Simple Irrigation Efficiency
Working Metric Version 1.0 | November 2018

The **Simple Irrigation Efficiency (SIE)** metric measures the amount of water applied to a crop relative to the crop's actual water demand. The SIE metric takes into account the crop's water need based on crop and site-specific evapotranspiration and considers a potential leaching requirement and rainfall contribution.

Metric

$$\text{Simple Irrigation Efficiency} = \frac{\text{Water applied}}{\text{Crop's water demand}}$$

Features:

- Applied water: total ground and surface water applied during growing season
- Crop's water demand accounts for evapotranspiration (the sum of crop transpiration and soil evaporation) and rainfall during the growing season (if any)
- Data collection period (annual crop): Unlike other SISC metrics, which measures water applied from harvest to harvest, the SIE metric includes all irrigation events between the planting date of a given crop and the termination date of that crop. This is because evapotranspiration starts when the crop is planted. The pre-planting period is accounted for in the SISC Applied Water Use Efficiency metric.
- Data collection period (perennial crop): For perennial crops, data collection starts at the end of harvest through the following harvest the year after
- Leaching requirement: The minimum leaching requirement needed to control salts in irrigation water is included as an optional data input
- Default reference vs local values: Evapotranspiration is calculated using a reference value, which is representative of the farm's specific location and weather, and a default crop coefficient specific to the specialty crop being grown. The user has the option to override default values for the crop coefficient and input local values -- *use of local values for the crop coefficient is strongly encouraged*.
- This metric is an end of season performance metric and not an irrigation management tool – there is the optional inclusion of environmental factors, but it does not include the grower-specific management factors like irrigation method and Distribution Uniformity. This is because these elements can be used to increase a grower's efficiency.

Difference Between SISC's Two Water Metrics

SISC has already developed one water use metric, the Applied Water Use Efficiency metric, which measures the total amount of applied water used to produce a crop. The Applied Water Use Efficiency metric is calculated by dividing the acre-inches applied water by tons of product harvested. Unlike the Applied Water Use Efficiency metric, the SIE metric allows comparison across regions and year-to-year.

Recommended Issues to Consider in the Future

Through working group discussions, technical review, and Metric Technical Advisory Committee (MTAC) discussions, the following items have been identified as issues to be considered in future iterations of this metric:

- A future consideration might be to include Distribution Uniformity (DU) as a grower lookup value corresponding to good management. DU would be included in the denominator of the metric, so that SIE = Applied Water / Recommended Water. DU would be a lookup value that represents a realistic ceiling (<1) to the actual DU that a particular field can expect based on irrigation system and local conditions. In order to use the metric to compare fields with different types of irrigation, the SIE metric currently does not include DU. If in the future, this component becomes more relevant to metric comparison and good management practices, it will be included within the SIE metric.
- A future upgrade, given that the technology to measure variables has been developed and do not place undue burden on the grower, could be to implement a soil water balance calculator. This calculator would take into account soil texture and organic matter to determine soil moisture holding capacity and could provide greater metric accuracy and help with improve water management.
- Harmonize the SIE metric with the Evapotranspiration tool that the Environmental Defense Fund is currently in the process of developing (Open ET) for the arid west

Technical Notes

The Simple Irrigation Efficiency Metric is calculated at the end of the growing season as follows:

$$SIE = \frac{Water\ Applied}{\frac{ET_c}{(1 - LR)} - Rainfall}$$

Each component is further explained here.

Water Applied

The Water Applied component is a direct data input from the grower in inches. Growers can input daily irrigation values directly into the calculator. Total water applied should include all applied water from start (planting) date to end of harvest date in inches. It can also be measured as the volume of water applied in acre-inches divided by the number of acres.

The amount of water applied should be estimated by following the protocol in "SISC Metric: Applied Water Use Efficiency" on the metrics page at www.stewardshipindex.org.

