Environmental Irrigation Sustainability in South Italy based on the Land Use/Irrigation Technique/Soil/Climate System: a Gis Approach for Water Management supporting the National Planning Strategy for Irrigated Agriculture

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NATIONAL FRAMEWORK

Irrigated agricultural productions represent about 72 % of total agriculture's GDP (Gross Domestic Product) of Southern Italy Regions. The total area covered by irrigated crops is about 1.600.000 hectares, and the extimated potential irrigation area all over the South Regions is about 5,5 Million of hectares. Irrigation represents the 60 % of the total water consumption, and the agricultural areas with water distribution networks are still increasing. A National Project “Technical Support to the Irrigated Land Local Managers and Consortia” was loaded by National Ministry of Agricultural and Forestry Policies (MIPAAF) to have a complete framework in order to address the assistance for irrigation network increasing. CRA-ISSDS was commissioned to make the environmental irrigation sustainability evaluation in the South Italian potential irrigated areas.

CLIMATIC DATABASE AND SPATIAL EVALUATION

Climatic database was organzed on the basis of the spazialization of 375 climatic stations data of Southern Italy, aggregated by monthly average Minimum and Maximum Temperature, and cumulative Rainfall values, over a 35 year climatic period (1950-1985). After the spazialization, on a grid cell of 250 m, two useful agroclimatic indexes, were obtained: the Annual Summation of Growing degree days and Annual Water Potential Deficit for crops (WPD)(fig.1). Finally, by cluster analisys of the agroclimatic indexes, eleven omogeneous climatic zones were obtained and assigned to soiscapes groups (fig.2).

For each area was selected a representative climatic station, and prepared a climatic database of the daily climatic data over the last ten years (1996-2006).

The “average” and “droughty” years further to the evaluation model were obtained by calculating the deviation of WPD from the medium values of the considered period.

AIM OF THE STUDY

Aim of this study is that to realize a GIS based land evaluation method for taking into specific consideration the interaction between irrigated land use, irrigation soil suitability and different irrigation techniques. This method will produce a final soil and irrigated land use sustainable map, to be used as Supporting Decision System for planning the new network development areas.

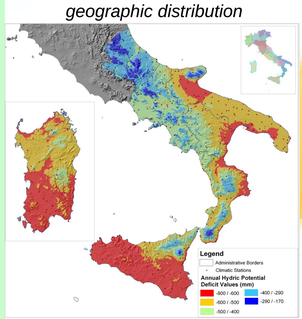
MATHERIALS AND METHODS (GIS APPROACH)

The definition of environmental sustainability to irrigated use of the land starts from determination of environmental efficiency: that is an optimal use of water minimizing the water crop requirements to the real needs according to the environmental conditions.

The GIS-Model approach used (fig.4) intends to determinate the environmental efficiency of the system soil-crop-thecnique-climate and evaluate the resulting sustainability class to irrigated use. Environmantal efficiency is extabilished on the basis of soil hydrological response under different cliamtic conditions and with an irrigated crop for the three mean different techniques adopted: **Flooding, Sprinkler and Drip irrigation**. The environmental efficiency rate is evaluated according to the situation that minimize water losses for runoff, ponding and deep percolation.

The evaluation methods requires several different databases (soil, climate, land use and climate) that were harmonized and filled for all the required data all over the Southern Italy.

Figure 1. Annual Water Potential Deficit and climatic stations geographic distribution



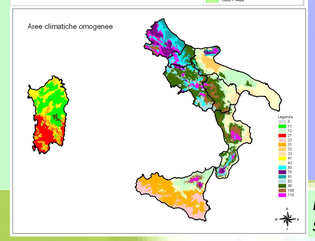
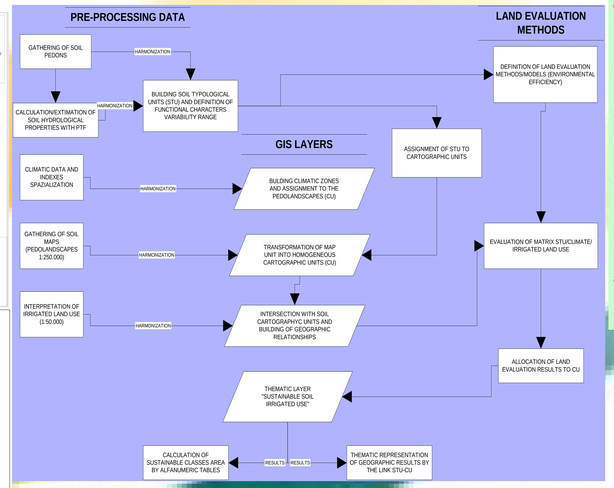


