Guidelines for calculating food supply GHG emissions with the ACGE calculator

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Contents

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DISCLAIMER:
The developer of this tool checked correctness through comparison with other calculations. However, since the secondary offered in this tool are based on averages the results cannot be expected to exactly predict the GHG emissions and food losses in a specific practical situation.

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1 Introduction

The Agro-Chain Greenhouse gas Emissions (ACGE) calculator is a tool for estimating total greenhouse gas emissions associated to a food product. It addresses the most common stages of ‘linear’ agro-food chains (chains for fresh and simple processed products: canned, frozen, packaged and other minimal processed forms). It combines a calculation framework with a datasets containing crops GHG emission factors and Food Loss factors along the chain. Combined with user-definition parameters for the product-chain considered it generates an estimate for GHG emissions associated to a product when bought by a consumer. The default data that the calculator derives from the dataset may be overruled by the user if more specific data are available; this would make the calculations more case specific.

2 Calculator details

The method can be used at relatively little effort. Based on a chain flow diagram (that includes region of production, transport modalities and distances, duration of refrigered and frozen storage, packaging material use and energy use) a spread-sheet can be filled, resulting in estimate of total impact per unit product bought by the consumer.

Table 1. Scope, impacts included and sources for default data.

Chain stage	Factors included	Sources for default data	User-defined parameters and potential adjustments
Agricultural production	Crop GHG emission factor	(Porter et al. 2016): Crop emission factor, aggregated to crop categories for 7 global regions, extended with outcomes of a few published LCA results.	(Default) GHG emission factor may be adjusted
Post-harvest handling and storage	Refrigerated storage energy use Other energy use	Refrigerated storage energy use: derived from (Evans et al. 2014) with estimated filling degree. “Other energy use”: default 0.	Duration of refrigerated storage. Other energy use per kg product (fuel-based and electric)
Collection transport	Fuel use, well-to-wheels (impacts related to vehicles and infrastructure construction and maintenance are neglected, EcotransIT 2018)	Values in line with EcoInvent 3 and ecotransit.org (visited December 2018). The following vehicles are included: • delivery van (average filling degree) • delivery van (full load capacity used) • lorries (small, medium, large, very large) • cargo train (electric, diesel) • cargo ships (inland, sea ship, sea ship containers) • air cargo (continental, intercontinental)	Distance Modality
Primary processing and packaging	Packaging materials Refrigerated storage energy Other energy use	Packaging materials: • plastics: (Hekkert et al. 2001) • paper and board: (Laurijssen et al. 2010) • steel: average from APEAL (APEAL 2012), Worldsteel Association (Association 2018) and (Garofalo et al. 2017) • aluminium: (Simon et al. 2016) (assuming 50% recycling), (Stotz et al. 2017) • glass: (Schmitz et al. 2011)	Packaging material use per kg product. Processing energy use per kg product

(International) Transport (optionally multi-modal)	Fuel use	see above	see above
(Secondary) processing, repackaging, cross-docking	See *Primary processing*	See above	see above
Distribution transport	Fuel use	Values in line with EcoInvent 3 and IMO (IMO 2015).	see above
Retail outlet	Energy use, specifically refrigeration	Refrigerated storage in retail shelfs: energy use data derived from literature study.	Duration of refrigerated storage (display cabinet)
All stages along the post-harvest chain	Percentage of FLW per chain stage	Values from (Porter et al. 2016).	(Default) FLW percentages may be adjusted
All stages along the post-harvest chain	GHG emissions due to waste management process (varying from landfilling to bio-fermentation)	Values from EPA (EPA 2016).	

Either default data can be used (only chain configuration parameters must be inserted then) or the analyis can be made more specific (through replacing some generic data (Table 1) by primary data or more specific data from literature).

More background information can be found in Broeze et al. (2019).

3 Calculator setup

The calculator is implemented in Excel, with a set of work sheets:

- Model (this is the actual calculator user-interface);
- DataEurope (contains crop GHG emission factors and Loss factors, averages for Europe);
- DataNAmOce (contains crop GHG emission factors and Loss factors, averages for North-America and Oceania);
- DataIndusAsia (contains crop GHG emission factors and Loss factors, averages for Industrialized Asia);
- DataNAWCA (contains crop GHG emission factors and Loss factors, averages for North Africa, West and Central Asia);
- DataSSA (contains crop GHG emission factors and Loss factors, averages for Sub-Sahara Africa);
- DataSSEAsia (contains crop GHG emission factors and Loss factors, averages for South and South-East Asia);
- DataLatAm (contains crop GHG emission factors and Loss factors, averages for Latin America);
- TransportModalities (contains emission factors for transportation modalities);
- ResiduesManagmOptions (contains emissions factors for residues management options).

