Nitrous Oxide and Methane emissions and Nitrogen Dynamics in Hedgerow Systems in the Uplands of Southern Philippines

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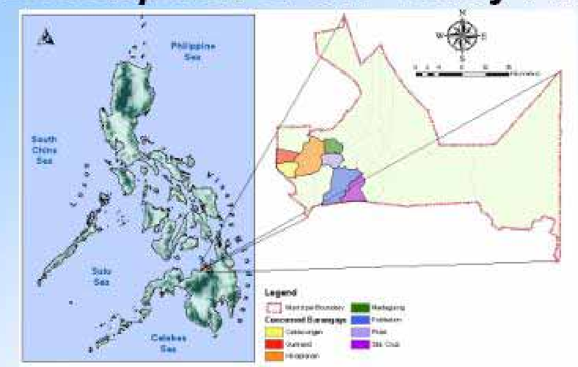
Overview

- Agricultural soils are the most important anthropogenic source of nitrogen oxide emissions (N_2O and NO) .
- Agroforestry is a dynamic, ecologically-based, natural resource management system.
- In hedgerow systems tree litter, crop residues and animal manure are used as green manure to restore or maintain soil fertility.
- Such systems may serve as source of N_2O and methane (CH_4).
- *Eucalyptus deglupta* and *Gmelina arborea* are the two top ranking trees planted in the agroforestry farms in Claveria, Misamis Oriental, Philippines.

Objective

This study aims to estimate the methane emissions from livestock holdings and nitrous oxide emissions through fertilization, tree litterfall and decomposition, maize residue incorporation and livestock manure in *G. arborea* and *E. deglupta* hedgerow systems. It also aims to present the nitrogen dynamics and other possible source of N_2O emissions in hedgerow agroforestry systems.

Description of the Study Area



The SAFODS Philippines Research Site

Claveria, Misamis Oriental

Claveria is a land-locked agricultural municipality in the province of Misamis Oriental in Northern Mindanao.

It is composed of 24 barangays.

Its topography is generally rugged, characterized by gently rolling hills and mountains with cliffs and escarpments.

The climate of Claveria is classified as having a C2 rainfall distribution, with 5 or 6 wet months (>200 mm/mo) and 2 or 3 dry months (<100 mm/mo).

Methodology

Experimental treatments

The experimental treatments (tree species, tree age, spacing) and number of replicates employed in the study.

Experiment No. 1 (7 year-old trees, 2 replicates per treatment)	**Experiment No. 2 (1 year-old trees, 3 replicates per treatment)**
Control for *G. arborea*, pure maize (*Z. mays*) 1 x 3 m (*G. arborea* + *Z. mays*) 1 x 9 m (*G. arborea* + *Z. mays*) Control for *E. deplupta*, pure maize (*Z. mays*) 1 x 3 m (*E. deglupta* + *Z. mays*) 1 x 9 m (*E. deglupta* + *Z. mays*)	Control, pure maize (*Z. mays*) 1 x 3 m (*G. arborea* + *Z. mays*) 1 x 9 m (*G. arborea* + *Z. mays*) 1 x 3 m (*E. deglupta* + *Z. mays*) 1 x 9 m (*E. deglupta* + *Z. mays*)



Management practices

- Planting: 1 seed per hill (Pioneer Hybrid 3014) at 60cm between furrows and 25-30cm between rows

- Fertilizer application:

Type of fertilizer	Application rate (kg ha^{-1})	Time of application
1. Solophos (0-18-0)	166.67	Before seed sowing
2. Urea (46-0-0)	195.65	30 DAE

- Other practices:
  - Inter-row cultivation at 30 and 60 DAE
  - Hand weeding

Litterfall

- Set-up: Four (4) litter traps were randomly positioned under the trees per plot.
- Litterfall collection: monthly


Soil erosion and runoff

- A micro-plot with a dimension of 4 x 6 m was constructed in each plot. A locally made galvanized iron with dimension of 7 ft in length, 1 ft in width and a depth of 0.5 ft were installed in each plot. A water meter was also attached to the collector for water runoff recording. Connected to the water meter is a 64 L capacity plastic for sediment load collection.