Figure 2. Climatic zones as result of climatic station data spazialization

Figure 4. Workflow Diagram of pre-processing, GIS layers and evaluation methods relationships.



SOIL DATABASE AND HYDROLOGICAL PROPERTIES

Soil evaluation was performed by using data coming from National Soil Database (CRA-ISSDS). About 9.700 pedons were estracted and organized in Soil Typological Units (STU), according to a) stational features (Parent Material, Land use, Soil Management, etc.), b) Soil Classification (USDA ST 2006), and c) dataset of Hydrological qualities and characteristics (Hydrological Group, Saturated Hydraulic Conductivity Ks, Characteristic Retention pF Curve, Avaliable Water Capacity) until 1.5 m of depth. Soil Typological Units were assigned to the Soilscapes geography at 1:250.000 scale, following the relationships already made into the Soil Map of Italy at the same scale.

RESULTS

SOIL/CLIMATE/LAND USE HYDROLOGICAL EFFICIENCY MODEL

The method is based on several steps:

1.Calculation of seasonal hydrological deficit;

2.Calculation of the efficiency of irrigation interventions: follow the known time length, the corrispondent soil potential infiltration is determined with Green & Ampt equation. This value is compared with specific irrigation volume: the potential soil infiltration exceeding rate is considered as runoff/ponding loss.

3.Calculation of the number of necessary interventions according to the evapotraspirative demand, and the gross water crop requirement.

4.The ration between the Net and Gross Crop Water Requirement define the **Environmental Efficiency Rate** (or coefficient), and it ranges from 1 to 0.

CLASS 1. **1.0-0.75 - SUSTAINABLE**

CLASS 2. **0.75-0.50 - PARTIALLY SUSTAINABLE** (it’s possible to modify into sustainable by changing actual hydrological soil properties with technical reclamation or change irrigation technique)

CLASS 3. **0.50-0.25 - POORLY SUSTAINABLE** (limitations of soil hydrological properties are so heavy that all possible changes are not economically sustainable)

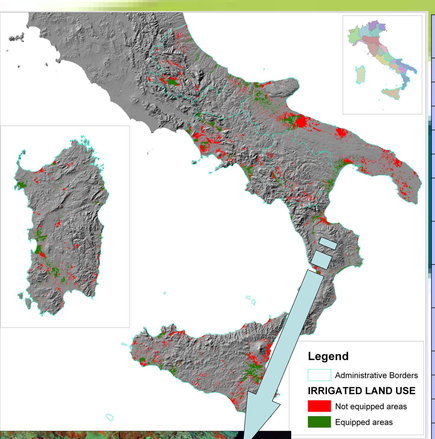
CLASS 4. **> 0.25 - NOT SUSTAINABLE**

Two case-study and General Sustainability Maps and Total Sustainable areas for Southern Italy are reported according to the different environmental efficiency vaues (fig.5 and 6)

BENCHMARK GINTP378 – LOCATION: **PLEISTOCENE ALLUVIAL TERRACE – PUGLIA REGION**
ST CLASSIFICATION: **Calcic Haploxeralf fine, mixed, thermic**
CLIMATIC ZONE 32: SOUTHERN PART OF PUGLIA “TAVOLIERE” AND BASILICATA BORDER, MEAN POTENTIAL HYDRIC DEFICIT **-634 mm**
REFERENCE CROP: **SUGAR BEET** – IRRIGATION TECHNIQUE: **SPRINKLER**
NET CROP WATER REQUIREMENT: **457 mm - CUMULATIVE RUN-OFF/PONDING: 57.5 mm**
ENVIRONMENTAL EFFICIENCY VALUE: 0.25 – NOT SUSTAINABLE

