

UNIVERSITY OF FLORENCE
DEPARTMENT OF AGRONOMY AND LAND MANAGEMENT (DISAT)
WADI PROJECT
SECOND PERIODIC REPORT (1 January 2007 - 31 December 2007)

The DISAT activity inside the WADI Project concerns the salinization phenomenon of the cultivated land of the Grosseto Plain induced by the irrigation practice.

The soil salinization is one of the main soil degradation processes in the Grosseto Plain as well as in the Mediterranean areas, and is, at the same time, a promoter and a consequence of desertification: when considered in relation to persistence and permanence, the sustainability of irrigated agriculture mainly depends on salinity and salinization of the irrigated soils, and considering that all irrigation water contains soluble salts it is only a matter of time until a salinity regime arises unless measures are taken to prevent it.

According to these statements and considering that the irrigated-soil salinization is a well known and present phenomenon in the Grosseto Plain, the DISAT activity inside the WADI Project aims the elaboration of three main deliverables:

- some aspects of the *climatological scenarios* of the Grosseto Plain, for evaluating the climatic risk of salinization of the soils through the valuation of the soil salt leaching effect of rainfall;
- the *map of the potential salinization risk of the soils*, which provides information about the inherent risk of salinization of each type of soil of the Grosseto Plain because of their chemico-physical characteristics and their spatial distribution;
- an *agronomic instrument* for the management of soil salinity and saline water irrigation, of simple and immediate use for farmers, useful for policy makers too, which is based on quantitative data for soil, crops and irrigation water, and that provides information about the yields expected, the irrigation crop water requirements and the leaching requirements for maintain a good salt balance in the soil.

The work methodology and the experimental plan involves:

- *climatological analysis*
- *soil investigations: sampling and analysis of soil*
- *agro-climatic elaborations*

Climatological analysis. Climate is the first factor to be considered in evaluating the potential risk of salinization of the soils. In fact, saline soils are formed in places where the amounts of salt

accumulating is greater than the amount removed. Since the migration of salts in soils occurs mainly through salt solutions, the main condition of salt accumulation in soils is the preponderance of evaporation over drainage and, as a consequence, the processes of salt accumulation are governed first and foremost by the water balance of each particular area. Both the water balance of the area and the ratio of evaporation to drainage depend on climatic conditions.

The climatic analysis extended to the Mediterranean area shows for the central and southern countries of the region the leaching due to natural rainfall of the salts bring to the soil with the irrigation is almost negligible. Moreover, scenarios developed using the most recent and advanced General Circulation Models (GCM) for assessing the hydrological impacts of climate changes show that by the year 2050 rainfall is predicted to decrease over much of the Mediterranean especially in the southern parts where it could diminish by up to 25% respect to the mean values of the period 1961-1990; decreased precipitation is predicted to be accompanied by a raise in temperature of between 1°C and 3°C. Reduced precipitation is predicted to have a major impact on water irrigation demand and potential leaching action of the climate.

In relation to these issues and based on available information, the climate of the Grosseto area has been analyzed as potential factor of salinization of the soils of the Grosseto plain.

The climatic risk of salinization of the soils in the Grosseto area has been investigated analysing the climatological data of the 50-year long period 1956-2005 at the meteorological station of Grosseto. Three climatological parameters have been considered: evapotranspiration, rainfall and the Climatic Water Balance. Other than the annual values, these parameters have been analysed for different seasonal aggregation of the climatic data: the dry season (April to September), the wet season (October to March), the spring season (March, April and May), the summer season (June, July, August), the autumn season (September, October, November) and the winter season (December, January and February).

The evapotranspiration requirements have been predicted as the reference or potential evapotranspiration (ET_o), and to predict it the Blaney-Criddle F.A.O. method has been used.

Because of the importance of rainfall as potential salt-leaching factor, other than the volume of water (mm) the rainfall parameter has been investigated considering the number of annual and seasonal days of rain.

