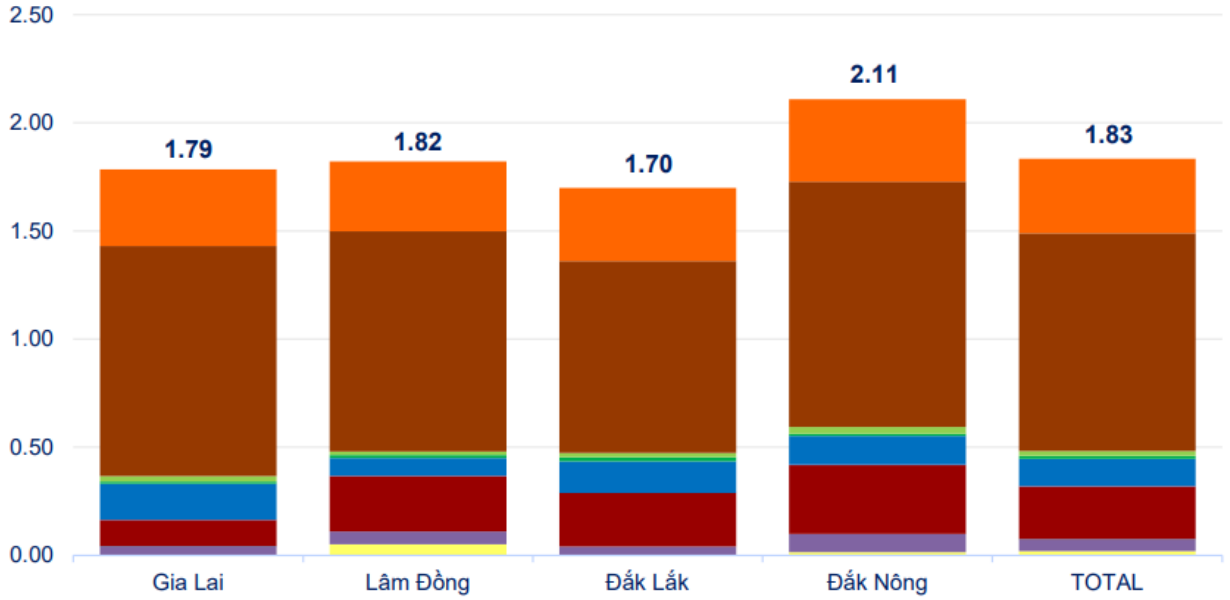
Knowledge grows

PACT CFT study
- Fertilizer update

March 2023

Central Highlands – Breakdown per category

Central Highlands



	Gia Lai	Lâm Đồng	Đắk Lắk	Đắk Nông	TOTAL	
Fertilizer production	0.35	0.32	0.34	0.38	**0.34**	(19%)
Fertilizer use and soil	1.06	1.02	0.89	1.14	**1.01**	(55%)
Energy use (field)	0.02	0.02	0.02	0.03	**0.02**	(1%)
Energy use (processing)	0.01	0.01	0.02	0.01	**0.01**	(<1%)
Energy use (irrigation)	0.17	0.08	0.15	0.13	**0.13**	(7%)
Crop protection	0.00	0.00	0.00	0.00	**0.00**	(<1%)
Residue management	0.12	0.26	0.25	0.32	**0.24**	(13%)
Waste water	0.00	0.00	0.00	0.00	**0.00**	(<1%)
Transport	0.04	0.06	0.04	0.08	**0.06**	(3%)
Land use change	0.00	0.05	0.00	0.02	**0.02**	(1%)

