Surface Irrigation Design, Water Quality Risk Assessment, & Irrigation Scheduling Tool

Global Design Team
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Quick Design & Assessment Tool

Getting Started

On the “Introduction” tab of the spreadsheet, users are given a concise description and tutorial of the software. Inputs for the model are kept basic in nature to ensure ease-of-use. Of course, design parameter outputs are only a computed suggestion and should be adapted to specific field conditions. The introduction page is shown in the screen capture to the right.

Surface Irrigation Design

In most instances the farmer knows what type of irrigation is best suited based on the crop being grown. The tool allows them to choose either furrow or basin irrigation, as these are the two most common types of irrigation used in under-developed countries that cannot afford sprinkler or drip systems.

Water Quality Risk Assessment

In addition to the development of the primary irrigation design spreadsheet, a water quality component has been added to provide a risk assessment of the irrigation water.

The user may enter pertinent information, such as pH and various chemical concentrations found in a water sample. If any outputs display a “High Risk” value, the water should be diluted to a safer level before use in irrigation.
Introduction

In developing countries, where food sources are limited, maximizing crop yield is essential to the survival and well-being of the local population. The Global Design Team (GDT) of Agricultural and Biological Engineering at Purdue University has been working in conjunction with the International Water Management Institute-West Africa Region to develop a master system in Microsoft Excel. This software package generates a variety output data which users can apply to find solutions for several common irrigation obstacles, including:

- Optimal design parameters for furrow and basin irrigation systems
- Risk assessment of irrigation water quality
- Suggested irrigation calendar

Global Design Team Specific Objectives:

- Develop software which outputs irrigation design parameters, irrigation water quality risk and a basic irrigation schedule.
- Ensure that the software is user-friendly by requiring only basic inputs and utilizing a streamlined layout.
- Communicate with contacts from IWMI’s Ghana extension to help guide software development.

Irrigation Design

The primary source of information used to develop the GDT’s master system is the Food and Agriculture Organization (FAO) of the UN. The FAO is the leader in the research and design of surface irrigation systems in Africa, hence their manual *Guidelines for Designing and Evaluating Surface Irrigation Systems*. The GDT also referenced a spreadsheet developed by USDA Arid-Land Agricultural Research Center.

There are many factors that determine the design of a furrow or basin system. The object of the design is to optimize Application Efficiency (AE). Following are some of the equations:

1) \[ E_a = \frac{Z_{req} \cdot L}{Q_o \cdot t_{co}} \]

2) \[ T_2 = T_1 + \frac{Z_{req} - kT_1^a - f_o T_1}{a \cdot k} \]

3) \[ V_Z = W \int_0^L (k \tau^a + c \tau) \, dx \]

Eq. 1 was used to determine the Application Efficiency. It takes into account the required volume of water that must infiltrate, the length of the field, flow rate, and cutoff time. Eq. 2 is a basic equation that was manipulated to help determine the intake opportunity time. Both 1 & 2 came from the FAO’s guidelines. Eq. 3 was found in the previously created spreadsheet which is manipulated to calculate the advance time. Eq. 3 comes from the American Society of Agricultural Engineers’ Standards, standard EP419.1 DEC99.
Irrigation Scheduling

Methodology

The irrigation scheduling design spreadsheet uses the water balance model to compute a suggested irrigation calendar:

\[
\text{Irrigation} + \text{Rainfall} = \text{Evapotranspiration} + \text{Runoff} + \text{Deep Percolation} + \text{Soil Moisture Change}
\]

Evapotranspiration is calculated using the Penman-Monteith equation (FAO-56).

Necessary inputs, including parameters for effective rainfall, climate data, soil properties and crop characteristics are derived from empirical information supplied by FAO and IWMI.

### User Interface

Six basic inputs are required for output of an irrigation calendar: Soil type, management-allowed depletion, soil moisture at time of seeding, crop type, planting date, and location.

If no pre-listed options for a basic parameter are appropriate (i.e. a crop type isn’t listed), users are able to enter custom information to best suit their needs.

When all basic inputs and any necessary custom inputs have been entered, users may click on the “Crop Calendar” tab to see a computed irrigation calendar. The calendar is based on a steady rainfall pattern and should be adjusted for adverse conditions.

The calendar shown to the left is a sample of the output determined by the basic inputs entered in the above image.

### Validation

With the main design of the program complete, we have now moved on to validating our program. We decided to test our program against one commonly used for furrow and basin design, WinSRFR 3.1 Project Management Tool. We have set up several case studies (some of which are shown to the right) and compare the results against one another.

With this information we have gone back and tweaked our program so that we are getting very similar answers out of both programs.

We decided to use the WinSRFR program because it is commonly used by the USDA and the Arid-Land Agricultural Research Center to improve on furrow design. We thank them for letting us use the program for comparison.

### References & Acknowledgements

**References**

- ASAE Standards, 2000
- FAO Corporate Document Repository

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