The relative importance of rainfall and evapotranspiration for the assessment of the climatic risk of soil salinization of the study area has been synthetized in the Climatic Water Balance (CWB) that is, for a defined length of time, the difference between cumulative rainfall and evapotranspiration requirements.

The statistical analysis of the annual and seasonal values of the climatic parameters has been performed with the Linear Regression procedure. The annual and seasonal rainfall data have been analysed also with the statistical procedure of the Quintile Method.

Soil investigations. The basic information for soil investigations is represented by the pedological cartography available for the study site. According to the “Soil map of the Grosseto area, scale 1:50.000” (University of Amsterdam, 1986), upgraded with the “Soil map of Tuscany, scale 1:250.000” (Regione Toscana, 2004), for each type of soil of the map, samples have been taken for laboratory analyses. The field investigations have been carried out following the FAO guidelines (FAO, 1990), while the chemical and physical analysis of the soil are performed according to the “*Official methods of soil analysis*” of the Italian Ministry of Agriculture and Forestry (MiPAF, 1994).

Soil samples have been taken in 46 sites of the agricultural land. For each site 3 soil samples at different depth (0-30 cm, 30-60 cm, 60-90 cm) have been taken by using an auger; for the determination of bulk density, field capacity and wilting point, a volume of 100 cm³ of soil has been taken from each depth of soil using the excavation method with metal cups.

The samples of soil have been processed at the DISAT Soil Laboratory to determine the chemical (reaction pH, electrical conductivity), physical (bulk density, texture) and hydropedological (hydraulic conductivity, field capacity, wilting point) characteristics of soils related to salinity and salinization.

Agro-climatic elaborations. The analysis of the statistical data of Regione Toscana about the cultivated land surfaces of the Grosseto Plain has permitted to single out the most important irrigated crops of the study area: sugarbeet, purple alfa-alfa, maize, melon, watermelon, tomato, spinach, peach-tree. For these crops the estimation of water requirements from climatological data according to the FAO methodology, and as a consequence the quantity of water to be applied for irrigation, is in progress.

The agro-climatic elaborations, according to the FAO procedure, are based on the reference or potential evapotranspiration (ET_o) values and different cultural coefficients (k_c) for crop and phenological phase, and are processed considering the climatological data of a 50-year long period (1956-2005) provided at the meteorological station of Grosseto which includes daily measurements of rainfall, temperature, humidity and evaporation.

Climatological scenarios: first results about the climatic risk of soil salinization in the

Grosseto Plain. The climatic risk of salinization of the soils in the Grosseto Plain has been investigated analysing the climatological data of a fifty-year long period (1956-2005) at the meteorological station of Grosseto, assuming that the frequencies as potential evapotranspiration, rainfall and water balance are experienced in the past will occur in the future.

The mean annual potential evapotranspiration is 1177 mm with a limited range of variability. Also the ETo of the wet season shows a restricted variability with a mean annual value of 392 mm. The same trend appears for the ETo of the arid season with a mean potential evapotranspiration of 785 mm. The Linear Regression analysis of the annual and seasonal ETo shows a slight increment of ETo in the course of the 50-year period for the annual and arid season ETo, while a slight decrease appears for the wet season ETo. According to the statistical analysis and to the most recent and advanced General Circulation Models for assessing the hydrological impacts of climate changes that predict for the Mediterranean by the year 2050 a raise in temperature of between 1°C and 3°C, and considering the direct link between temperature and ETo, a raise in ETo of the Grosseto Plain by the next decades is expected.

The mean annual rainfall of the Grosseto Plain for the period 1956-2005 is about 640 mm; most of this rain falls in the wet season (October to March), while only 223 mm (the 35% of the annual rainfall) falls in the arid season from April to September. The linear regressions of rainfall data have pointed out a decreasing tendency of the amounts of the annual and seasonal rainfall, and a remarkable variability of the rainfall data. The same decreasing trend has been pointed out by the linear regressions of the number of the seasonal rainy days, especially for the wet season. Because of the relative decrease of the number of days of rainfall of the wet season pointed out with the statistical analysis, the decrease of the infiltration rate of rainfall is predictable, with a correspondent increase of runoff. As a consequence it is expected a quantitative decrease of the salt-leaching action of rainfall from October to March.

