems and the resources;
- Census of the unauthorized wells present in the territory and the effective pumped discharge;

Therefore it results evident the necessity to inquire into the ambit of the potentialities of the territory, of alternative forms of cultivation that would solve the problem of diversification of the production, to relaunch the competitiveness of the territory and to safeguard the resources soil and water for the future generations.
6 Conclusions

The study realised in the area of the Tavoliere points out the concomitant presence of a prevalently arid climate, of repeated periods of drought, of a generalized reduction in the precipitations, of an exploitation of groundwater and of an intense utilization of the land (the intense agricultural exploitation), of seawater intrusion in groundwater as well as the increase of salt content in the soil.

From the analysis carried out it results that, although agriculture is not the principal agent of decay, it constitutes the weakest ring of the whole system because it could feel in a strong way the effect of a potential process of desertification mainly by climatic nature.

That’s the case in which the increase in the irrigated surfaces, together with the passage to nontraditional cultivations, has lead to the affirmation of fragile economical systems that appear particularly sensitive to extreme climatic events such as the protracted dry spells. The peculiar character of the territory and the negative pressure exerted on it by human activities request adequate measures that are to be considered as ‘responses’ of the civil society to the environmental decay.

The mitigation of the risk of desertification makes it necessary to link the socio economical development with a sustainable management of the natural resources, that is to say to pass from an eminently productive outlook of the territory to an ecocompatible one. In other words the strategic lines for sustainable management the development of adequate social-economic behaviours, a protective environmental policy, specific restoring programs, incentive programs for restoring and for correct behaviours.

References