Collection and recording

Soil erosion: after an erosive rainfall event

Surface runoff: every after rainfall event

Stemflow

- Open plastic hose fitted around the trunk of 4 randomly selected hedgerow trees
- Collection and recording: after every rainfall event

Throughfall

- 16 plastic container were randomly placed within the plot
- Collection and recording: after every rainfall event

Harvesting and biomass determination of maize

- Harvesting: 105-110 days after planting
- Plant Biomass: destructive sampling of 16 sample plants per plot. Root, stalk, leaf and cob were segregated.
- Dry weight: One hundred fifty grams (150g) fresh weight of the sub-sample for each component was taken for oven drying at 70° C for 48 hours.

Leaf litter decomposition

- Set-up: A total of eight (8) net bags (12 x 12 in) containing 50g leaf samples were randomly placed inside each plot.
- Collection: Two bags per plot were collected every 21 days. Collected samples were weighed for fresh weight and oven-dried.
- Decomposition rate: percent loss in weight

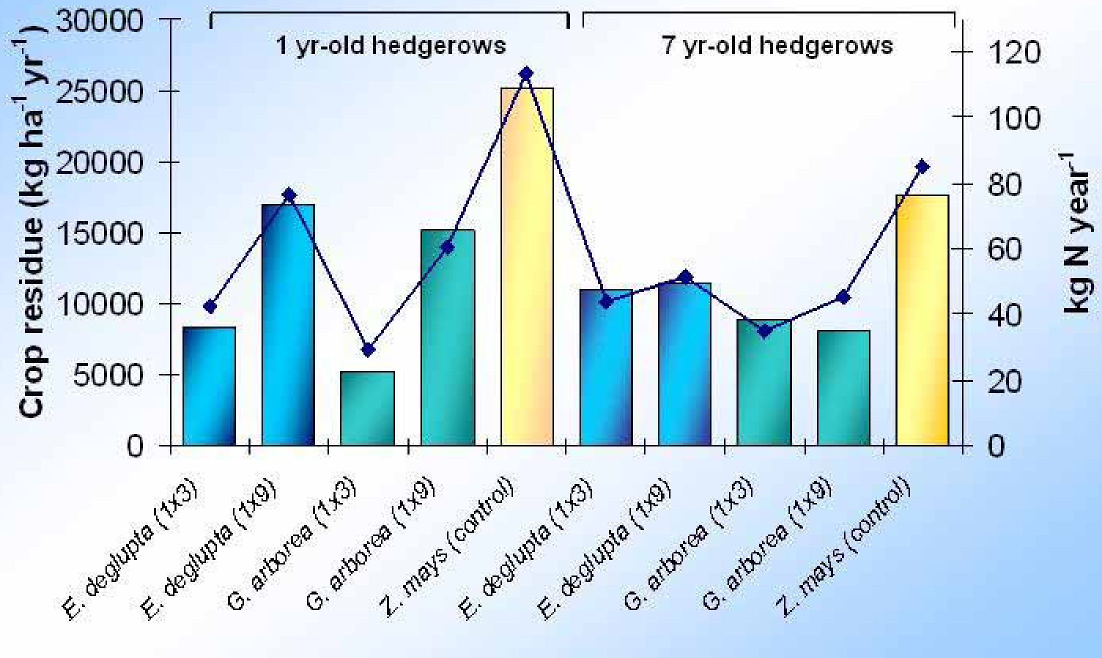
Livestock survey in Claveria

- Sampling technique: stratified random sampling
- Respondents: 300 farmers were randomly selected for the household interview
- Basis: elevation and agroforestry system classes
- Survey instrument: composed of set of questions related to livestock holdings and feed requirements