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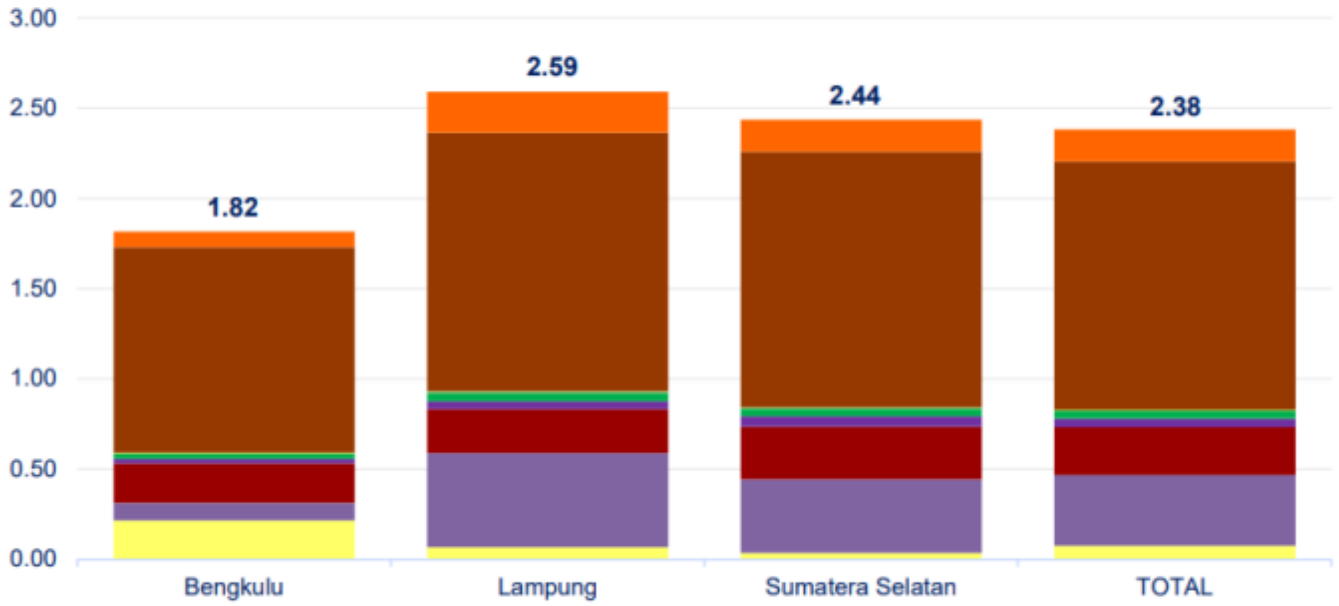
Source: PACT/ENVERITAS study (03/2023)

Southern Sumatra – Breakdown per category

Southern Sumatra



	Bengkulu	Lampung	Sumatera Selatan	TOTAL	
Fertilizer production	0.09	0.23	0.18	**0.18**	(8%)
Fertilizer use and soil	1.14	1.43	1.42	**1.38**	(58%)
Energy use (field)	0.01	0.01	0.01	**0.01**	(<1%)
Energy use (processing)	0.02	0.05	0.04	**0.04**	(2%)
Energy use (irrigation)	0.00	0.00	0.00	**0.00**	(<1%)
Crop protection	0.03	0.04	0.06	**0.05**	(2%)
Residue management	0.22	0.24	0.29	**0.26**	(11%)
Waste water	0.00	0.00	0.00	**0.00**	(<1%)
Transport	0.10	0.52	0.41	**0.39**	(16%)
Land use change	0.22	0.07	0.04	**0.08**	(3%)

