Definition:

$$\frac{Grain/Fruit/\ Tuber\ yield}{Water}$$

Description

Benefit: This impact area refers to the weight of harvested parts of plants that possess economic value. It is suitable, where production is to be used food or feed purposes or as a non-energetic production factor in bio-refineries. Crops with high per hectare yield will show high efficiencies in this impact area.

Resource: Even in rainfed agriculture, water can constitute a stressed resource, impacting for example on farmers' decisions whether or not to plant cover crops. Irrigation water is always a stressed resource. In cases of seasonal water shortages, the use of water can also be specified as use during critical time periods.

Correlation with soil management

[57] Treatment with constant groundwater table showed higher water use efficiency than crops in irrigated field, irrespective of planting density

[67] Application of hydrogel, on sandy soils improves water holding capacity and availability of the nutrients. The higher the amount of hydrogel the higher the water use efficiency

[73] Water is clearly a key resource in potato production that affects the use efficiency of other resources

[98] Limiting irrigation or changing irrigation patterns in areas with high water pressure, as well as expanding irrigation in areas with abundant water resources increases water use efficiency. Improving irrigation efficiency and reducing irrigation water per unit area are methods to increase regional water use efficiency. Enhancing crop varieties and crop yield can contribute to increase regional water use efficiency

[130] The treatments with alternate furrow and surge flow irrigation had higher crop yield and water use efficiency of all treatments

[135] Water use efficiency of the treatment with micro irrigation was higher than with check basin irrigation for both crops

[195] Results showed a positive and additive effect of water and nitrogen application on Water Use Efficiency, reflected by yield enhancement

[241] Highest land use efficiencies (potato yield per hectare of area) were achieved in regions that produce potatoes under irrigation in summer where solar radiation is high and lowest land use efficiencies were reported for the predominantly dryland and partially dryland regions

[242] Water-saving irrigation and high nitrogen use efficiency are becoming more and more important in rice production aimed at high and stable yield due to the shortage of water resources and the spread of non-point source pollution caused by irrational fertilization

[252] In the case of crop rotations, increasing resource-use efficiency while reducing yield gaps can be addressed by suitable agricultural management practices

[266] Alternate partial root-zone irrigation usually resulted in a higher water use efficiency improvement with no significant difference in yield but 33.3% less irrigation water
[274] Result suggests that in the presence of superabsorbent polymer, maize leaf and grain carbon isotope discrimination could be good indicators for evaluating maize water use efficiency during periods of low rainfall
[284] System of rice intensification methods were beneficial for improving soil fertility because of effects on soil microbial biomass. Results also suggest that there is a substantial potential to raise rice yields by changing field management and cultivation methods rather than depending on genetic modifications or increases in agrochemical inputs
[286] AquaCrop model has been widely used and calibrated to simulate yield for a number of crops under diverse environments and types of water management

Strength & weaknesses pertaining to measurement of this impact area

Yield: Yield values are generally easy to measure and readily available at farm level or in the form of national inventories. However, their informative value is limited where they do not account for qualitative differences between types of biomass and are not accompanied by information on site conditions such as local climate or soil fertility. Therefore, comparisons between efficiencies of different production processes with regard to yields should only be made where products and site conditions are similar. In some cases, it may be advisable to select alternative indicators where the type of benefit is more clearly defined (e.g., energetic value, financial benefit).

Sample Indicators

Indicator values from		Survey	
Experiment or direct measurement		Statistical- or census data	
Expert assessment		Literature values	
Model		Maps or GIS	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	Unit	Indicator values from
[57] Water use efficiency of seed yield (Yield (bean seeds)/Amount of evapotranspiration)	g * mm $^{-1}$	
[67,130,242] Water use efficiency (Yield/Amount of irrigation water)	kg * m $^{-3}$	
[73] Water use efficiency (Potato yield/Irrigation water)	g * l $^{-1}$	,
[135] Water use efficiency (Grain yield (pea and bean)/ Amount of irrigation water)	kg * mm $^{-1}$	
[266] Water use efficiency at fresh yield scale (Fruit fresh yield/Crop evapotranspiration over the growth period)	gm^{-2} * mm $^{-1}$	
[266] Water use efficiency at dry yield scale (Fruit dry yield/Crop evapotranspiration over the growth period)	gm^{-2} * mm $^{-1}$	
[274] Water use efficiency at the yield level (Grain yield [kg]/Evapotranspiration [mmol m−2 s−1])	kg * mmol $^{-1}$ * m^2 * s	
[284] Water use efficiency (Grain yield/Water consumed for system of rice intensification)	ton ha^{-1} * mm $^{-1}$	
[284] Irrigation water use efficiency (Grain yield/Irrigation water)	ton ha^{-1} * mm $^{-1}$	
[286] Water use efficiency (Crop yield/Evapotranspiration)	ton * mm $^{-1}$	