Results

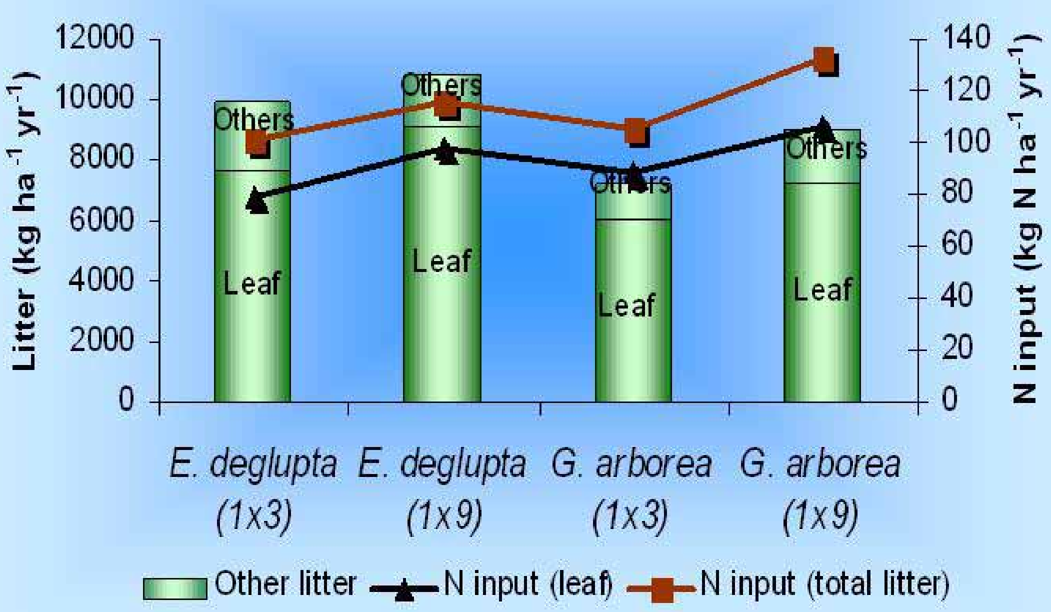
Crop residue and N input



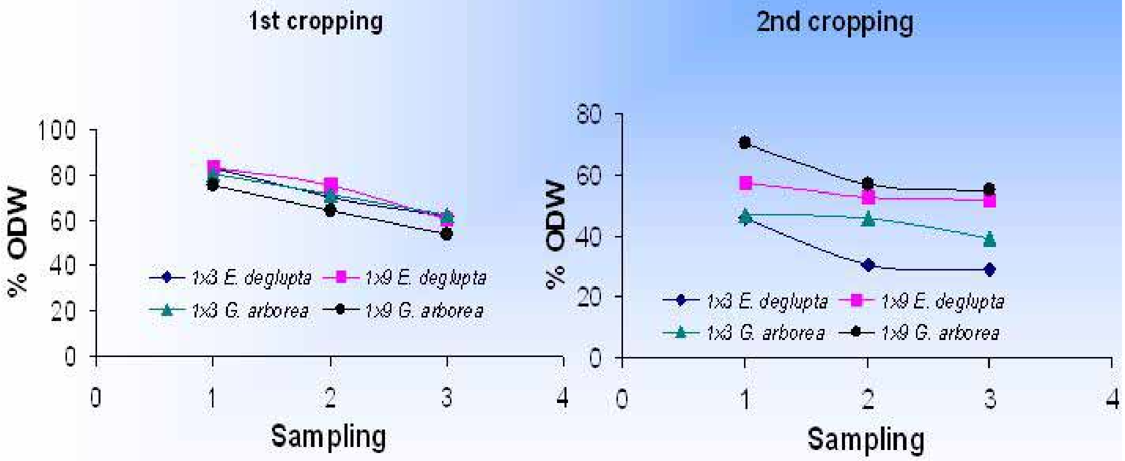
Fertilizer nitrogen applied in the different plots

Tree Species	Tree Age (yrs)	Tree spacing (m x m)	Plot size (ha)	N applied (kg N ha^{-1} yr^{-1})	1-$Frac_{GASF}$	F_{SN} (kg N ha^{-1} yr^{-1})
E. deglupta	1	1 x 3	0.018	221	0.9	199
E. deglupta	1	1 x 9	0.018	188	0.9	169
G. arborea	1	1 x 3	0.018	221	0.9	199
G. arborea	1	1 x 9	0.018	188	0.9	169
Z. mays			0.018	201	0.9	181
E. deglupta	7	1 x 9	0.032	346	0.9	311
E. deglupta	7	1 x 3	0.032	221	0.9	199
G. arborea	7	1 x 9	0.032	346	0.9	311
G. arborea	7	1 x 3	0.032	221	0.9	199
Z. mays			0.032	201	0.9	181

Leaf and total (leaf, twigs, branches) litter from 7-year old E. deglupta and G. arborea