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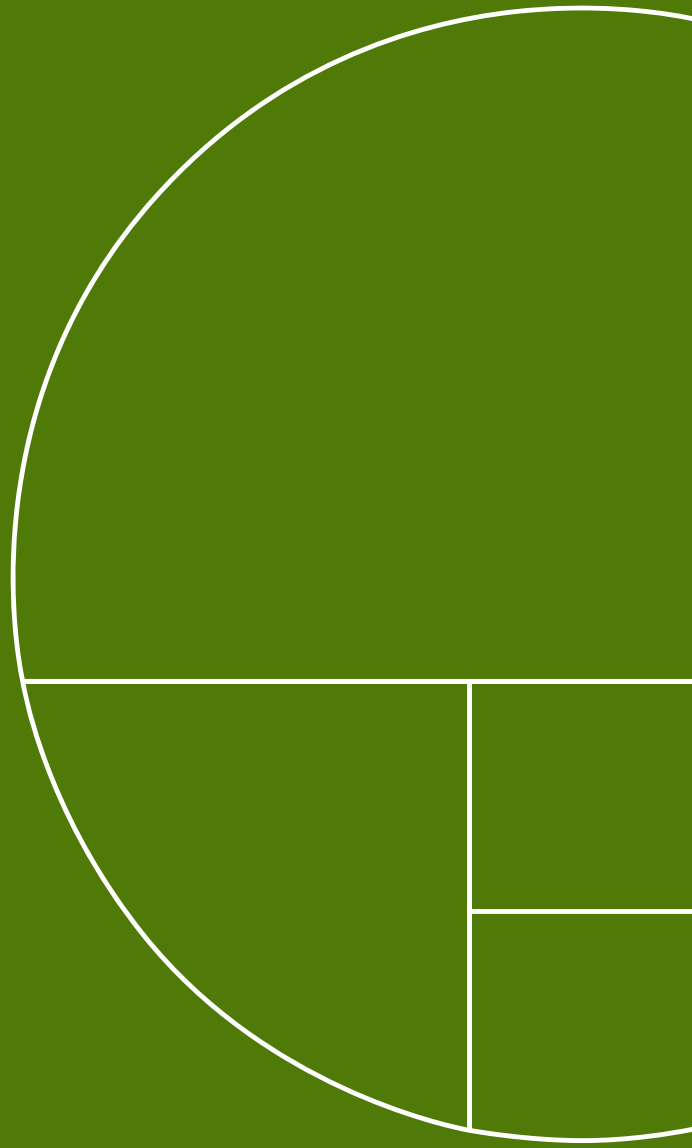
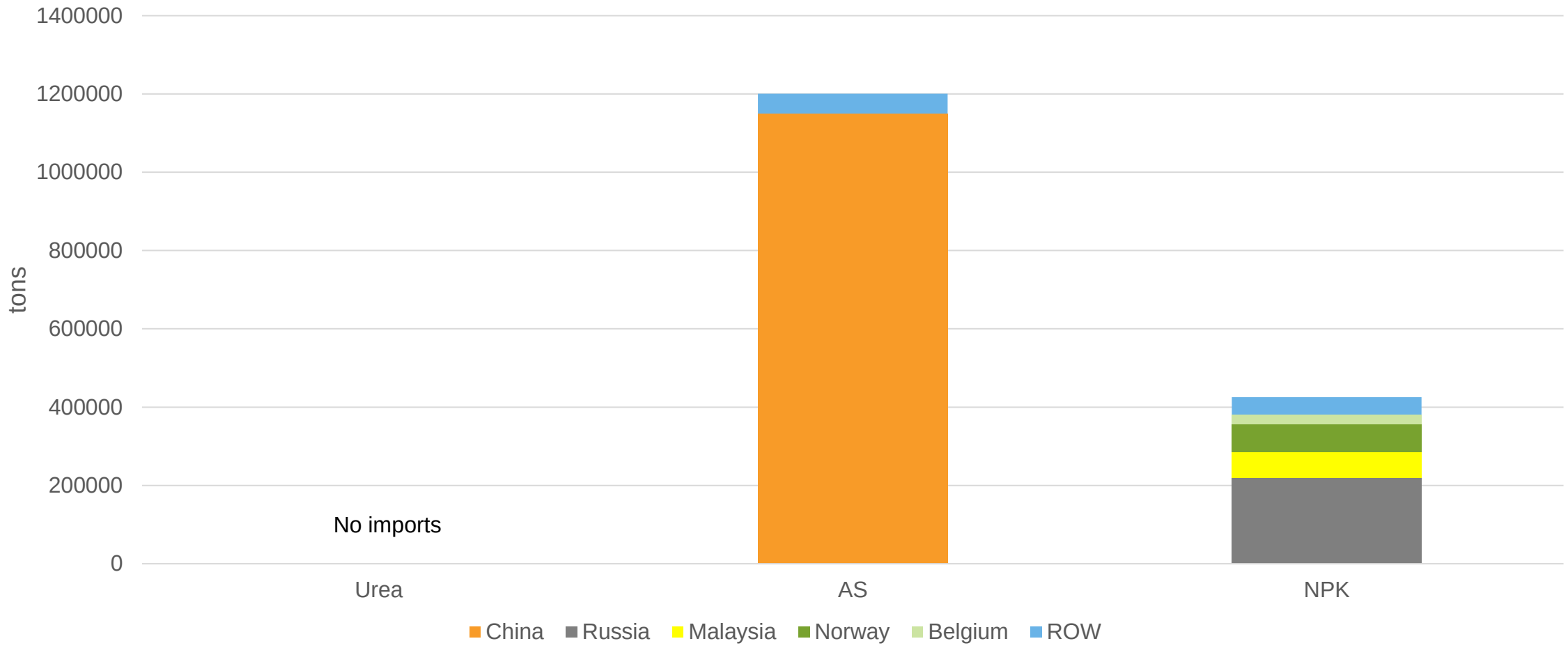
Source: PACT/ENVERITAS study (03/2023)

