Climate MRV for Africa – Phase 2
Development of National GHG Inventory
Uncertainty Assessment

Lead partner

Project of the European Commission
DG Clima Action

EuropeAid/136245/DH/SER/MULTI

Amr Osama Abdel-Aziz, Assen Gasharov, Mike Bess and Laura Lahti
Team Leader and Key Experts

April 2017

Content

- Uncertainty Assessment - General
- Sources/reasons of uncertainty
- Level of uncertainty
- Parameters and types of uncertainties
- Methods of uncertainty
- Uncertainties N2O emission factor and N input to soils (Activity data)

Uncertainty Assessment General

- Uncertainty estimates are essential element of a complete inventory of GHG emissions/ removals.
- They should derived from uncertainties of emission factors, activity data and other estimation parameters
- Uncertainties are determined interns of variance and standard deviation (StDev) and variance (Var)
- Variance measures how far a data set is spread out. The formula for the variance of binomial distribution
- StDev is a measure to quantify the amount of variation or dispersion of a set of data values from its mean

Uncertainty Assessment General cont…

Sample Variance

$$s^2 = \frac{\sum(x-\bar{x})^2}{n-1}$$

Sample Standard Deviation

$$s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$$

$$s^2 = \frac{\sum(x-\bar{x})^2}{n-1}$$

x	$\bar{x}$	$x - \bar{x}$	$(x-\bar{x})^2$
1	2.83	1 – 2.83 = (-1.83)	(-1.83)^2 = 3.35
2	2.83	2 – 2.83 = (-0.83)	(-0.83)^2 = 0.69
2	2.83	2 – 2.83 = (-0.83)	(-0.83)^2 = 0.69
3	2.83	3 – 2.83 = (0.17)	(0.17)^2 = 0.03
4	2.83	4 – 2.83 = (1.17)	(1.17)^2 = 1.37
5	2.83	5 – 2.83 = (2.17)	(2.17)^2 = 4.71