Decomposition of 7 year-old E. deglupta and G. arborea leaf litter



Livestock Survey

Local values for nitrogen input from animal wastes based on average live weight

Animal	Average animal live weight (kg)	Daily manure production (% of LW)	Daily manure production (FW, kg)	Dry matter (%)	Daily manure production (ODW, kg)	Nitrogen content (%)	Total N animal^{-1} yr^{-1} (kg N yr^{-1})
Cattle	300	5	15.0	15	2.25	1.5	12.3
Carabao	350	5	17.5	15	2.60	1.5	14.2
Goat	15	3	0.45	25	0.11	1.5	0.6
Pig	80	5	4.00	20	0.80	2.0	5.84
Chicken	1.2	3	0.04	20	0.01	3.0	0.11

Sources of nitrogen inputs, N_2O and CH_4 emissions in hedgerow systems

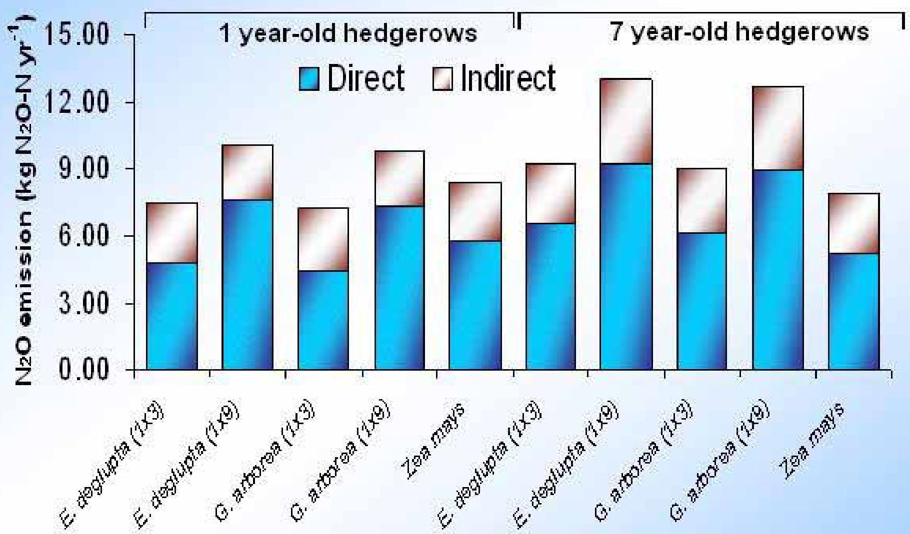
Nitrous oxide emissions from grazing animals (N_{EXPR}) using local values for N excretion per animal type

Livestock Type	Number of animals	N excretion per animal type (kg head^{-1} yr^{-1})	Total annual N excretion (kg N)	Fraction pasture range and paddock	N_{EXPR} (kg N yr^{-1})	EF3 (kg N_2O-N/kg N)	$N_2O_{GRAZING}$ (kg N_2O yr^{-1})
Non-dairy cattle	258	12.3	3,173.4	1	3,173.4	0.02	99.74
Carabao	62	14.2	880.4	1	880.4	0.02	27.67
Goat	46	0.6	27.6	1	27.6	0.02	0.87
Swine	398	5.8	2,308.4	1	2,308.4	0.02	72.55
Poultry	1,252	0.1	125.2	1	125.2	0.02	3.94
Total			6515	1		0.02	204.77