Fertilizer production



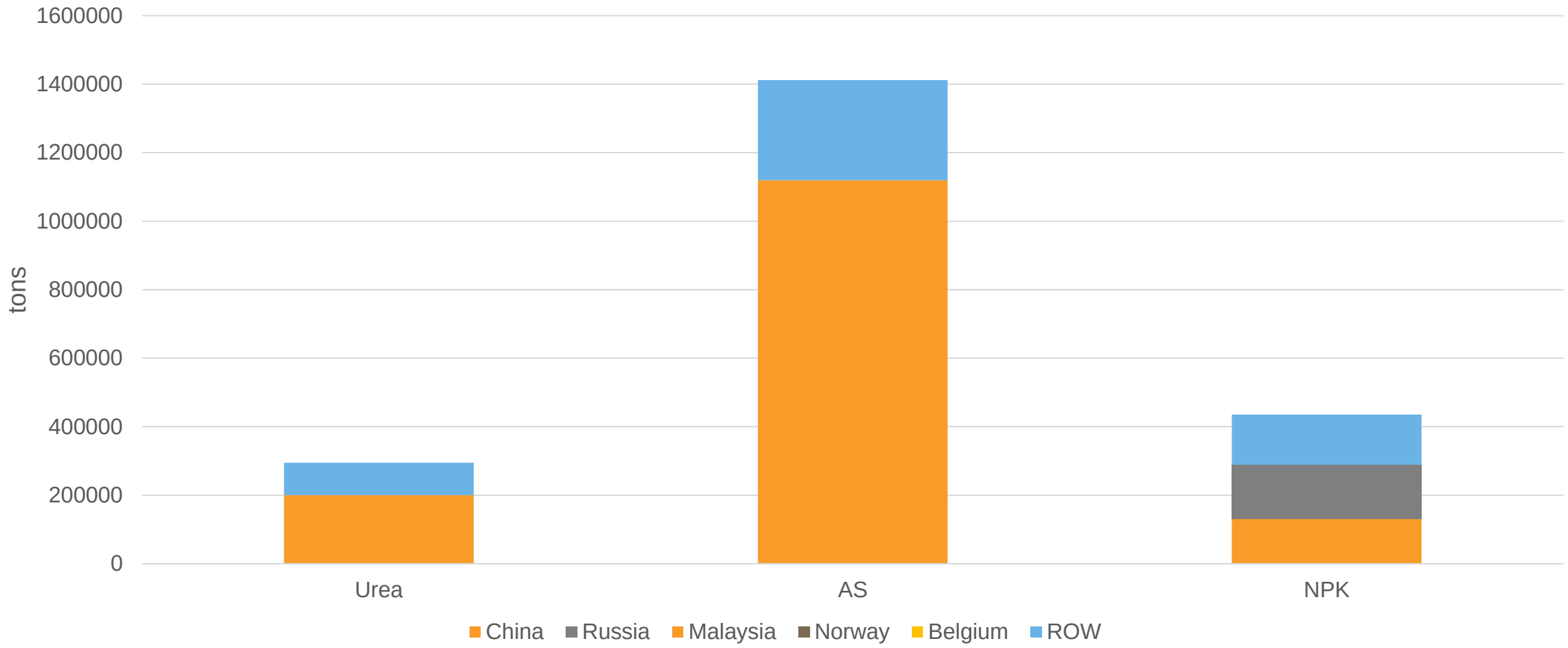
Fertilizer imports to Indonesia (2021)