$$3.35 + 0.69 + 0.69 + 0.03 + 1.37 + 4.71 = 10.84$$

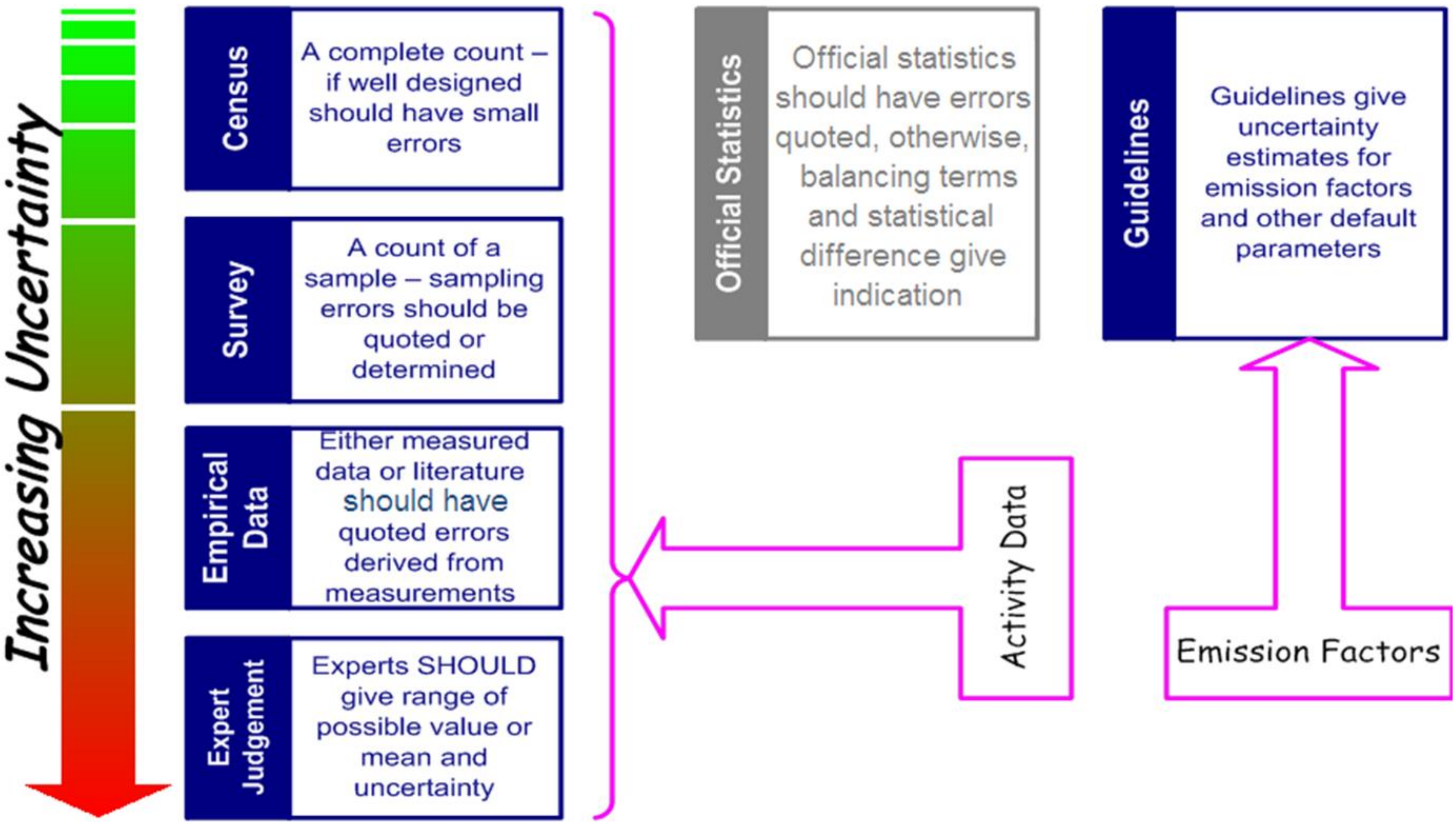
$$s^2 = \frac{10.84}{6-1} = 2.17$$

S= SQRT of S^2

Reasons for Uncertainty in Input Data

- Lack of data (missing data or extrapolation)
- Measurement error
- Data not truly representative
- Statistical random sampling error
- Misreporting/misclassification

Levels of Uncertainty



Source: consultative group of expert (CGE) training material on uncertainty analysis

Benefits of Uncertainty Analysis

Credibility

Inventories are estimates – uncertainty analysis gives a clear statement of what we do and do not know

Utility

Users of the inventory need to know how reliable the numbers are – especially if they are input into policy or inventory improvement actions

Requirement

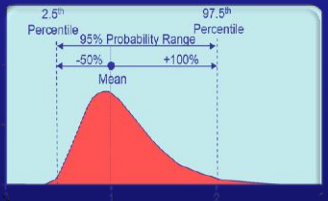
Uncertainty analysis is a requirement of all good practice inventories

Scientific

All scientific analysis should include an uncertainty assessment

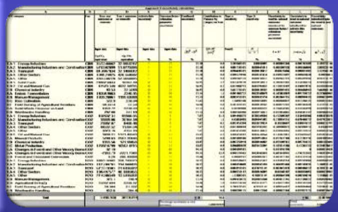
Source: consultative group of expert (CGE) training material on uncertainty analysis