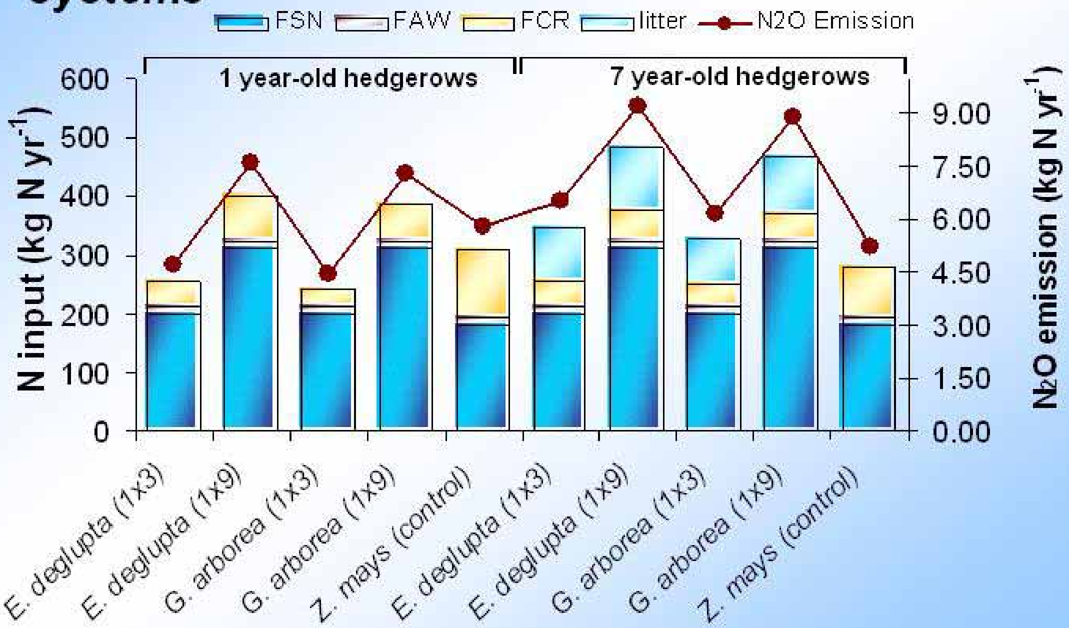
Nitrous oxide emissions from grazing animals (N_{EXPR}) using IPCC (1997) default values for N excretion per animal type

Livestock Type	Number of animals	N excretion per animal type (kg $head^{-1} yr^{-1}$)	Total annual N excretion (kg N)	Fraction pasture range and paddock	N_{EXPR} (kg N yr^{-1})	EF3 (kg N_2O-N/kg N)	$N_2O_{GRAZING}$ (kg N_2O yr^{-1})
Non-dairy cattle	258	40	10,320	1	10,320	0.02	324.34
Carabao	62	40	2,480	1	2,480	0.02	77.94
Goat	46	12	552	1	552	0.02	17.35
Swine	398	16	6,368	1	6,368	0.02	200.14
Poultry	1,252	0.6	751.2	1	751.2	0.02	23.61
Total			20,471.2	1		0.02	643.38

Direct and indirect N_2O emissions in E. deglupta and G. arborea hedgerow systems



Nitrogen inputs and total N_2O emission in E. deglupta and G. arborea hedgerow systems



Total methane (CH_4) emissions from enteric fermentation and manure management per animal type

Animal Type	Enteric fermentation (kg CH_4 yr^{-1})	Manure management (kg CH_4 yr^{-1})	Total methane emissions (kg CH_4 yr^{-1})
Non-dairy cattle	11,352	516	11,868
Carabao	3,410	186	3,596
Goat	230	10.1	240.1
Swine	597	2,786	3,383
Poultry	-	28.8	28.8
Total			19,115.3

Issues regarding GHG inventory

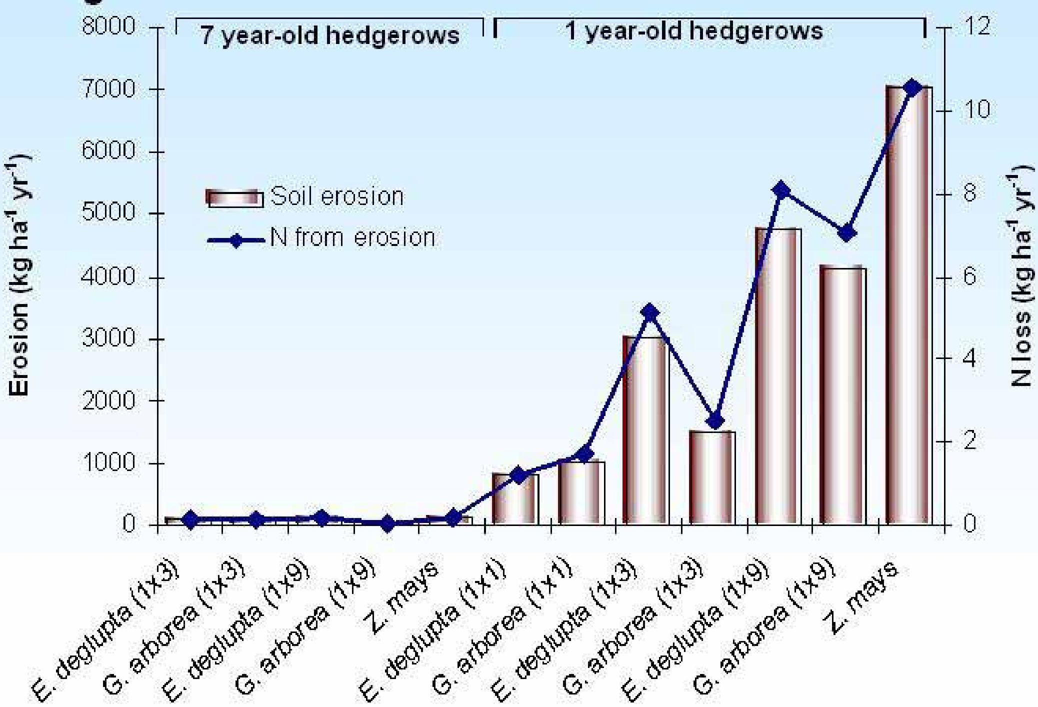
Ratios of crop residue:grain and residue: grain+cob

