SUPPLEMENTARY MATERIALS

Equations used for direct N_2O emission from excreta deposition on soil, and for indirect N_2O emissions from volatilisation and atmospheric deposition on soil, leaching and runoff of N (IPCC, 2019):

$$N_2O - N_{PRP} = F_{PRP} \; x \; EF_{3PRPi} \quad (1)$$

where:

$N_2O–N_{PRP}$ = annual direct N_2O–N emissions from urine and dung inputs to grazed soils, kg N_2O–N yr^{-1}

F_{PRP} = annual amount of urine and dung N deposited on pasture, range, paddock and by grazing animals, kg N yr^{-1}

EF_{3PRPi} = emission factors developed for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals under conditions i (kg N_2O–N (kg N input)$^{-1}$)

$$F_{PRP} = \sum_T \left[\left(N_{(T)} \; x \; Nex_{(T)} \right) x \; MS_{(T,PRP)} \right] \quad (2)$$

where:

F_{PRP} = annual amount of urine and dung N deposited on pasture, range, paddock and by grazing animals, kg N yr^{-1}

$N_{(T)}$ = number of head of livestock species/category T in the country

$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country, kg N $animal^{-1}$ yr^{-1}

$MS_{(T,PRP)}$ = fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock

$$N_2O_{(ATD)} - N = [(F_{SN} x Frac_{GASF}) + ((F_{ON} + F_{PRP}) x Frac_{GASM})) x EF_4] \quad (3)$$

where:

$N_2O_{(ATD)}–N$ = annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils, kg N_2O–N yr^{-1}

F_{SN} = annual amount of synthetic fertiliser N applied to soils, kg N yr^{-1}

$Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1}

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1}

$Frac_{GASM}$ = fraction of applied organic N fertiliser materials (FON) and of urine and dung N deposited by grazing animals (FPRP) that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied or deposited)$^{-1}$

EF_4 = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N–N_2O (kg NH_3–N + NO_x–N volatilised)$^{-1}$]

$$N_2O_{(L)} - N = (F_S + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) x Frac_{LEACH-(H)} x EF_5 \quad (4)$$

where:

$N_2O_{(L)}$–N = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs, kg N_2O–N yr^{-1}

F_{SN} = annual amount of synthetic fertiliser N applied to soils, kg N yr^{-1}

$Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1}

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1}

F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N yr^{-1}

$Frac_{LEACH-(H)}$ = fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$

EF_5= emission factor for N_2O emissions from N leaching and runoff, kg N–N_2O (kg N leached and runoff)$^{-1}$