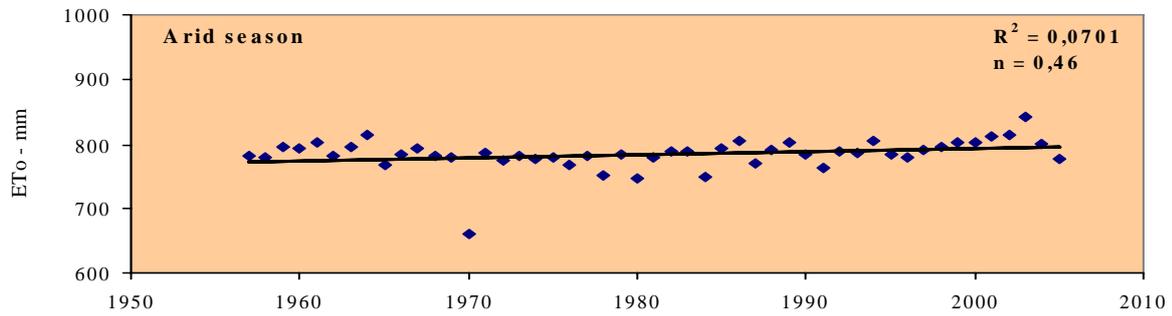
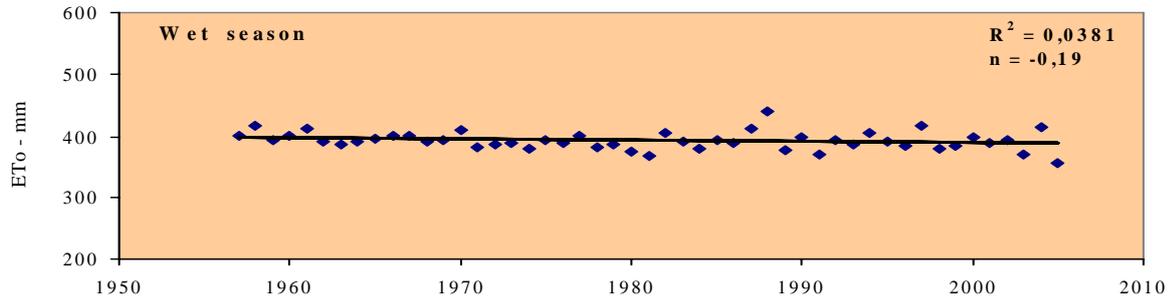
The mean annual difference between cumulative rainfall and evapotranspiration requirements (Climatic Water Balance – CWB) of the period 1956-2005 for the Grosseto area is about -537 mm, with a remarkable annual variability. The Grosseto Plain with an annual water deficit between 250 and 750 mm shows a moderate risk of soil salinization, but the statistical analysis of the CWB data has pointed out a tendency to the enhancing of the difference in the course of the 50-year period, and as a consequence the risk of soil salinization due to climate appears to be progressively enhanced in the last decades.

The most important result of the climatological analysis related to the soil salinization phenomenon of the Grosseto area appears the persistent and progressive contraction of the Climatic