Tree species	Tree age	Spacing	Maize residue (g plant^{-1})	Grain yield (g plant^{-1})	Grain + cob (g plant^{-1})	Ratio (residue: grain)	Ratio (residue: grain+cob)
E. deglupta	1	1x3	220.75	81.74	101.72	2.70	2.17
E. deglupta	1	1x9	287.12	111.07	135.78	2.59	2.11
G. arborea	1	1x3	176.07	60.71	74.99	2.90	2.35
G. arborea	1	1x9	203.13	74.45	90.88	2.73	2.24
Z. mays			308.26	115.23	138.14	2.68	2.23
E. deglupta	7	1x3	195.11	58.83	72.41	3.32	2.69
E. deglupta	7	1x9	307.23	86.27	103.88	3.56	2.96
G. arborea	7	1x3	122.11	29.96	40.30	4.08	3.03
G. arborea	7	1x9	272.59	75.31	89.95	3.62	3.03
Z. mays			439.93	110.37	138.42	3.99	3.18

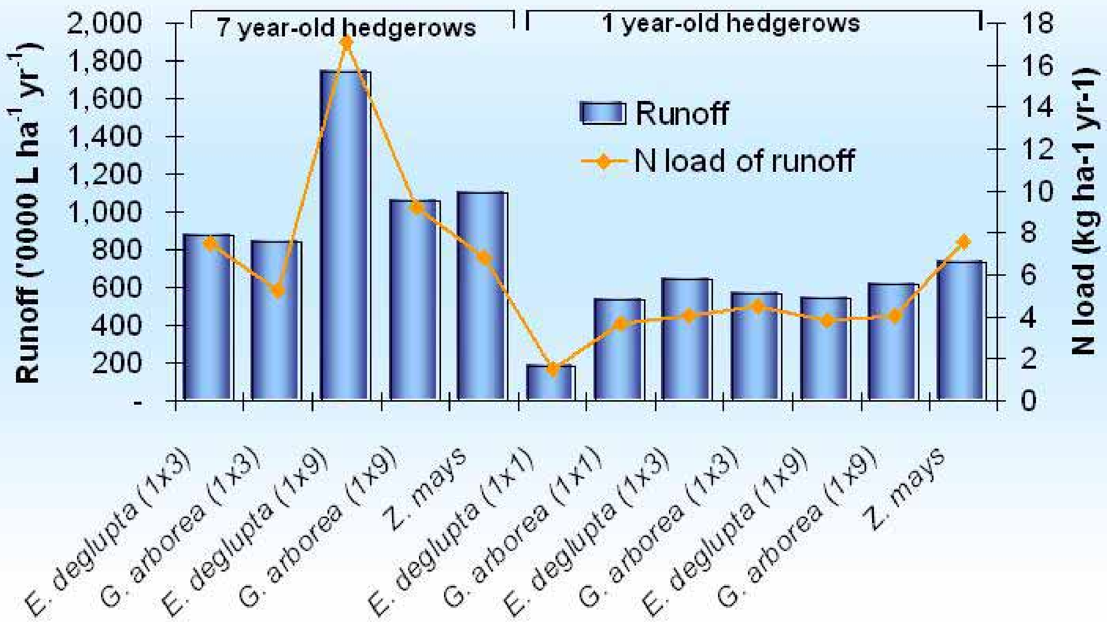
Local and IPCC default values for the N excretion values for the different animal types