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[175] Rainfall use efficiency for grain (Total grain yield/ Total rainfall)	kg * ha $^{-1}$ * mm $^{-1}$	
[252] Water use efficiency (Grain yield/Crop evapotranspiration)	kg * m $^{-3}$	
[252] Irrigation water use efficiency (Grain yield/Seasonal irrigation water applied)	kg * m $^{-3}$	

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[98] Marginal water productivity (Grain or tuber yield/Amount of irrigation water)	kg * m $^{-3}$	
[233] Yield/Unit of Irrigation Water	ton * m $^{-3}$	
[241] Water use efficiency (Tuber yield/Total amount of rainfall + irrigation water applied)	kg * m $^{-3}$	

Table 4: Global Scale

Indicator	Unit	Indicator values from
[195] Water productivity of irrigation (Fruit yield/Irrigation water)	kg * mm $^{-1}$	
[195] Normalized Water productivity of yield (Fruit yield/Irrigation water applied + effective rainfall/evapotranspiration)	kg * mm $^{-1}$	

References

ID	Citation	[1]Soil type/ texture
57	de Medeiros, G. A., et al. (2014). "Water use efficiency as an indicator of environmental impact of irrigated crops under subtropical conditions." **181**: 455-466.	Red Latosol (Oxisoil); Clay texture (61% clay)
67	"Water and fertilizer use efficiency by squash grown under stress on sandy soil treated with acrylamide hydrogels." Journal of Applied Sciences Research **7**(12): 1828-1833.	Sandy soil
73	Franke, A. C., et al. (2018). "Resource use efficiencies in potato production." Water Wheel **17**(2): 18-21.	Sandy soil
98	Guo, X., et al. (2018). "Spatial-temporal distribution and impact factors of irrigation water use efficiency in the grain production of China." International Journal of Agricultural and Biological Engineering **11**(5): 131-138.	n/a
130	Kifle, M., et al. (2017). "Effect of surge flow and alternate irrigation on the irrigation efficiency and water productivity of onion in the semi-arid areas of North Ethiopia." Agricultural Water Management **187**: 69-76.	Clay texture
135	Kumar, M., et al. (2009). "Integrating water harvesting and gravity-fed micro-irrigation system for efficient water management in terraced land for growing vegetables." Biosystems Engineering **102**(1): 106-113.	n/a
175	Moore, A. D., et al. (2011). "Evaluation of the water use efficiency of alternative farm practices at a range of spatial and temporal scales: A conceptual framework and a modelling approach." Agricultural Systems **104**(2): 162-174.	Black vertosol soil
195	Pascual, M., et al. (2016). "Water use efficiency in peach trees over a four-years experiment on the effects of irrigation and nitrogen application." Agricultural Water Management **164**: 253-266.	Petrocalcic calcixerept (Petrocalcic Calcisol); Loamy textured (20% clay and 40% sand) and pH (1:2.5) is basic(8.3)

[1]**Soil type/ texture:** If provided, what are type and texture of the soils studied in the paper?

233	Solieman, N. Y. and R. M. Barghash (2016). "The economic efficiency of water irrigation usage and restructuring cultivation of agricultural crops." International Journal of ChemTech Research **9**(10): 62-71.	n/a
241	Steyn, J. M., et al. (2016). "Resource use efficiencies as indicators of ecological sustainability in potato production: A South African case study." Field Crops Research **199**: 136-149.	Loam, sandy-loam, sand
242	Sun, Y., et al. (2012). "The effects of different water and nitrogen managements on yield and nitrogen use efficiency in hybrid rice of China." Field Crops Research **127**: 85-98.	Sandy loam
252	Tomaz, A., et al. (2018). "Efficient use of water and nutrients in irrigated cropping systems in the Alqueva region." Spanish Journal of Soil Science **8**(1): 12-23.	Chromic Cambisols (Bc); Silt loam
266	Wei, Z. H., et al. (2016). "Carbon isotope discrimination shows a higher water use efficiency under alternate partial root-zone irrigation of field-grown tomato." Agricultural Water Management **165**: 33-43.	Arid; Sandy loam
274	Yang, W. and P. F. Li (2018). "Association of carbon isotope discrimination with leaf gas exchange and water use efficiency in maize following soil amendment with superabsorbent hydrogel." Plant, Soil and Environment **64**(10): 484-490.	Sandy loam
284	Zhao, L., et al. (2010). "Comparisons of yield, water use efficiency, and soil microbial biomass as affected by the system of rice intensification." Communications in Soil Science and Plant Analysis **41**(1): 1-12.	n/a
286	Zhuo, L. and A. Y. Hoekstra (2017). "The effect of different agricultural management practices on irrigation efficiency, water use efficiency and green and blue water footprint." Frontiers of Agricultural Science and Engineering **4**(2): 185-194.	n/a