Leaching Requirement (LR)

The leaching requirement is the minimum amount of water needed to control salt accumulation in the soil caused by irrigation water and to maintain soil salinity within the crop's tolerance range. It is an optional data input – if growers choose not to account for the leaching requirement, the calculator will factor in zero for the leaching requirement value. The leaching requirement (LR) is measured using the Rhoades equation[1] and requires values[2] for the salinity of applied irrigation water (EC_w) and the soil salinity tolerated by the crop (EC_e*):

$$LR = \frac{EC_w}{5 * EC_e^{*} - EC_w}$$

EC_w = salinity of applied irrigation water
EC_e* = average soil salinity tolerated by the crop

Evapotranspiration (ETc)

Evapotranspiration of the crop is calculated by multiplying the grass reference evapotranspiration (ETo) by the crop coefficient (Kc). The calculator computes[3] Kc values, defaulting to reference values[4]; however, users are encouraged to input local data based on crop development models from local universities or research and extension institutions.

Input variables for adjusting Kc to climate include wind speed, minimum relative humidity, and height of mature crop. The crop coefficient is dependent on the growth stage of the crop[3], which is normalized given the type of crop that is planted[4]. These formulas are used in the calculator and are listed in the document "SIE User's Guide; Methodology section" on the metrics page at www.stewardshipindex.org.

Some reference evapotranspiration sources use alfalfa instead of grass – when alfalfa is the reference crop, the crop coefficient is converted, adjusted for climate and alfalfa specific data[5].

Rainfall

The amount of rainfall is an optional variable for those regions that will need to account for it. Growers should input daily effective rainfall data from the growing period directly into the calculator. The total

[1] Equation 9 - Ayers, R.S. and Westcot, D.W. 1994. Water Quality for Agriculture. Irrigation and Drainage Paper 29, Rev. 1. Food and Agriculture Organization of the United Nations, Rome.
[2] Table 4 - Ayers, R.S. and Westcot, D.W. 1994. Water Quality for Agriculture. Irrigation and Drainage Paper 29, Rev. 1. Food and Agriculture Organization of the United Nations, Rome.
[3] Equation 66 – FAO 56
[4] Table 11 – FAO 56
[5] Based on Equation 62 – FAO 56. Kc mid = 1.2, based on the value listed for alfalfa in FAO 56 Table 12; and h = 0.5, based on the average height of alfalfa

amount of rainfall is measured in inches and is the sum of all rain events between planting and end of harvest dates.

The grower will be required to determine the effective rainfall during the growing season – rainfall in excess of .10 inches and up the cumulative ETc since the last irrigation or rain event will be counted. Rainfall will not be counted in growing conditions where full-bed plastic mulch, hoop houses, or any other method that blocks access of the root zone to rainfall are used.

Data Inputs

Variables included in the spreadsheet as references

- Kc values
- Soil salinity tolerated by crop (ECe* for optional leaching requirement)
- Length of crop growth stages

Variables that the user must look up externally

- Reference ETo data from local weather station; select alfalfa or grass reference

Required User Input Variables

- Number of crops (of interest) annually rotated on management area (select from drop-down: 1 crop, 2 crops, or 3 crops – populates data input cells for crops 2 and 3 if more than one crop was rotated; for perennial crops, select 1 crop)
- Type of crop (select from drop-down list)
- Plant and end of harvest dates
- Best fit for growth stage and best fit for Kc values (select from drop-down)
- Wind speed (select from drop-down: light, light to moderate, moderate to strong, strong)
- Daily minimum relative humidity (select from drop-down: arid, semi-arid, sub-humid, humid, very humid)
- Amount of water applied (inches per day)

Optional User Input Variables

- User Management Area Name
- Rainfall (inches per day)
- User-specified growth stages (override of normalized growth stages if user has data)
- Local Kc values (override of adjusted Kc values if user has local data)
- Height of mature crop (override of crop height if user has data)
- Salinity of applied irrigation water (ECw for leaching requirement)