# Operation of a Digital Advisory Service for Irrigation Water Management: Case Study for Maize and Alfalfa Crops in Greece

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**Abstract**

Efficient ICT tools covering extensive areas consist important tools for tackling poor efficiency in participatory irrigation networks. IRMA_SYS, a climate smart irrigation DSS that assists implementation of good agricultural practices regarding the use of irrigation water without requiring in-situ equipment installation, is implemented to document irrigation practices for maize and alfalfa applied by the farmers of the Land Reclamation Organization of Poros, located at Ioannina, Epirus. The evaluation of the estimated irrigation timing yielded from IRMA_SYS against the actual irrigation dates, demonstrated that in most cases IRMA_SYS spotted the irrigation patterns followed by the farmers, respecting the prevailing weather conditions. For the maize, a ten-day delay was evident between the IRMA_SYS' output and the first two actual irrigations, while for the rest of the irrigation period the irrigations matched. For the alfalfa, the IRMA_SYS suggested to irrigate earlier and apply smaller amounts of water frequently. The differences can be explained since the farmers irrigate based only on traditional practices and experience, while IRMA_SYS implements a novel soil water budget irrigation scheduling approach.

**Keywords**

IRMA_SYS, Irrigation, Good Agricultural Practices, Maize, Alfalfa

## 1. Introduction

Considering the fact that during the last decades there is an evident decrease of the available water resources for agriculture while irrigation demands increase due to poor efficiency of the utilized irrigation methods and/or lack of maintenance of the centralized irrigation networks, pressing on the application of the EU directive 60/2000 is crucial. Land Reclamation Organizations (LRO) are the legal entities that manage participatory irrigation and drainage networks in Greece, so the irrigation water use efficiency in the areas of their interest is bonded to the efficient operation of the LRO's themselves.

In this context, irrigation tools that are efficient while covering extensive areas without requiring in-situ equipment installation, is a priority and an important factor for achieving the above-mentioned goals. IRMA_SYS is a climate smart irrigation decision support system that assists implementation and documentation of good agricultural practices regarding the use of irrigation water since 2015 [1]. It provides recommendations to farmers on irrigation management through an integrated IoT system, aiming to optimize use of water and energy and saving labor. More precisely, IRMA_SYS uses ICT to collect, store and process necessary data from point sources (agrometeorological stations) and transform them to maps that cover large areas. In this way, basic weather data and reference evapotranspiration are available for each point inside the covered area. This information is then combined with information provided by the users for their fields and the irrigation events they apply, to provide irrigation management recommendations [2].

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The present study intents to provide information about the use of IRMA_SYS to document irrigation practices for maize and alfalfa applied by the farmers of the LRO of Poros, located on the south side of the Ioannina basin, Epirus. Also, evaluation of the estimated irrigation timing yielded from IRMA_SYS, against the actual irrigation dates will be presented.

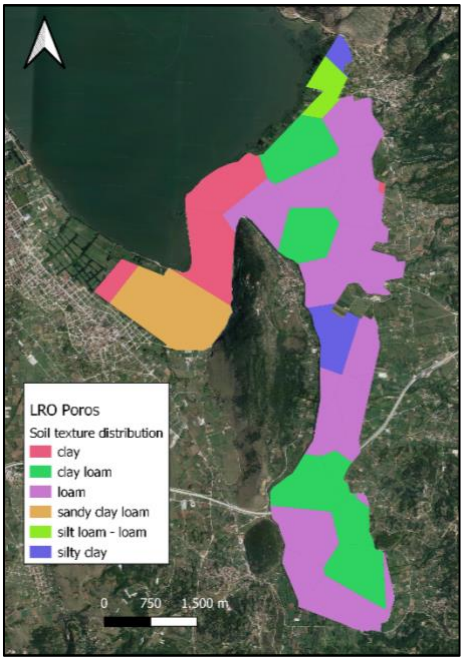
## 2. Materials and Methods

### 2.1. Study Area

The study area (Figure 1) consisted of the area covered by the LRO of Poros, located on the south side of the Ioannina basin. This LRO covers an area of approximately 1500 ha, but only 500 ha i.e., 33% are cultivated systematically. The main crops are maize, and alfalfa used for livestock feed, totaling 414 ha.