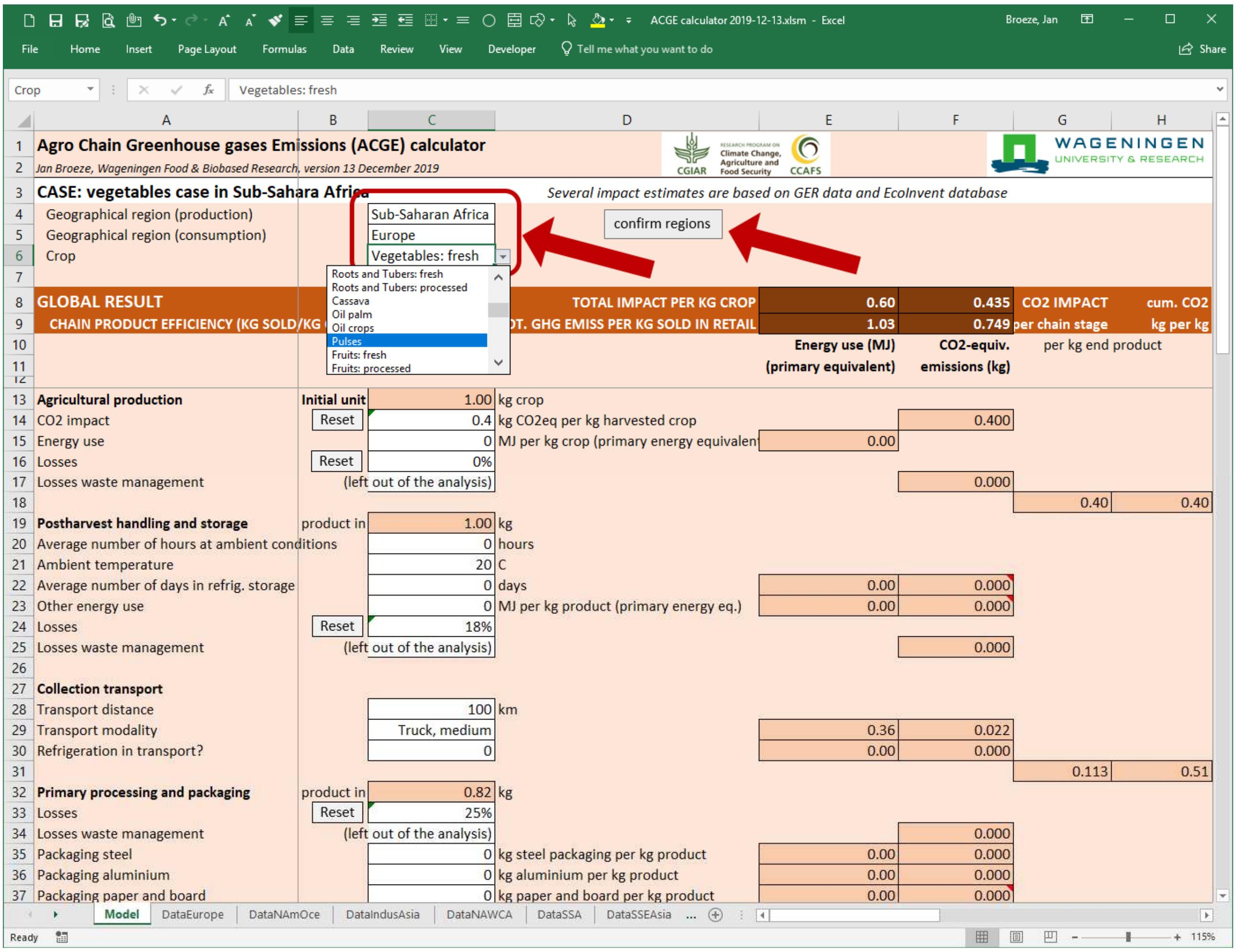
Definition of the geographic areas can be found in the supplementary material by Porter et al. (2016)

The data sheets for crops are open for editing; when available the user may add a crop with more specific data to enrich his working set.
Also the last two datasheets are user-amendable, for instance for correcting the data to country-specific best-known values or by adding alternative technology options.

4 Instructions for use of the calculator

4.1 Selecting geographic location and crop

Since GHG emission factors and loss factors largely differ amongst global regions, the first step must be choice a region of production, a region of consumption and a crop.