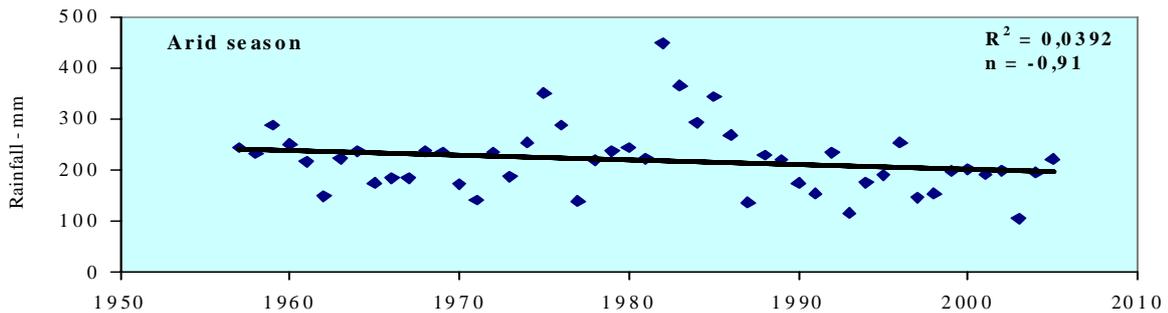
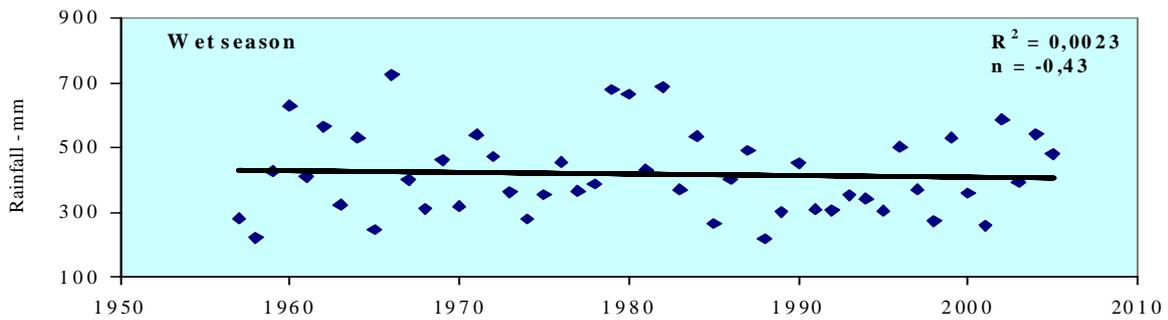
Water Balance: the spring and summer seasons are characterized by a permanent lack of water surplus and the climatic arid period appears prolonged to the autumnal months that point out an average CWB around zero. December, January and February (the winter season) are characterized by a positive climatic water balance as average but not every year, and most of all it is going towards values close to zero, pointing out the risk of a chronic condition of water deficit extended also at the winter months. Such trend could prejudice the autumn-winter rainfall leaching action of the salt accumulated in the soil because of the irrigation practises during the spring-summer cultivation season, and, in the long period, this set of climatic conditions could prejudice the sustainability of the farming systems, with the improvement of desertification.

In the Grosseto Plain the risk of increase of the salt concentration in the soils is a well known problem, but usually it is not considered a dangerous soil degradation process because the salt leaching action of the autumn-winter rainfalls is considered able and sufficient to prevent the soil salt accumulation. Such believe, in the lights of the results of this study and of the future climatic scenarios, appears to be reviewed, paying attention to the agronomic management of the salinization process with the use of proper cultivation techniques for the control of soil salt accumulation.