Estimated Market Figures – to be confimed by official statistics



Fertilizer imports to Vietnam (2021)

Estimated Market figures – to be confimed by official statistics



Relative difference in production emissions for imported fertilizers compared with local production in SE-Asia

% of SE-Asia	SE-Asia	Europe	Russia	China
AS	100	68	105	172
NPK 3x15	100	55	100	142
Urea	100	95	118	214

Reference carbon footprint values for main mineral fertilizer products from all main production regions

Table 1: Reference carbon footprint (CFP) values for main mineral fertilizer products from different regions[8] (reference year 2014)

Fertilizer product	**Nutrient content (%)**	**Carbon footprint (kg CO_2e/kg product)**									
		Europe	CIS (e.g. Russia)	Africa	Middle East	North America	Latin America	China	South Asia	South-East Asia	Oceania
Ammonium nitrate (gran.)[1]	33.5N	1,14	2,42	2,10	2,44	2,28	2,17	3,50	2,32	2,39	2,09
Ammonium nitrate (prill.)[1]	33.5N	1,11	2,38	2,06	2,40	2,25	2,13	3,44	2,27	2,34	2,05
Ammonium sulphate	21N, 24S	0,56	0,68	0,62	0,59	0,61	0,66	1,12	0,81	0,65	0,56
Ammonium sulphate nitrate	26N, 14S	0,80	1,39	1,22	1,33	1,29	1,27	2,08	1,42	1,35	1,18
Anhydrous ammonia[2]	82N	2,30	2,67	2,38	2,19	2,49	2,56	4,20	2,92	2,38	2,05
Calcium ammonium nitrate	27N	0,95	1,98	1,72	2,00	1,87	1,78	2,86	1,90	1,96	1,72
Calcium nitrate	15.5N	0,64	1,66	1,44	1,75	1,58	1,47	2,34	1,53	1,68	1,48
NPK (mixed-acid)[3]	15N, 15P_2O_5, 15K_2O	0,62	1,13	1,00	1,13	1,06	1,03	1,61	1,13	1,13	1,01
NPK (nitrophosphate)[4]	15N, 15P_2O_5, 15K_2O	0,71	1,22	1,09	1,22	1,15	1,11	1,71	1,24	1,22	1,10
Diammonium phosphate	18N, 46P_2O_5	0,63	0,75	0,70	0,68	0,67	0,73	1,15	0,89	0,74	0,66
Monoammonium phosphate	11N, 52P_2O_5	0,44	0,53	0,51	0,51	0,46	0,52	0,81	0,66	0,55	0,51
Super phosphate	18P_2O_5, 12S	0,08	0,09	0,10	0,11	0,08	0,09	0,13	0,13	0,11	0,11
Triple super phosphate	48P_2O_5	0,18	0,21	0,22	0,24	0,18	0,21	0,27	0,28	0,25	0,25
Urea[5]	46N	0,88	1,10	0,93	0,81	1,01	1,01	1,99	1,27	0,93	0,75
Urea ammonium nitrate (liq.)[5,6]	30N	0,78	1,43	1,23	1,34	1,33	1,29	2,20	1,44	1,36	1,17
Limestone[7]	55$CaCO_3$	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07
Potassium chloride[7]	60K_2O	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25
Potassium sulphate[7]	50K_2O, 18S	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12

Today, Urea is the main N source globally. It contains carbon, which is released as CO_2 after application to soil.

