Definition:

$$\frac{Grain/Fruit/\,Tuber\ yield}{Area\ of\ land}$$

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: Agricultural land is always a limited resource. The type of land can be specified to distinguish between different land qualities. Distinctions are often made, for example, between cropland and pasture, high nature value (HNV) farmland and other farmland, or based on soil fertility and yield potential. For this indicator, the temporal reference must always be specified. However, in case of the standard period of one year, this information is sometimes omitted in scientific publications.

Correlation with soil management

[38] Controlled traffic system showed lower value in winter wheat production, but higher value in summer maize production
[67] Application of hydrogel, on sandy soils improves water holding capacity, availability of the nutrients, leading to higher productivity. The higher the application rate of the hydrogel, the higher the productivity
[157] For sustainable agricultural systems is required to improve the efficiency of crop nitrogen recovery and to reduce gaseous and leaching losses. Poultry manure, rice hulls and mineral fertilizer combination may represent a good soil amendment to obtain a high yield with a lower environmental impact, at least in the short-term
[162] Studies proved reduction of field crop yields from organic fields in comparison to conventional ones
[177] Extensive farming produces lower yield and requires more land than intensive farming
[182] Improving the conditions of mineral nutrition by introducing balanced doses of fertilizers for all elements contributed to a sufficiently high yield
[207] Nitrogen utilization efficiency played a significant role in determining grain yield, while a negative and poor dependence of grain yield on Nitrogen uptake efficiency was observed
[214] In Brazil, biodiesel addition into diesel is mandatory and soybean oil is its main source. Energy balance showed linearity with yield, whereas for EROI, the increases in input and yield were not affected
[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 dry land and partially dry land 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
[245] Higher nitrogen fertilizer rates applied to spring wheat results in an increase of grain and aboveground biomass N and in a decrease of the N effectiveness indicators
[248] Small rice-producing farms ranging from 0.61 to 1.0 ha yielded higher energy ratios (4.14) than larger ones
[250] Paper anticipates that the development and implementation of an integrated modeling platform across worlds regions could build capabilities in understanding the agriculture-centered food,energy and water (FEW) nexus and guiding policy and land management decision making for a sustainable future
[252] In the case of crop rotations, increasing resource-use efficiency while reducing yield gaps can be addressed by suitable agricultural management practices
[260] Inoculation of rice with dark septateendophytic (DSE) fungi represents a strategy to improve green manure-N recovery, grain yield per plant, and grain quality in terms of micronutrients contents in cropping systems with a low N input
[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
[268] Nitrogen (N) efficient maize (Zea mays L.) varieties capable of producing higher maize grain yields under conditions of low soil N supply and infertile soils condition
[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
[281] Paper indicates the importance of Arbuscularmycorrhizal fungi (AMF) inoculation in improving P efficiency of rice production
[284] System of rice intensification methods was 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

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).

Area of land: While area of land is a standard measure that is used as reference in most statistics and inventories, a weakness of this indicator is that other relevant information like soil type, soil fertility or management history is often not provided.

In short, one hectare of dry, sandy cropland soil is very different from one hectare of pasture on drained peat soils.

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: No Scale

Indicator	**Unit**	**Indicator values from**
[250] Crop yield/Area of land	ton * ha^{-1}	

Table 2: Field Scale

Indicator	**Unit**	**Indicator values from**
[67] Marketable yield(Squash) /Area of land (feddan = arabic unit of area)	mg * feddan^{-1}	
[207]Grain yield/Area of land	ton * ha^{-1}	
[242]Grain yield/Area of land	kg * hm^{-2}	
[245,260,274]Grain yield/Area of land	kg * ha^{-1}	
[246]Grain yield/Plot	kg * ha^{-1}	
[247]Grain yield/Field	ton * ha^{-1}	

[266]Fresh yield /Area of land	g * ha^{-1}	
[266] Dry yield/Area of land	g * ha^{-1}	
[268]Mean grain yield/Area of land	Mg * ha^{-1}	
[281]Biological yield/Area of land	kg * ha^{-1}	
[281]Economic yield/Area of land	kg * ha^{-1}	
[284] Yield/Area of land	ton * ha^{-1}	

Table 3: Farm Scale

Indicator	**Unit**	**Indicator values from**
[157] Tuber yield/Area of land	kg * m^{-2}	
[162] Additional yield from fertilization/Area of land	kg * ha^{-1}	
[162] Additional yield from fertilization in the previous year/Area of land	kg * ha^{-1}	
[175, 252]Grain yield/Area of land	kg * ha^{-1}	
[175] Fodder conservation rate (Fodder conserved/Area of land)	kg * ha^{-1}	
[176] Annual Gross Product (Average yield/ Fodder area)	kg * ha^{-1}	,

Table 4: Regional Scale

Indicator	**Unit**	**Indicator values from**
[38] Crop productivity (Yield/Area of land)	kg * ha^{-1}	
[110] Average yield (Yield/Area of land)	ton * ha^{-1}	
[182] Grain yield/Area of land	ton * ha^{-1}	
[185] Extension Yield(Yield of main crop (s)/Area of land)	Not provided* ha^{-1}	,

[190] Grain yield/Area of land	kg * ha^{-1}	 , 
[202] Gross yield (weight of all harvested fruits) /Area of land	mg * ha^{-1}	
[202] Fresh marketable yield (gross yield minus the fruit discarded as a result of fruit rot or small size, or fruit used for processed products) /Area of land	mg * ha^{-1}	
[214] Yield (obtained product) /Area of land	kg * ha^{-1}	 , 
[241] Land use efficiency (Potato yield /Area of land)	ton * ha^{-1}	
[248] Rice yield/Area of land	kg * ha^{-1}	 , 