BENCHMARK VAB1P19 – LOCATION: **RECENT ALLUVIAL PLAIN – BASILICATA REGION**
ST CLASSIFICATION: **Typic Xerofluvents, coarse loamy, mixed, thermic**
CLIMATIC ZONE 32: SOUTHERN PART OF PUGLIA “TAVOLIERE” AND BASILICATA BORDER, MEAN POTENTIAL HYDRIC DEFICIT **-634 mm**
REFERENCE CROP: **SUGAR BEET** – IRRIGATION TECHNIQUE: **SPRINKLER**
NET CROP WATER REQUIREMENT: **457 mm -** CUMULATIVE DEEP PERCOLATION LOSSES: **28.6 mm**
ENVIRONMENTAL EFFICIENCY VALUE: 0.63 – PARTIALLY SUSTAINABLE

IRRIGATED AREAS: LAND USE DATABASE



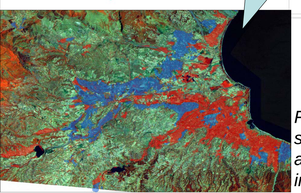


Figure 3. Remote sensing interpretation and general map of irrigated land use

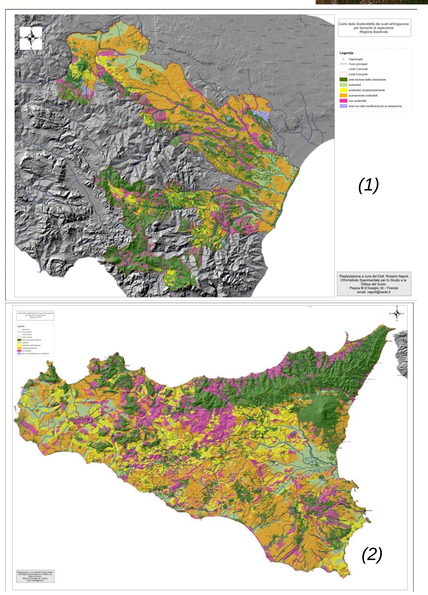
ID_crop_group	*Description*
1	Brassicacee crop family
2	Cultivation under glass
3	Industrial crops
4	Cucurbitacee crop family
5	Forage crops
6	Underground Orchard vegetables with summer-spring farm cycle
7	Surface Orchard vegetables with fall-spring farm cycle
8	Surface Orchard vegetables with summer-spring farm cycle
9	Surface Orchard vegetables with spring-summer farm cycle
10	Solanacee crop family
11	Rice
12	Dried fruit
13	Fruit trees with fall-winter harvest
14	Fruit trees with spring-summer harvest
15	Vineyards
16	Olive trees

Table 1. Crop Groups

A specific Land use database of the irrigated areas was built at 1:50.000 scale. The geographic database was realized by Supervised classification on remote sensing summer cover (Landsat Thematic Mapper 2006), based on INEA irrigated crops spectral signatures reference dataset and definition of final geographic extension based on detailed digital orthoimages with 1 meter of pixel resolution (fig.3).

Related crop and thecniques DB informative structure

The 59 different irrigated crops existing all over Southern Italy were grouped into sixteen main groups (Tab.1). For each group in the land use layer, were collected in the info table the informations related to the “reference crop”, as crop code and description, root extraction depth (cm), Leaf area Index, Irrigation intervention threshold (mm), Summation of growing degree days, Cultural coefficient (Kc).



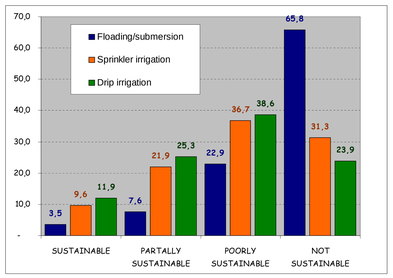


Figure 6. Cumulative percentage areas for the different sustainability classes and three reference irrigation in the Southern Italy irirgated areas

Figure 5. Irrigated Use Sustainability maps of Basilicata (1), Sicily (2) and Puglia (3) Regions for Sprinkler irrigation technique