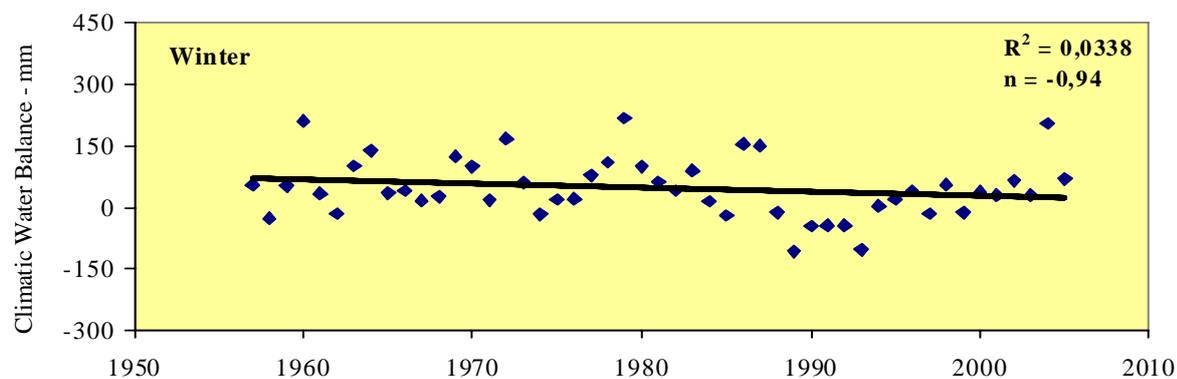
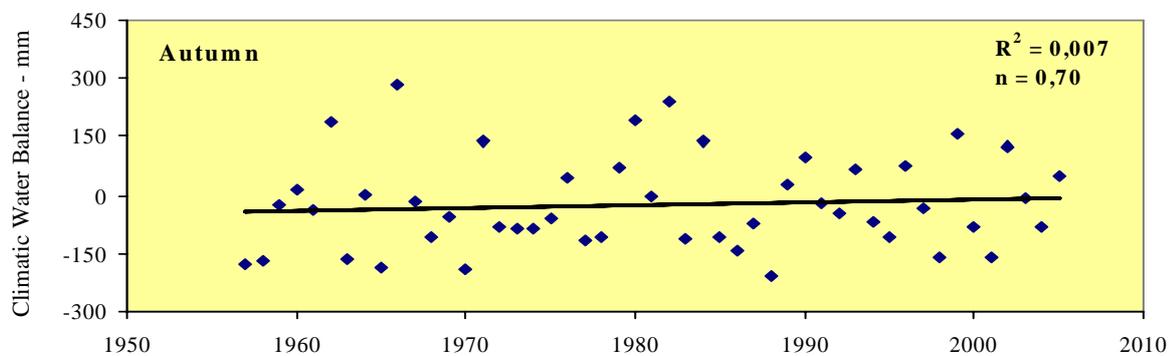
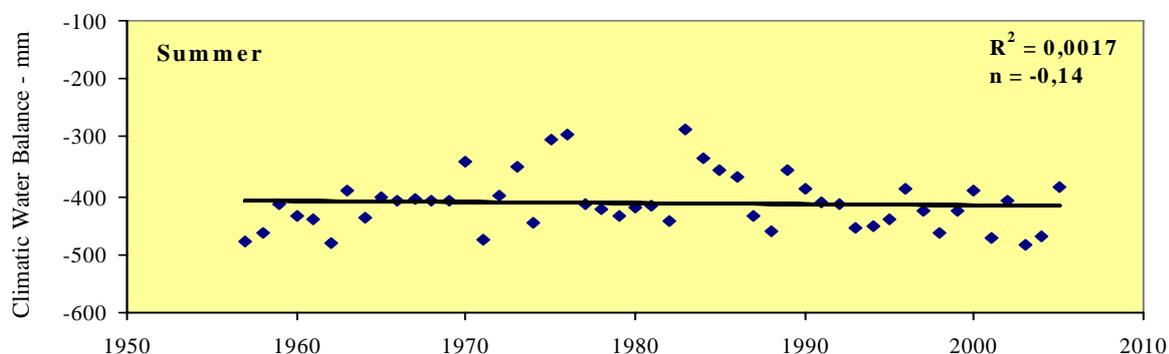
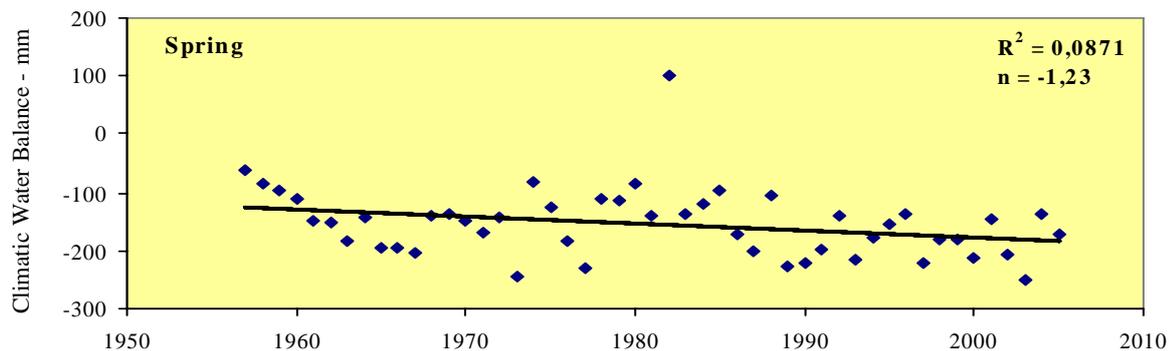
Linear regression of the Potential Evapotranspiration (mm) of the wet and arid season in the course of the fifty-year long period 1956-2005 at the meteorological station of Grosseto