Livestock type	N excretion per animal type (IPCC, kg head^{-1} yr^{-1})	N excretion per animal type (local, kg head^{-1} yr^{-1})
Non-dairy cattle	40	12.3
Carabao	40	14.2
Goat	12	0.6
Swine	16	5.8
Poultry	0.6	0.1

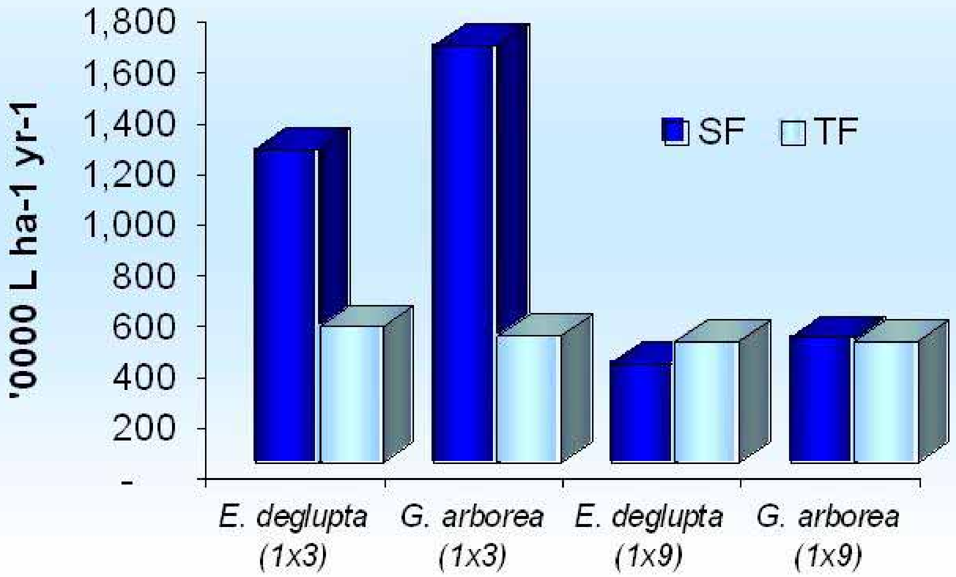
Soil erosion and N loss under 7 and 1 year old hedgerows



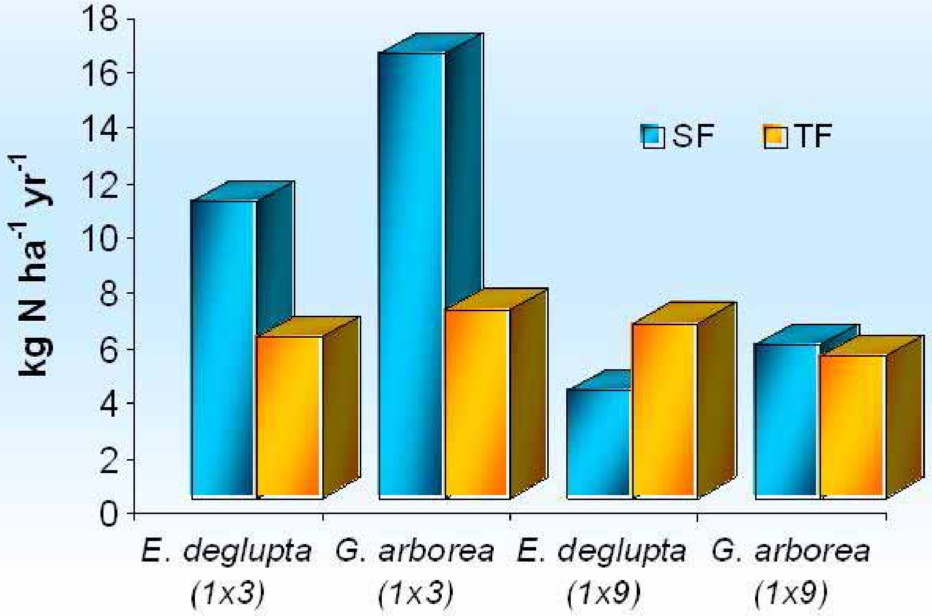
Runoff and N loss under 7 and 1 year old hedgerows