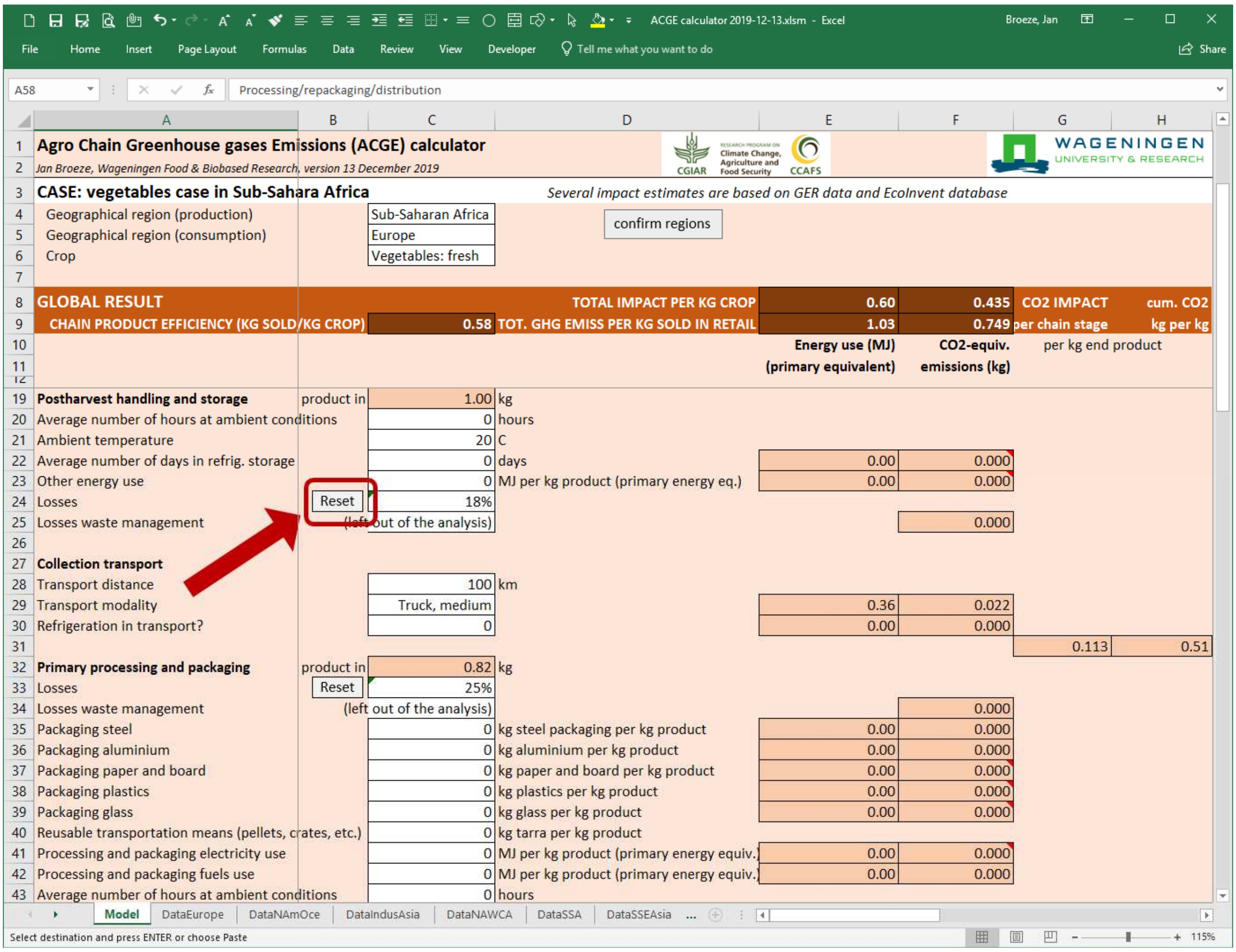


After selection of the Geographical region of production and Geographical region of consumption, the user must press the button "confirm regions" to let the tool select the correct data.

4.2 Inserting chain configuration data and optionally overrule default parameter values

Based on the selection of geographic regions and crop, the tool automatically inserts default crop GHG emission factor and loss percentages in the post-harvest chain (differentiated to 'Postharvest handling and storage', 'Primary processing and packaging', 'Processing/repackaging/distribution' and 'Retail' stages). Since losses in transport mostly become apparent in the handling afterwards, the losses in transport are not separately listed.

The user may override the default crop GHG emission factor and loss factors by inserting a new values in the concerning fields. This ‘overruling’ destroys the link to the default values. However this link can be repaired by clicking the ‘Reset’ button next to the field.



