

Irrigation water requirement

By:

A.M. van Lieshout / J.A.M. de Brouwer

Department of Earth Resources Surveys,

International Institute for Aerospace Survey and Earth Sciences (ITC),

P.O. Box 6, 7500 AA Enschede, The Netherlands.

Tel: +31 53 4874306, Fax: +31 53 4874336, e-mail: LIESHOUT@ITC.NL

Tel: +31 53 4874283, Fax: +31 53 4874336, e-mail: BROUWER@ITC.NL

Summary

For a command area with different crops and soils the total water requirement has to be calculated. The table and map calculation features of ILWIS for Windows are used to combine different map layers and table attributes.

Getting started

The data for this case study are stored on the ILWIS 2.1 CD-ROM in the directory d:\appguide\chap09. If you have already installed the data on your hard-disk, you should start up ILWIS and change to the subdirectory where the data files for this chapter are stored, c:\ilwis21\data\appguide\chap09. If you did not install the data for this case study yet, please run the ILWIS installation program (see ILWIS Installation Guide).



- Double-click the ILWIS program icon in the ILWIS program group.
- Change the working drive and the working directory until you are in the directory c:\ilwis21\data\appguide\chap09.

Now you are ready to start the exercises of this case study.

9.1 Objectives

In this case study the irrigation water requirement for a command area under various crops, texture and conveyance loss conditions has to be calculated. Various basic GIS principles such as crossing of maps, linking of tables and aggregation have to be implemented.

In the exercise the irrigation water requirement has to be calculated for a 10-day period during the harvest stage.

9.2 Available data

Maps of an irrigation scheme have been prepared for the command-area, irrigation channels, soil and land cover. The command area is divided in blocks, each block has one inlet. Tables are present with the crop coefficients (kc) for various crops and infiltration rates for various textures.

The following maps are available:

| | |
|----------|---|
| Scheme | Command area with names of the irrigation blocks. |
| Canal | Position of irrigation channels. |
| Inletpnt | Inlet points per block. |
| Soil | Soil texture of the command area. |
| Crop | Crops in the command area. |

The following tables are available:

| | |
|----|--|
| Kc | crop coefficients (kc) for different crops under various growing stages. |
|----|--|

The percolation losses per soil texture are:

| Texture | Percolation loss (mm/day) |
|------------|---------------------------|
| Clay | 4 |
| Loam | 12 |
| Sandy clay | 14 |
| Clay loam | 7 |

The conveyance loss per meter channel length is:

0.2 m³ per day for clay channels.

0.01m³ per day for concrete channels.

Each block receives water only one day every 10-day period.

ETo reference crop is 8 mm/day.



- Display the available maps.
- Display the available table.

9.3 Methodology

9.3.1. Balancing input-output

To calculate the required irrigation gift for the entire command area a simple water balance has to be set-up. The total water demand has to be calculated by summing up the following components:

- seepage through the channel,
- infiltration through the soil,
- maximum evapotranspiration of the crop.

The optimum irrigation gift equals the total of the demand aggregated for the whole area.

9.3.2. Maximum evapotranspiration

Crop water requirements are normally expressed by the rate of evapotranspiration (ET) in mm/day or mm/period. The evaporative demand can be expressed as the reference crop evapotranspiration (ET_o) which predicts the effect of climate on the level of crop evapotranspiration; ET_o represents the rate of evapotranspiration of an extended surface of an 8-15 cm tall green grass cover **not** short of water. Empirically-determined crop coefficients (k_c) can be used to relate ET_o to maximum crop evapotranspiration (ET_m) when water supply fully meets the water requirement of the crop. The value of k_c varies with crop and development stage.

For a given climate, crop and crop development stage, the maximum evapotranspiration (ET_m) in mm/day of the period considered is:

$$ET_m = k_c * ET_o \quad [9.1]$$

Maximum evapotranspiration refers to conditions when water is adequate for *unrestricted* growth and development under *optimum* agronomic and irrigation management.