Natural gas (CH_4)

CH_4

Nitrogen (**N_2**) from air

Steam reforming

Haber-Bosch

H_2

Ammonia plant

Ammonia (**NH_3**)

Nitrates **(AN/CAN/CN)**

Typical carbon footprint with „BAT“ technology: 3.5 - 4 t CO_2e/t N

CO_2

Urea plant

Urea = **$CO(NH_2)_2$**

CO_2 to air (after application)

In a decarbonized future, hydrogen is produced by electrolysis of water and no more CO_2 is available for urea production.

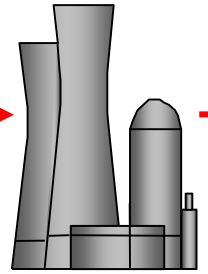
Nitrogen (**N_2**) from air

Estimated carbon footprint: <0.5 t CO_2e/t N

Electrolysis of **H_2O** (with renewable power)

H_2

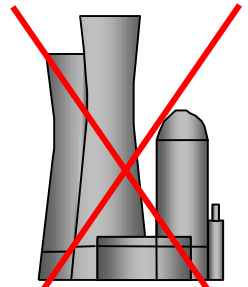
Haber-Bosch



Ammonia plant

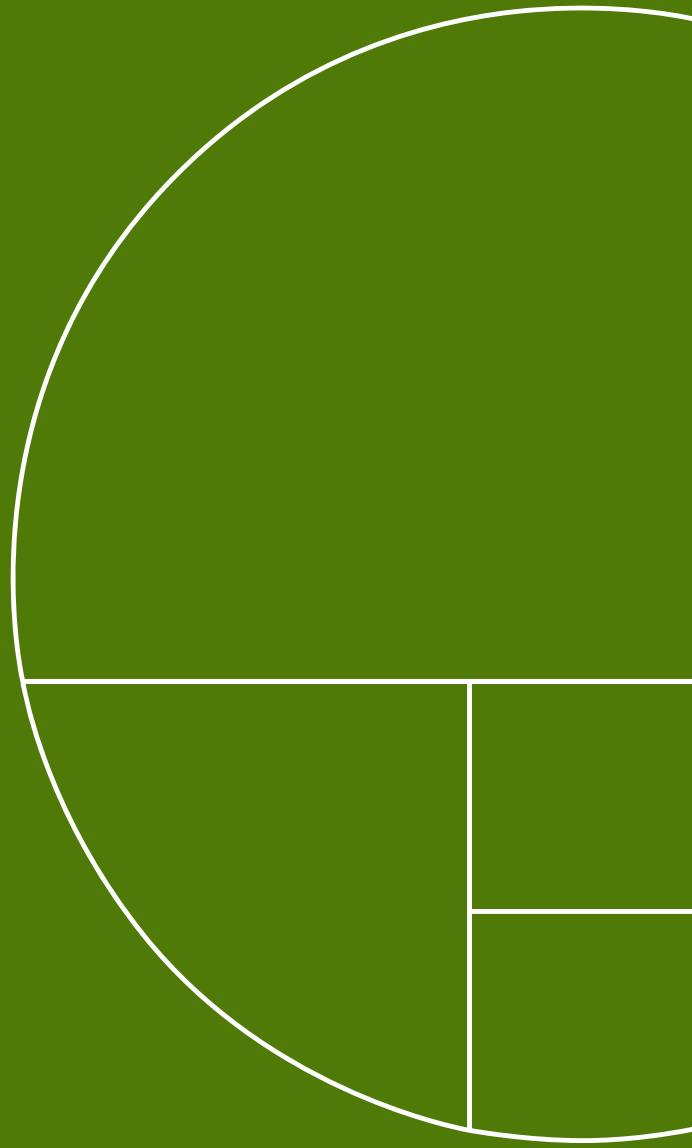
Ammonia (**NH_3**)