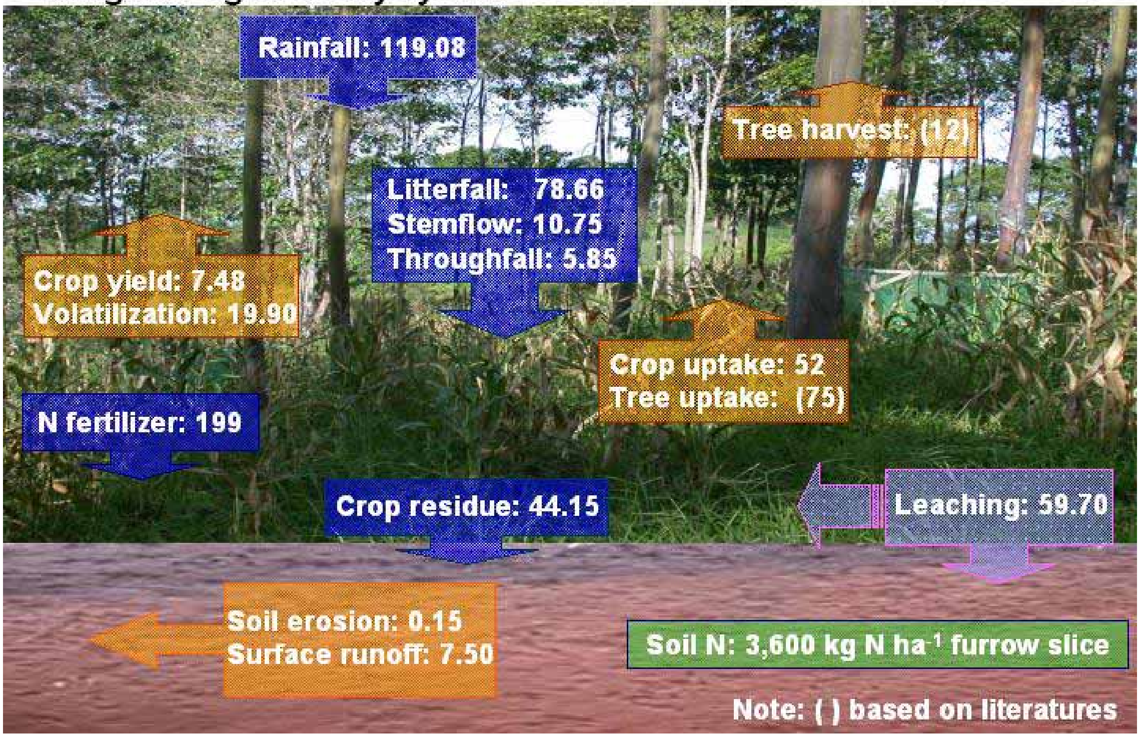
Stemflow (SF) and Throughfall (TF) under 7 year old hedgerows



Nitrogen load of Stemflow (SF) and Throughfall (TF) under 7 year old hedgerows



Nitrogen flow (kg ha^{-1} yr^{-1}) in a 7 year old 1x3 Eucalyptus deglupta hedgerow agroforestry system



Conclusions

- In tree-based hedgerow systems, crop residue incorporation and fertilizer application are the major sources of nitrogen inputs. Animal manure, litterfall, stemflow and throughfall are other sources of nitrogen inputs into the soil.
- Nitrogen losses from hedgerow systems include soil erosion, surface runoff, crop harvest (grain yield) and volatilization and leaching of N fertilizer.
- Indirect sources of N_2O emissions in hedgerow systems are atmospheric deposition of NH_3 and NO_x and N leaching.

Conclusions

- The major source of N_2O emissions from the agroforestry systems studied is the direct N_2O emissions from soil.
- Maize monocropping system had higher N_2O emissions than hedgerow systems.
- Enteric fermentation is the major source of methane emissions from domestic livestock in Claveria.
- Soil erosion is significantly reduced in a established 7-year old hedgerows.

Conclusions

- Considerable amounts of N are contained in stemflow, throughfall, runoff and erosion which could be possible source of N emission in hedgerow AF systems.
- Use of local values for N excretion factors will reduce uncertainties in the estimates of N excretion from animal manure.
- A number of factors identified in this study that needs further research to improve estimates of N_2O emissions were the N excretion factor per animal type, residue to grain (residue to crop) ratio, fraction leaching and fraction volatilization.

Acknowledgement

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END OF PRESENTATION