The calculation procedure includes the following steps:

1. Determine the Reference Evapotranspiration (ET_o).
2. Determine growing period and length of crop development stage and select k_c values.

3. Calculate Maximum Evapotranspiration (ET_m) for each 10-day period.

The K_c-values for each crop are available in a table. For each block the ET_m can be calculated .

9.3.3. GIS procedures

The following GIS/Data base procedures have to be used to calculate the irrigation water requirement:

1. Crossing of maps: If two maps are crossed data can be obtained of the areas occupied by each unique combination of mapA values and mapB values. (e.g. cropping area per block). Input are two maps the output is a cross table with the area of each unique combination and (optional) a cross map with unique values for each combination.
2. Linking of table with map: A map can be created using the attribute data present in a table. Linking can only be done if the domain of the map is the same as the domain of the table (e.g. crop with k_c values)
3. Linking of tables: attribute data of one table can be transferred to another table using common *key columns* (the relational data base concept). In such a way tabular data can be transferred to histogram tables created from maps.
4. Table calculations: calculations can be performed on individual columns or a combination of columns. (e.g. ET_m 10-day = k_c*ET_o*10)
5. Aggregation: for each unit (e.g. block number) columns can be aggregated. For example the total infiltration of the whole command area can be calculated per block.

9.4 Exercise

9.4.1. Problem analyses

Look at the problem and available data carefully. All the data needed to determine the water requirement for a *10-day period* during the *harvesting period* has to be calculated for the whole command area.



- Fill in the following formulas (per block for a 10-day period). Do not forget the dimensions!
Percolation =
Conveyance loss =
Maximum evapotranspiration =
- Design a flow diagram for the calculation of the three separate water demanding components: the maximum evapotranspiration, the percolation and the conveyance losses.

- ! The calculations can be done with maps or with tables. It is advisable is to work with tables from which the overview can be easily obtained. For displaying the final result the table can be linked to the Scheme map.
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9.4.2. GIS procedure

The step to calculate the infiltration loss is given below. The other steps you have to do on your own. The infiltration loss has to be calculated per block for a period of 10 days.



- To determine the area of each texture class in each block the maps Scheme and Soil have to be crossed. A table with the domain Scheme*Soil and the attributes Scheme, Soil, Npix and Area.
- Create a table with the percolation data.
- Join the percolation table to the cross table to get the percolation for each texture in each block.
- To calculate the percolation for each soil texture per block enter the formula.
- In order to calculate total percolation loss per block aggregate the cross table and group by scheme.

In the same manner you have to calculate the conveyance losses and the crop water requirements. At the end, the total requirements for the whole irrigation area have to be calculated.

- ! To get the 'distinct' total water requirement for each block the aggregated values (SUM) have to be written in a new table which will get the domain Scheme. These values can be linked to the map Scheme and an attribute map can be created.
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9.5 Reclassification

An output map can be created depicting the total irrigation water requirement for each block. Use the following table to reclassify the total values.

| Upper boundary | Irrigation class |
|----------------|------------------|
| 4000 | 1 |
| 6000 | 2 |
| 8000 | 3 |
| 10000 | 4 |
| 12000 | 5 |
| 14000 | 6 |



- Create a new domain of type **Group** called `irrclas` with the boundaries given above.
- Create an output map including the annotations of the irrigated area with the classes.

9.6 Script

Scripts are used to automate a sequenced list of operations in ILWIS. By creating a script, a complete GIS or Remote Sensing analysis can be automatically done. The procedure to calculate the total irrigation water requirement is quite suitable to be put in a script.



- Create a script to automate the calculation procedure. In the command line all the actions which you have executed to come to the final result can be read. The correct script syntax is displayed there.

Use the file `Ilwis.log`. It keeps record of all executed applications.
- Test the script and modify it so it can calculate the irrigation water requirement for a 10-day period in the middle (mid) of the growing stages of the crop.