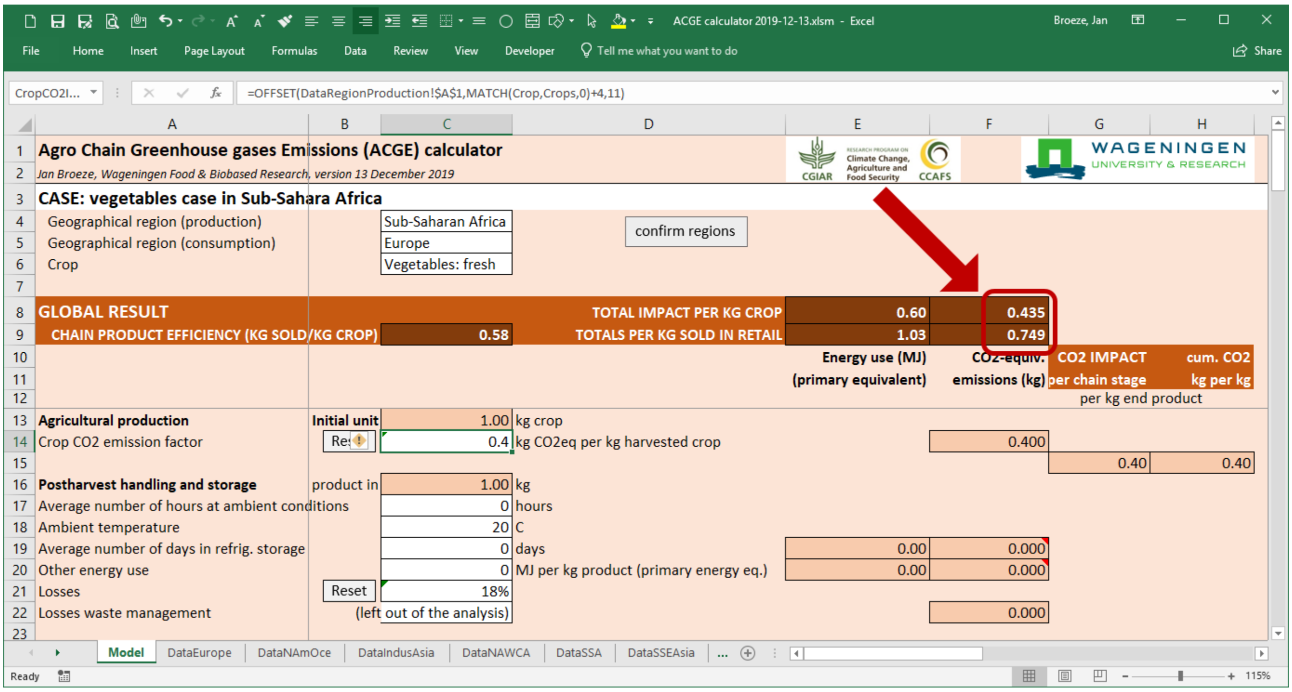
Next, the user can further specify the product, amongst others (see also Table 1):

- durage of refrigerated storage in different stages of the chain;
- packaging material use (in ‘Primary processing and packaging’ and ‘Processing / repackaging / distribution’)
- transportation distances and modalities (including size of the vehicles)
- losses waste management options (default: left out of the analysis).

The white cells are user-editable.

4.3 Results

The results are summarized in cells E8:F9.
Cells E8 and E9 summarize total enery use associated to the product, per kg crop and per kg sold in retail respectively.
Cells F8 and F9 summarize total GHG emissions induced by the production chain, per kg crop and per kg sold in retail respectively. F9 is considered the essential result of a calculation.


ACGE calculator 2019-12-13.xlsm - Excel
Broeze, Jan
File Home Insert Page Layout Formulas Data Review View Developer Tell me what you want to do
Share
CropCO2I...
=OFFSET(DataRegionProduction!A1,MATCH(Crop,Crops,0)+4,11)
Agro Chain Greenhouse gases Emissions (ACGE) calculator
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CGIAR
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CCAFS
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CASE: vegetables case in Sub-Sahara Africa
Geographical region (production) Sub-Saharan Africa
Geographical region (consumption) Europe
Crop Vegetables: fresh
confirm regions
GLOBAL RESULT
TOTAL IMPACT PER KG CROP 0.60 0.435
CHAIN PRODUCT EFFICIENCY (KG SOLD/KG CROP) 0.58
TOTALS PER KG SOLD IN RETAIL 1.03 0.749
Energy use (MJ) (primary equivalent)
CO2-equiv. emissions (kg)
CO2 IMPACT per chain stage
cum. CO2 kg per kg
per kg end product
Agricultural production Initial unit 1.00 kg crop
Crop CO2 emission factor 0.4 kg CO2eq per kg harvested crop 0.400
0.40 0.40
Postharvest handling and storage product in 1.00 kg
Average number of hours at ambient conditions 0 hours
Ambient temperature 20 C
Average number of days in refrig. storage 0 days 0.00 0.000
Other energy use 0 MJ per kg product (primary energy eq.) 0.00 0.000
Losses Reset 18%
Losses waste management (left out of the analysis) 0.000
Model DataEurope DataNAmOce DataIndusAsia DataNAWCA DataSSA DataSSEAsia
Ready
115%

5 References

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