No CO_2 available for urea

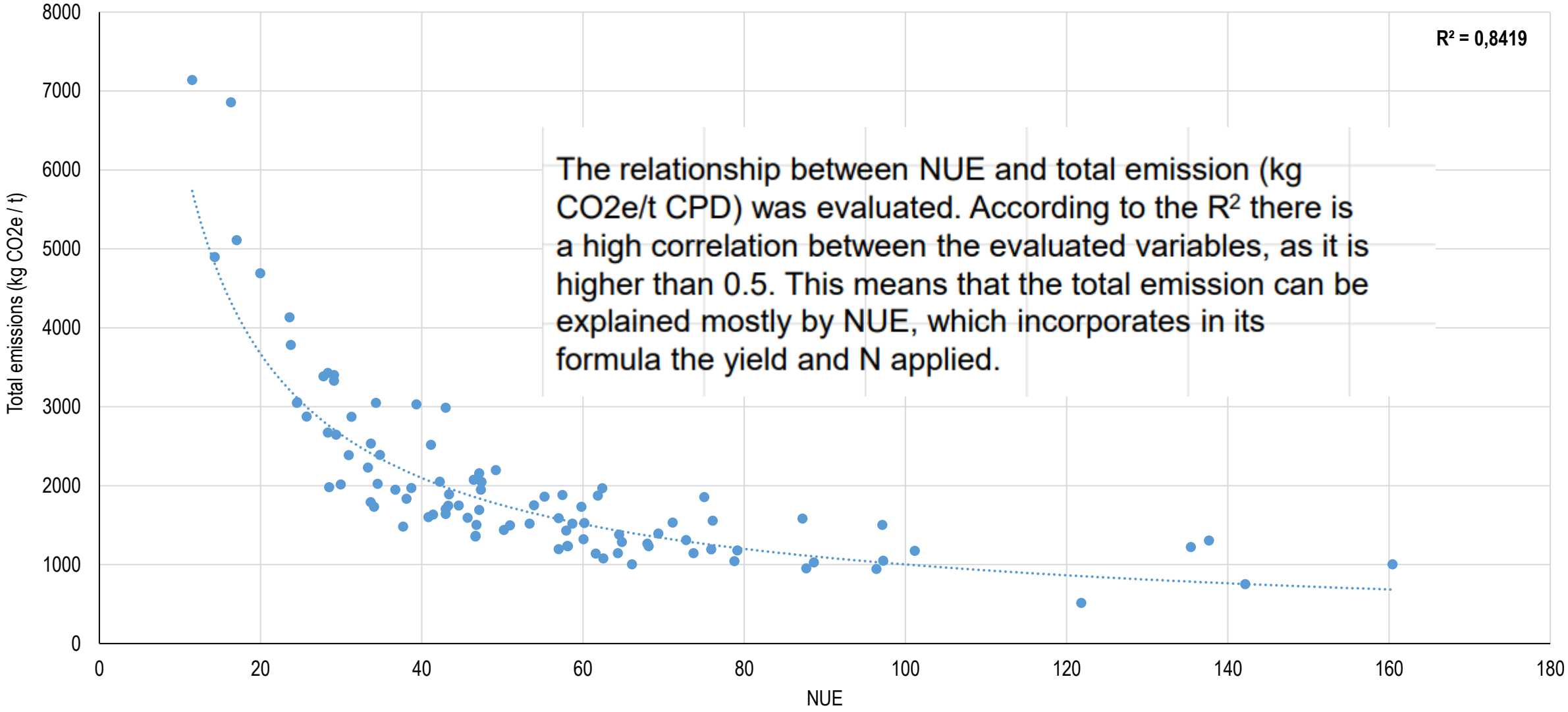


Urea plant

Fertilizer use



Relationship between NUE and Total emissions.



Key actions to reduce GHG emissions from crop production

Use fertilizers with low carbon footprint at production i.e. produced with BAT (today) and green ammonia (future)

Increase Nitrogen Use Efficiency (NUE) to produce more crop with the same or even less N

Avoid GHG emissions (mainly N_2O) and other **N losses** (mainly NH_3 and NO_3) from soil as much as possible

Increase productivity on existing farmland to avoid further land-use change with associated carbon loss

Protect soil carbon and **support carbon sequestration** through agricultural practices