Uncertainty Estimation



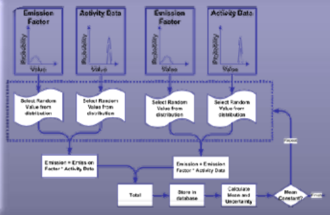
Gather Information

- Collect uncertainty information on activity data and emission factors



Decide approach to use

- Error Propagation
- Monte Carlo



Perform Inventory Analysis

- Spreadsheet
- Software tool

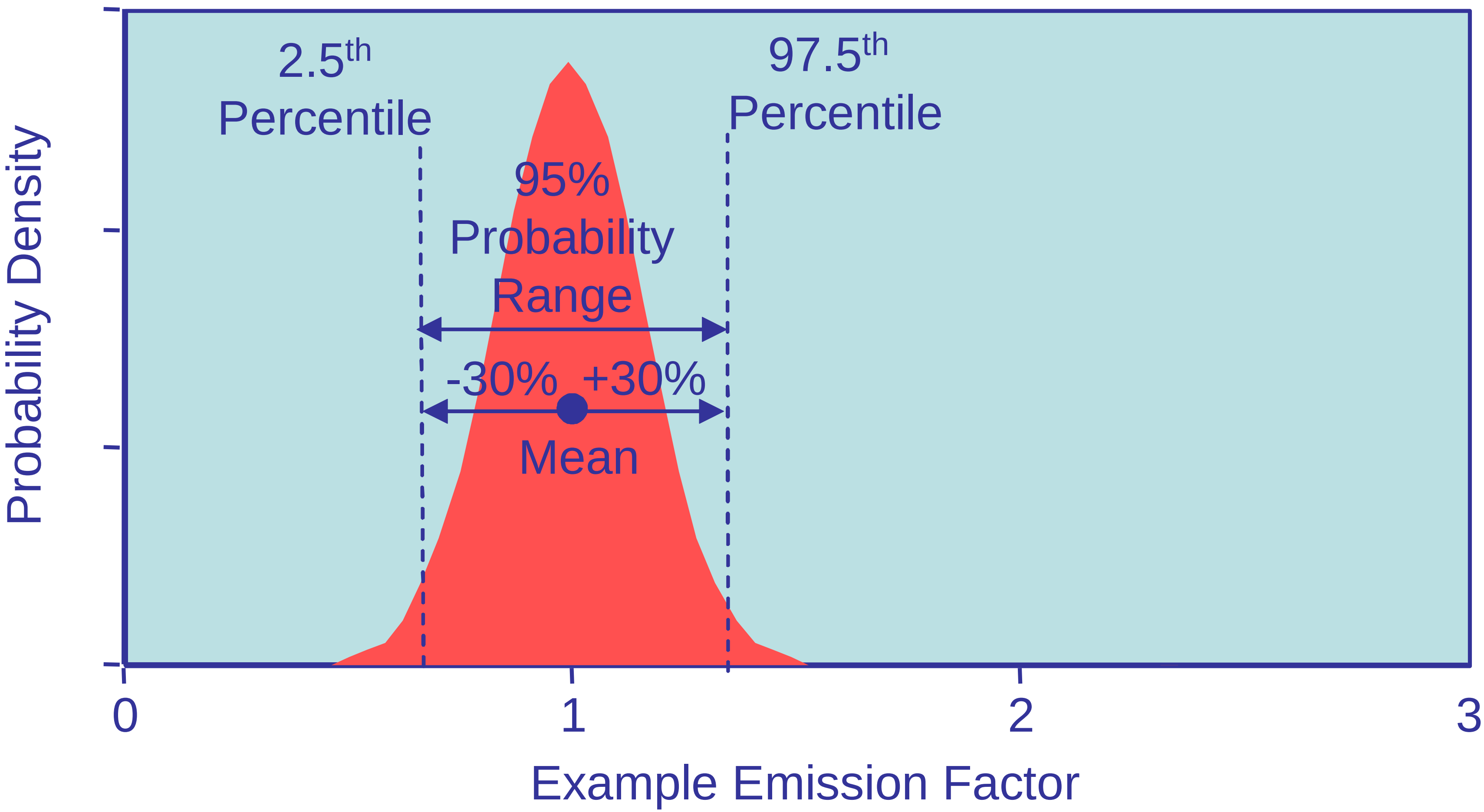
Source: consultative group of expert (CGE) training material on uncertainty analysis