Table 5: National Scale

Indicator	**Unit**	**Indicator values from**
[177] Marginal yield (yield at the level of fertilization where the curves: "yield per fertilizer unit" and "groundwater nitrate content per fertilizer unit" intersect/Area of land	ton* ha^{-1}	 , 
[202] Gross yield (weight of all harvested fruits) /Area of land	mg * ha^{-1}	
[202] Fresh marketable yield (gross yield minus the fruit discarded as a result of fruit rot or small size, or fruit used for processed products) /Area of land	mg * ha^{-1}	

References

ID	Citation	[1]Soil type/ texture
38	Chen, H., et al. (2016). "Effect of controlled traffic on energy use efficiency in wheat-maize production in North China Plain." Journal of Computational and Theoretical Nanoscience**13**(4): 2634-2638.	Silt loam; Porous and homogenous
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
110	Homolka, J. and R. Mydlar (2011). "Efficiency evaluation in intensive growing of winter rape." Agricultural Economics-ZemedelskaEkonomika**57**(5): 247-257.	Pararendzina on terraced broken stones and gravel sands from the acid material
157	Machado, D., et al. (2010). "The use of organic substrates with contrasting C/N ratio in the regulation of nitrogen use efficiency and losses in a potato agroecosystem." Nutrient Cycling in Agroecosystems**88**(3): 411-427.	Sandy-loam texture
162	Manolova, V., et al. (2015). "Economic efficiency of fertilization and its residual-effect during conversion period to organic field crop production." Bulgarian Journal of Agricultural Science**21**(5): 1022-1026.	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
176	Moreau, P., et al. (2012). "Reconciling technical, economic and environmental efficiency of farming systems in vulnerable areas." Agriculture Ecosystems & Environment**147**: 89-99.	Deep loamy and shallow brown soils
177	Mozner, Z., et al. (2012). "Modifying the yield factor based on more efficient use of fertilizer-The environmental impacts of intensive and extensive agricultural practices." Ecological Indicators**16**: 58-66.	n/a

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

182	Neshchadim, N. N., et al. (2018). "Bioenergetic assessment and economic efficiency of predecessors and fertilizer systems in the cultivation of winter wheat." International Journal of Engineering and Technology(UAE)**7**(4.38 Special Issue 38): 685-689.	Ordinary chernozem with low content of humus (4.5-5.5%)
185	Oladele, O. I. (2013). "Towards Developing a set of Indices to assess the Effectiveness and Efficiency of Agricultural Extension Policy." Life Science Journal-Acta Zhengzhou University Overseas Edition**10**(1): 3309-3314.	n/a
190	Pan, G., et al. (2009). "Using QuickBird imagery and a production efficiency model to improve crop yield estimation in the semi-arid hilly Loess Plateau, China." Environmental Modelling & Software**24**(4): 510-516.	n/a
202	Plénet, D., et al. (2009). "Using on-field data to develop the EFI© information system to characterise agronomic productivity and labour efficiency in peach (Prunuspersica L. Batsch) orchards in France." Agricultural Systems**100**(1-3): 1-10.	n/a
207	Rehman, A., et al. (2011). "Grain quality, nutrient use efficiency, and bioeconomics of maize under different sowing methods and NPK levels." Chilean Journal of Agricultural Research**71**(4): 586-593.	Sandy clay loam
214	Romanelli, T. L., et al. (2012). "Material embodiment and energy flows as efficiency indicators of soybean (Glycine max) production in Brazil." Engenharia Agricola**32**(2): 261-270.	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
245	Szmigiel, A., et al. (2016). "Efficiency of nitrogen fertilization in spring wheat." International Journal of Plant Production**10**(4): 447-456.	LuvicChernozem

246	Szulc, P., et al. (2018). "The size of the nminsoil pool as a factor impacting nitrogenutilization efficiency in maize (Zea mays L.)." Pakistan Journal of Botany**50**(1): 189-198.	Clay lightweight sand, shallow defaulting on light clay; Deer soil
247	Szulc, P., et al. (2016). "Efficiency of nitrogen fertilization based on the fertilizer application method and type of maize cultivar (Zea mays L.)." Plant Soil and Environment**62**(3): 135-142.	Granulometric composition of shallow, light clay sand on light clay, belonging to the good rye soil class;Luvisol
248	Talukder, B., et al. (2019). "Energy efficiency of agricultural systems in the southwest coastal zone of Bangladesh." Ecological Indicators**98**: 641-648.	n/a
250	Tian, H., et al. (2018). "Optimizing resource use efficiencies in the food–energy–water nexus for sustainable agriculture: from conceptual model to decision support system." Current Opinion in Environmental Sustainability**33**: 104-113.	n/a
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.	Silt loam; Chromic Cambisols (Bc)
260	Vergara, C., et al. (2018). "Dark SeptateEndophytic Fungi Increase Green Manure-N-15 Recovery Efficiency, N Contents, and Micronutrients in Rice Grains." Frontiers in Plant Science**9**.	Sandy soil (3% clay, 5% silt, and 92% sandy); HaplicPlanosol
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.	Sandy loam; Arid
268	Worku, M., et al. (2012). "Nitrogen efficiency as related to dry matter partitioning and root system size in tropical mid-altitude maize hybrids under different levels of nitrogen stress." Field Crops Research**130**: 57-67.	Reddish brown clay soil (Nitosol, FAO soil classification); EutricFluvisol
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
281	Zhang, S., et al. (2016). "Arbuscularmycorrhiza improved phosphorus efficiency in paddy fields." Ecological	n/a

	Engineering**95**: 64-72.	
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