**Figure 1**: Study area limits with maize and alfalfa fields.

Figure 2 presents the soil texture distribution of the study area, from which is apparent that the dominant soil texture is Loam (47.2%) followed by Clay Loam (22.7%).



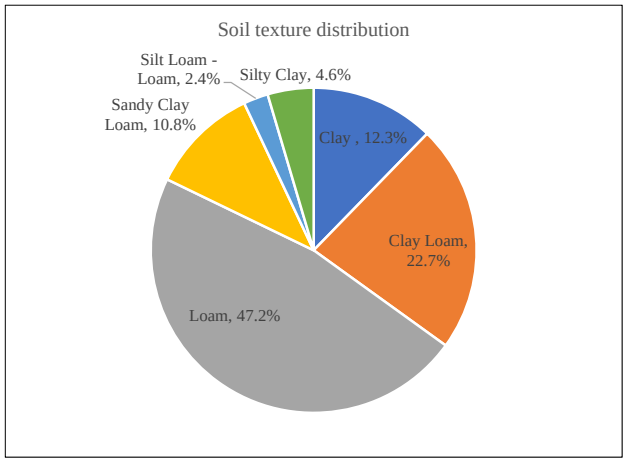
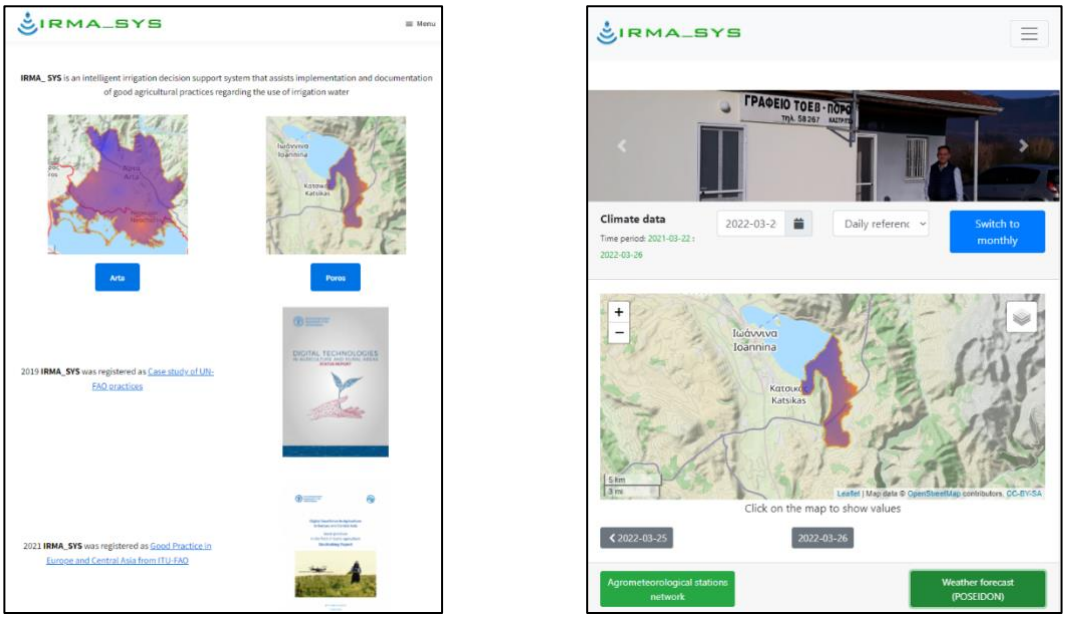




**Figure 2**: Soil texture distribution.

## 2.2. IRMA_SYS

IRMA_SYS (https://irmasys.com - Figure 3a) was installed at the LRO of Poros in 2021 (https://poros.irmasys.com - Figure 3b). It uses real time (10-min averages) data from two agrometeorological stations. Data are sent via VHF to a communication center, which is connected to the system's server. All this information, along with data concerning irrigation events (inserted by the user) and weather forecast data, is used to estimate irrigation water requirements on daily time step. A modification of the FAO56 [3] soil water budget irrigation scheduling approach is implemented for this task. The service is available in both Greek and English languages.