Linear regression of the Rainfall (mm) of the wet and arid season in the course of the fifty-year long period 1956-2005 at the meteorological station of Grosseto



Linear regression of the seasonal Climatic Water Balance (mm) in the course of the fifty-year long period 1956-2005 at the meteorological station of Grosseto



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SOIL SALINIZATION OF THE GROSSETO PLAIN (MAREMMA)

Foreword

- The **soil salinization** is one of the main **soil degradation processes** in the Grosseto Plain as well as in the irrigated areas of the Mediterranean: when considered in relation to persistence and permanence, the sustainability of irrigated agriculture mainly depends on salinity and salinization of the irrigated soils.
- In the Grosseto Plain the problems due to soil salinity and saline irrigation water are well known. The causes of this soil degradation process have been identified in the **use of saline water for irrigation** and the **raise of salts from ground water to the surface** of the soil by capillary action; this process is mainly the consequence of the **intrusion of salt water from the sea into the ground water table** because of the overexploitation of water resources for both irrigation and domestic uses.
- In the Grosseto Plain the risk of increase of the salt concentration in the soils, although well known and current, usually is not considered a dangerous soil degradation process because the **salt leaching action of the autumn-winter rainfalls** is considered able and sufficient to prevent the soil salt accumulation.

Climatological scenarios

- **Climate** is the first factor to be considered in evaluating the potential risk of salinization of the soil since the process of soil salt accumulation is governed first and foremost by the **ratio of evaporation to drainage** and by the **water balance** of an area, which both depend on climatic conditions.
- The **climatic risk of salinization of the soils** in the Grosseto Plain has been investigated analysing the climatological data of a fifty-year long period (1956-2005) at the meteorological station of Grosseto, assuming that the **frequencies as potential evapotranspiration, rainfall and water balance are experienced in the past will occur in the future**.
- The most important result of the climatological analysis related to the soil salinization phenomenon of the Grosseto area appears the **persistent and progressive contraction of the Climatic Water Balance** (the difference between cumulative rainfall and evapotranspiration requirements).
- The spring and summer seasons are characterized by a **permanent lack of water surplus** and the climatic arid period appears prolonged to the autumnal months that point out an average Climatic Water Balance around zero. The winter season is characterized by a **positive climatic water balance as average but not every year**, and most of all it is going **towards values close to zero**, pointing out the risk of a **chronic condition of water deficit** extended also at the winter months.

Topics for discussion

- The climatic trend pointed out could **prejudice the autumn-winter rainfall leaching action** of the salt accumulated in the soil because of the irrigation practises during the spring-summer cultivation season, and, in the long period, this set of climatic conditions could **prejudice the sustainability of the farming systems**, with the improvement of **desertification**.
- The believe that in the Grosseto Plain the risk of **increase of the salt concentration** in the soils is not a **dangerous soil degradation process** because of the **salt leaching action of the autumn-winter rainfalls**, in the lights of the results of the climatological analysis and of the future climatic scenarios, appears to be reviewed.
- The **agronomic management** of the salinization process with the use of proper cultivation techniques for the control of soil salt accumulation appears of great consequence for the **sustainability** of the Maremma **agro-ecosystem**.