Specifying Uncertainty

- **Uncertainty** is quoted as the 2.5 and 97.5 percentile i.e. bounds around a 95% confidence interval.
- This **can be expressed as**:
  - 234 ± 23%
  - 26,400 (- 50%, + 100%)
  - 2,000 (a factor of 2) (i.e. - 50%, + 100%)
  - An order of magnitude (i.e. 1 to 100)

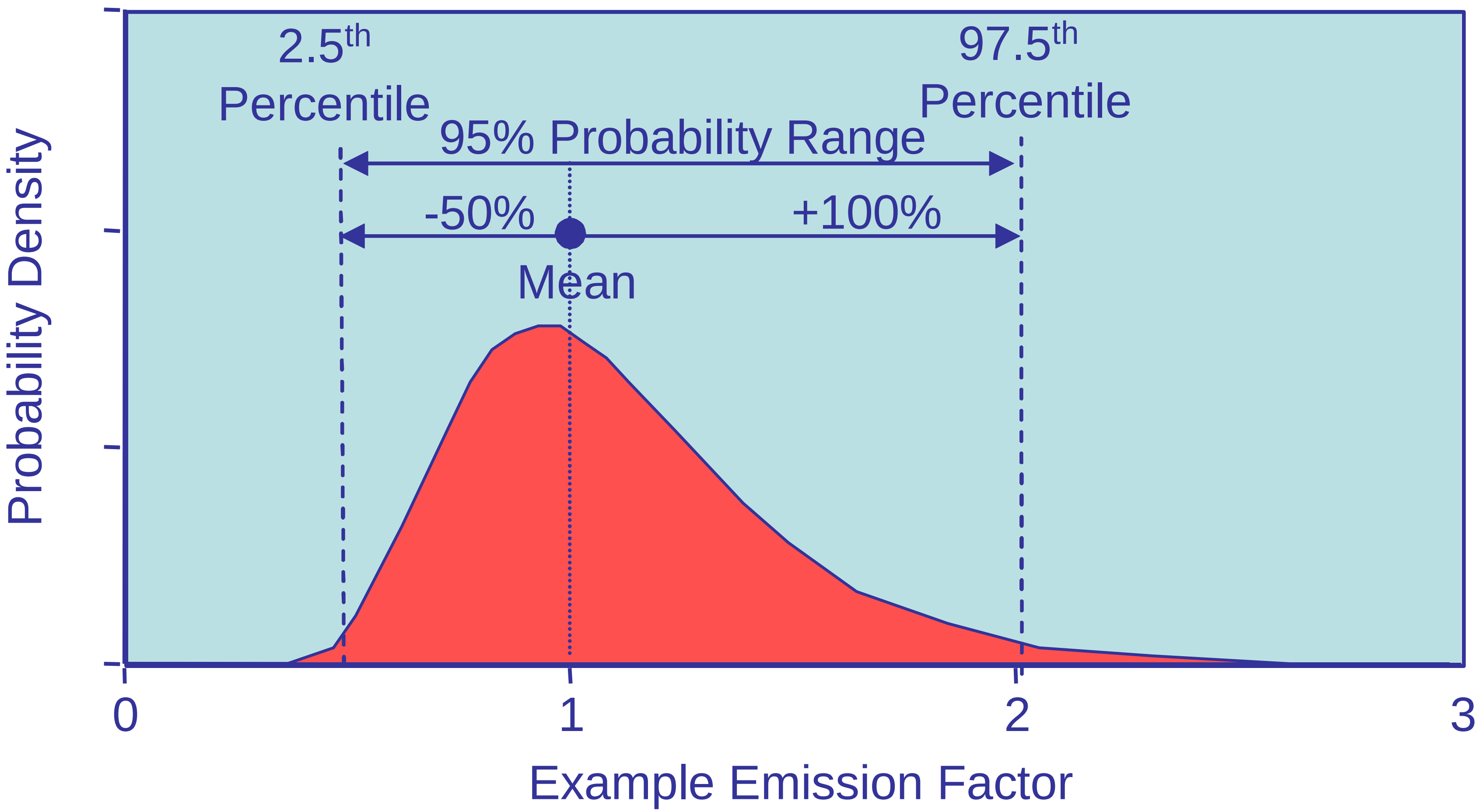
Source: consultative group of expert (CGE) training material on uncertainty analysis