(a) (b)

**Figure 3**: IRMA_SYS main web page, https://irmasys.com (a), along with the IRMA_SYS installation for the LRO of Poros, https://poros.irmasys.com (b)

Also, timeseries of data from the virtual meteorological station of each field are available for downloading, based on spatial interpolation of the meteorological stations point data. These data comprise from rainfall, air temperature, relative humidity, solar radiation, wind speed and reference evapotranspiration according to FAO56 [3].

IRMA_SYS provides means of extracting registered information of each of the listed fields, such as timeseries of effective rainfall, estimated irrigations and actual irrigations registered by the users. During the irrigation period of 2021 actual irrigations were registered for every field inside the study area. For the purposes of the present study, actual irrigation timing for the main crops i.e., maize and alfalfa, applied by the farmers along with comparison against the estimated irrigations dates yielded from IRMA_SYS follows.

## 3. Results and Discussion

Figure 4 presents the rainfall events during the irrigation period of 2021, totaling 153 mm on average. During this period three major rainfalls occurred: the first took place on the 15$^{th}$ of May with 22 mm of rainfall, the second occurred on the 10$^{th}$ of July with 34.4 mm, while the third took place on the 29$^{th}$ of September with 25 mm of rainfall.

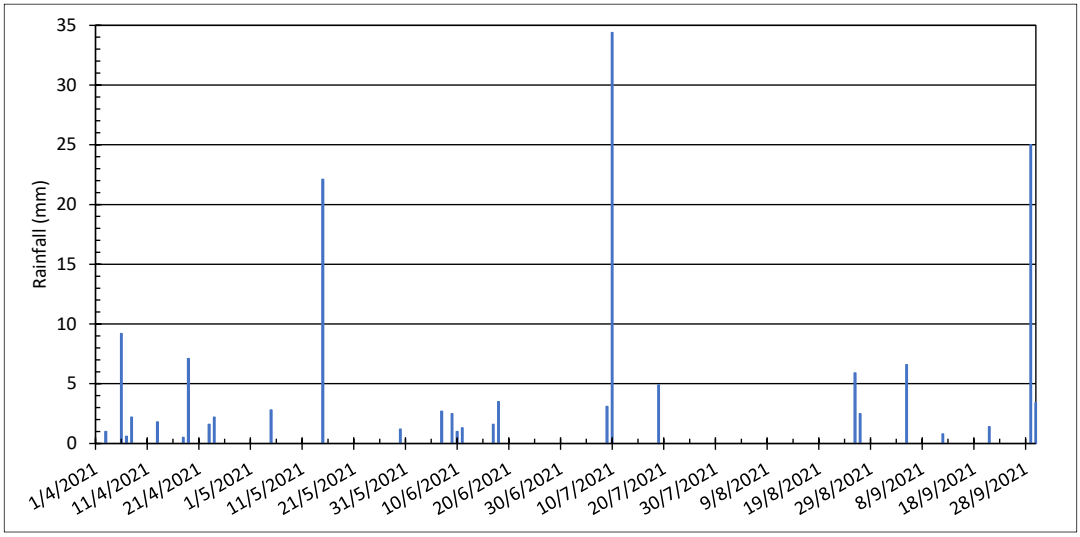



**Figure 4**: Rainfall events at the area of LRO of Poros during the irrigation period of 2021.

Table 1 presents the distribution of the IRMA_SYS modelled irrigations for the maize crop during the irrigation period of 2021. The irrigated maize fields were 131 in total, with 100% of them needing three irrigations, while 89.3% of them needing four irrigations and 55.7% of them needing five irrigations. For thirty-seven fields, six irrigations were recommended while for one field a total of eight irrigations were recommended.