Probability Density – Normal



Source: consultative group of expert (CGE) training material on uncertainty analysis

Probability Density – Asymmetric



Source: consultative group of expert (CGE) training material on uncertainty analysis

Methods to Combine Uncertainty

Error propagation

- Uncertainty in individual categories, in the inventory as a whole, and in trends between a year
- Simple - standard spread sheet can be used
  - IPCC Guidelines give explanation and equations
- Difficult to deal with correlations
- Strictly (standard deviation/mean) < 0.3
  - A simple solution is provided

Monte-Carlo Simulation

- More complex - Use specialized software
- Suitable where uncertainties are large, non-Gaussian, complex algorithms, correlations exist and uncertainties vary with time

Uncertainty of Annual Estimate

Example error propagation equation for multiplication

$$U_{SG} = \sqrt{U_{EF}^2 + U_{AD}^2}$$

- U_{SG} = percentage uncertainty in emissions of source category
- U_{EF} = percentage uncertainty in Emission Factor
- U_{AD} = percentage uncertainty in Activity Data

Source: consultative group of expert (CGE) training material on uncertainty analysis version 2 April 2012

Uncertainty of Annual Estimate

Example error propagation equation for addition & subtraction

$$U_{total} = \frac{\sqrt{(U_{SG1} * x_{SG1})^2 + (U_{SG2} * x_{SG2})^2 + \ldots + (U_{SGn} * x_{SGn})^2}}{\left| x_1 + x_2 + \ldots xn \right|}$$

- U_{total} = percentage uncertainty in total emissions
- U_{SGn} = percentage uncertainty in emissions of source category
- X_{SGn} = Emissions from SGn

Source: consultative group of expert (CGE) training material on uncertainty analysis version 2 April 2012

Uncertainty in Trend

- Overall uncertainty in Trend is estimated based on:
  - Type A: Change in difference in overall emissions between base year and inventory year as a result of 1% change in both base year and inventory year (systematic uncertainty)
  - Type B: Change in difference in overall emissions between base year and inventory year as a result of 1% change in inventory year only (random error)

Source: consultative group of expert (CGE) training material on uncertainty analysis version 2 April 2012

Uncertainties for default Ef of N2O from managed soils

TABLE 11.1
DEFAULT EMISSION FACTORS TO ESTIMATE DIRECT N_2O EMISSIONS FROM MANAGED SOILS

Emission Factor	Default Value	Uncertainty Range
EF_1 for N additions from mineral fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon [kg N_2O-N (kg N)$^{-1}$]	0.01	0.003-0.03
EF_{1FR} for flooded rice fields [kg N_2O-N (kg N)$^{-1}$]	0.003	0.000-0.006
$EF_{2\,CG,\,Temp}$ for temperate organic crop and grassland soils (kg N_2O-N ha^{-1})	8	2-24
$EF_{2\,CG,\,Trop}$ for tropical organic crop and grassland soils (kg N_2O-N ha^{-1})	16	5- 48
$EF_{2F,\,Temp,\,Org,\,R}$ for temperate organic nutrient rich forest soils (kg N_2O-N ha^{-1})	0.6	0.16-2.4
$EF_{2F,\,Temp,\,Org,\,P}$ for temperate organic nutrient poor forest soils (kg N_2O-N ha^{-1})	0.1	0.02-0.3
$EF_{2F,\,Trop}$ for tropical organic forest soils (kg N_2O-N ha^{-1})	8	0-24
$EF_{3PRP,\,CPP}$ for cattle (dairy, non-dairy and buffalo), poultry and pigs [kg N_2O-N (kg N)$^{-1}$]	0.02	0.007-0.06
$EF_{3PRP,\,SO}$ for sheep and 'other animals' [kg N_2O-N (kg N)$^{-1}$]	0.01	0.003-0.03

Uncertainties for default values of N inputs to soils from residue

TABLE 11.2
DEFAULT FACTORS FOR ESTIMATION OF N ADDED TO SOILS FROM CROP RESIDUES [A]

Crop	Dry matter fraction of harvested product (DRY)	Above-ground residue dry matter $AG_{DM(T)}$ (Mg/ha): $AG_{DM(T)} = Crop_{(T)} * slope_{(T)} + intercept_{(T)}$					N content of above-ground residues (N_{AG})	Ratio of below-ground residues to above-ground biomass (R_{BG-BIO})	N content of below-ground residues (N_{BG})
		Slope	± 2 s.d. as % of mean	Intercept	± 2 s.d. as % of mean	R^2 adj.			
Soyabean[f]	0.91	0.93	± 31%	1.35	± 49%	0.16	0.008	0.19 (± 45%)	0.008
Dry bean[g]	0.90	0.36	± 100%	0.68	± 47%	0.15	0.01	NA	0.01
Potato[h]	0.22	0.10	± 69%	1.06	± 70%	0.18	0.019	0.20 (± 50%)[m]	0.014
Peanut (w/pod)[i]	0.94	1.07	± 19%	1.54	± 41%	0.63	0.016	NA	NA
Alfalfa[j]	0.90	0.29[k]	± 31%	0	-	-	0.027	0.40 (± 50%)[n]	0.019
Non-legume hay[j]	0.90	0.18	± 50% default	0	-	-	0.15	0.54 (± 50%)[n]	0.012

[a]Source: Stephen A. Williams, Natural Resource Ecology Laboratory, Colorado State University. Email: stevewi@warnercnr.colostate.edu. Taken in large part from a manuscript in preparation and data compiled for CASMGS (http://www.casmgs.colostate.edu/).

[b]The average above-ground residue:grain ratio from all data used was 2.0 and included data for soya bean, dry bean, lentil, cowpea, black gram, and pea.

[c]Modelled after potatoes.

[d]Modelled after peanuts.

[e]No data for rye. Slope and intercept values are those for all grain. Default s.d.

[f]The average above-ground residue:grain ratio from all data used was 1.9.

[g]Ortega 1988 (see Annex 11A.1). The average above-ground residue:grain ratio from this single source was 1.6. default s.d. for root:AGB.

[h]The mean value for above-ground residue:tuber ratio in the sources used was 0.27 with a standard error of 0.04.

[i]The mean value for above-ground residue: pod yield in the sources used was 1.80 with a standard error of 0.10.

[j]Single source. Default s.d. for root:AGB.

[k]This is the average above-ground biomass reported as litter or harvest losses. This does not include reported stubble, which averaged 0.165 X reported yields. Default s.d.

[l]Estimate of root turnover to above-ground production based on the assumption that in natural grass systems below-ground biomass is approximately equal to twice (one to three times) the above-ground biomass and that root turnover in these systems averages about 40% (30% to 50%) per year. Default s.d.

[m]This is an estimate of non-tuber roots based on the root:shoot values found for other crops. If unmarketable tuber yield is returned to the soil then data derived from Vangessel and Renner 1990 (see Annex 11A.1) (unmarketable yield = 0.08 * marketable yield = 0.29 * above-ground biomass) suggest that the total residues returned might then be on the order of 0.49 * above-ground biomass. Default s.d.

[n]This is an estimate of root turnover in perennial systems. Default s.d.

[p]It is assumed here that grass dominates the system by 2 to 1 over legumes.

Thank you!

Amr Osama Abdel-Aziz, Assen Gasharov, Mike Bess and Laura Lahti