**Table 1**
Distribution of modelled irrigations for maize during the 2021 irrigation period

| Month | Decade | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
|---|---|---|---|---|---|---|---|---|---|
| June | 1 | | | | | | | | |
| | 2 | 0.8% | | | | | | | |
| | 3 | | | | | | | | |
| July | 1* | **55.0%** | 0.8% | | | | | | |
| | 2 | 33.6% | 0.8% | | | | | | |
| | 3 | 10.7% | **54.2%** | 0.8% | | | | | |
| August | 1 | | 42.0% | **55.0%** | 0.9% | | | | |
| | 2 | | 2.3% | 33.6% | **60.7%** | 1.4% | | | |
| | 3 | | | 7.6% | 0.9% | **79.5%** | | | |
| September | 1 | | | 3.1% | 6.0% | 17.8% | | | |
| | 2 | | | | 31.6% | 1.4% | | | |
| | 3* | | | | | | 2.7% | | |
| October | 1 | | | | | | | **100.0%** | |
| | 2 | | | | | | **64.9%** | | |
| | 3 | | | | | | 32.4% | | **100.0%** |
| Number of irrigated fields | | 131 | 131 | 131 | 117 | 73 | 37 | 1 | 1 |

* denotes that rainfall greater 20 mm occurred

According to IRMA_SYS, most of the fields (55%) should have been irrigated for the first time on the start of July, before the rainfall event that occurred on the 10th. The second irrigation was estimated at the third and the first decade of July and August (96.2% of the fields in total), correspondingly. For the majority of the fields (55%), the third irrigation period was completed during the first ten days of August, while during the second decade another 33.6% completed the same irrigation. The fourth irrigation was completed in two major parts: the first one (60.7% of the fields) from 11th to 20th of August and the second (31.6% of the fields) from 11th to 20th of September. The fifth irrigation was estimated from the 21st of August until the 10th of September. The remaining three irrigations were intended for October.

Table 2 presents the actual irrigations distribution for the maize crop during the irrigation period of 2021 for the LRO of Poros. All fields but one, were irrigated four times, starting at the end of May, and ending on the 10th of September. The field that was irrigated three times, significantly delayed the first irrigation, which was performed at 12/7/2021. Most of the farmers irrigated for the first time during the last ten days of June up to the 10th of July (73.2% of the fields). The other three irrigations followed by a ten-day offset between them, practically ending by the end of August.

**Table 2**
Distribution of actual irrigations for maize during the 2021 irrigation period

| Month | Decade | 1st | 2nd | 3rd | 4th |
|---|---|---|---|---|---|
| May | 1 | | | | |
| | 2* | | | | |
| | 3 | 2.3% | | | |
| June | 1 | 6.9% | | | |
| | 2 | 13.0% | 3.8% | | |
| | 3 | **42.7%** | 6.1% | | |
| July | 1* | 30.5% | 22.9% | 4.6% | |
| | 2 | 4.6% | **41.2%** | 12.2% | |
| | 3 | | 23.7% | 29.0% | 3.1% |
| August | 1 | | 2.3% | **39.7%** | 16.9% |
| | 2 | | | 13.7% | **37.7%** |
| | 3 | | | 0.8% | 36.2% |
| September | 1 | | | | 6.2% |
| | 2 | | | | |
| | 3* | | | | |
| Number of irrigated fields | | 131 | 131 | 131 | 130 |

* denotes that rainfall greater than 20 mm occurred

Table 3 presents the distribution of the IRMA_SYS modelled irrigations for the alfalfa crop during the irrigation period of 2021. The irrigated alfalfa fields were 46 in total, with 100% of them needing four irrigations, while 69.6% of them needing five irrigations and 52.2% of them needing six irrigations. For seven fields, seven irrigations were estimated while for one field a total of nine irrigations were estimated.

According to IRMA_SYS, half of the fields (50%) should have been irrigated for the first time during the first ten days of June, while the rest irrigations were uniformly spread across the remaining days of June. The second irrigation was estimated at the third decade of June (52.2% of the fields), correspondingly. For the majority of the fields (82.6%), the third irrigation period was completed during the first ten days of August, while during the second decade the remaining 15.2% completed the same irrigation. The fourth irrigation was completed in three almost equal parts, from the 21th of July up to the end of August. The fifth irrigation was concentrated at the second decade of August. The remaining four irrigations were intended for September.

**Table 3**
Distribution of modelled irrigations for alfalfa during the 2021 irrigation period

| Month | Decade | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th |
|---|---|---|---|---|---|---|---|---|---|---|
| May | 1 | | | | | | | | | |
| | 2* | | | | | | | | | |
| | 3 | 2.2% | | | | | | | | |
| June | 1 | **50.0%** | | | | | | | | |
| | 2 | 23.9% | 2.2% | | | | | | | |
| | 3 | 23.9% | **52.2%** | 2.2% | | | | | | |
| July | 1* | | 15.2% | 2.2% | | | | | | |
| | 2 | | 6.5% | **41.3%** | 2.2% | | | | | |
| | 3 | | 23.9% | 8.7% | **26.1%** | 3.1% | | | | |
| August | 1 | | | 30.4% | **26.1%** | | 4.2% | | | |
| | 2 | | | 15.2% | | **71.9%** | | 14.3% | | |
| | 3 | | | | 21.7% | | | | | |
| September | 1 | | | | | 3.1% | **62.5%** | | **100.0%** | |
| | 2 | | | | 8.7% | 3.1% | 33.3% | | | |
| | 3* | | | | 15.2% | 18.8% | | 85.7% | | **100.0%** |
| Number of irrigated fields | | 46 | 46 | 46 | 46 | 32 | 24 | 7 | 1 | 1 |

* denotes that rainfall greater 20 mm occurred

Table 4 presents the actual irrigations distribution for the alfalfa crop during the irrigation period of 2021 for the LRO of Poros. All fields, were irrigated four times, starting at the second decade of May, and ending on the 10th of September. The majority of the farmers irrigated for the first time during the first twenty days of June (73.9% of the fields). The second was after twenty days, while the other two irrigations followed in ten-day intervals correspondingly.

**Table 4**
Distribution of actual irrigations for alfalfa during the 2021 irrigation period

| Month | Decade | 1st | 2nd | 3rd | 4th |
|---|---|---|---|---|---|
| May | 1 | | | | |
| | 2* | 2.2% | | | |
| | 3 | 2.2% | | | |
| June | 1 | 34.8% | | | |
| | 2 | **39.1%** | | | |
| | 3 | 19.6% | 4.3% | | |
| July | 1* | 2.2% | 21.7% | | |
| | 2 | 2.2% | **50.0%** | 2.2% | |
| | 3 | | 23.9% | 23.9% | |
| August | 1 | | | **45.7%** | |
| | 2 | | | 28.3% | 21.7% |
| | 3 | | | | **52.2%** |
| September | 1 | | | | 26.1% |
| | 2 | | | | |
| | 3* | | | | |
| Number of irrigated fields | | 46 | 46 | 46 | 46 |

* denotes that rainfall greater 20 mm occurred

## 4. Conclusions

IRMA_SYS was implemented to document irrigation practices for maize and alfalfa applied by the farmers of the LRO of Poros and model irrigations according to the soil water budget approach. Considering the estimated number of irrigations, IRMA_SYS, recognized the irrigation patterns followed by the farmers, for most of the fields, respecting the prevailing weather conditions.

For the maize crop, a ten-day delay was evident between the IRMA_SYS' output and the first two actual irrigations, while for the rest of the irrigation period the irrigations matched. For the alfalfa crop, the IRMA_SYS suggested to irrigate earlier and apply smaller amounts of water frequently. The differences can be explained since the farmers' approach is based only on traditional practices and experience.

Conclusively, it seems that farmers are obviously skeptical about weather forecasting and insist on scheduling irrigations based only on their established experience. Nevertheless, the calibration procedures of IRMA_SYS will consider those practices and evolve them into valuable information for further improvement of the system, as systematic improvement of sets of parameters of crops is one of the main aspects of the IRMA_SYS approach.

## 5. Acknowledgements

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## 6. References


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