Supplementary Information

Supplementary Information 1 – Data used to calculate N balances

No.	Parameters	Unit*	Value	Source
Ethiopia				
1	Maize area	Mha	2.27	CSA, 2020a
2	Wheat area	Mha	1.83	CSA, 2020a
3	Legume area	Mha	1.56	CSA, 2020a
4	Maize annual production	MT	9.63	CSA, 2020a
5	Wheat annual production	MT	5.15	CSA, 2020a
6	Proportion of fertilized maize area	-	0.6 - 0.7	Abate et al., 2015; Assefa et al., 2021; Central Statistical Agency of Ethiopia 2019
7	Proportion of fertilized wheat area	-	0.71	Minot et al., 2015; Central Statistical Agency of Ethiopia 2019
8	Proportion of maize area under organic fertilizer	-	0.20	Abate et al., 2015
9	Proportion of wheat area under organic fertilizer	-	0.03	CSA, 2021, 2020b, 2016
10	N rate applied to maize from synthetic sources	kg ha^{-1}	61	Kraaijvanger et al., 2015; Tefera et al., 2020

11	N rate applied to wheat from synthetic sources	kg ha^{-1}	54	Kraaijvanger et al., 2015; Tefera et al., 2020
12	Manure application rate - maize	t ha^{-1}	5.0	Burayu et al., 2001; MoALR, 2017
13	Manure application rate - wheat	t ha^{-1}	5.0	MoALR, 2017
14	N content of manure	%	1.83	Lupwayi et al., 2000
Malawi				
15	Maize area	Mha	1.73	FAO, 2022
16	Rice area	Mha	0.07	FAO, 2022
17	Legume area	Mha	1.33	FAO, 2022
18	Maize annual production	MT	3.26	FAO, 2022
19	Rice annual production	MT	0.13	FAO, 2022
20	Proportion of maize area under inorganic fertilizer	-	0.71	NSOM, 2022; Katengeza et al., 2019; Musafiri et al., 2020
21	Proportion of rice area under inorganic fertilizer	-	0.22	NSOM, 2022; Katengeza et al., 2019; Musafiri et al., 2020
22	Proportion of maize area under organic fertilizer	-	0.28	NSOM, 2022; Katengeza et al., 2019; Musafiri et al., 2020
23	Proportion of rice area under organic fertilizer	-	0.03	NSOM, 2022; Katengeza et al., 2019; Musafiri et al., 2020
24	N rate applied to maize from synthetic sources	kg ha^{-1}	57.6	Ludemann et al., 2022

25	N rate applied to rice from synthetic sources	kg ha^{-1}	20.0	Ludemann et al., 2022
26	Manure application rate - maize	t ha^{-1}	2.0	Katengeza, et al., 2019; Musafiri, et al., 2020
27	Manure application rate - rice	t ha^{-1}	2.0	Katengeza, et al., 2019; Musafiri, et al., 2020
28	N content of manure	%	1.25	Katengeza, et al., 2019; Musafiri, et al., 2020
India				
29	Maize area	Mha	9.87	FAO, 2022
30	Wheat area	Mha	31.36	FAO, 2022
31	Rice area	Mha	45	FAO, 2022
32	Legume area	Mha	33.18	FAO, 2022
33	Maize annual production	MT	30.2	FAO, 2022
34	Wheat annual production	MT	107.6	FAO, 2022
35	Rice annual production	MT	178.3	FAO, 2022
36	Proportion of fertilized maize area	-	0.9	https://www.indiastat.com/
37	Proportion of fertilized wheat area	-	1.0	https://www.indiastat.com/
38	Proportion of fertilized rice area	-	1.0	https://www.indiastat.com/

39	Proportion of maize area under organic fertilizer	-	0.03	Khurana and Kumar, 2022
40	Proportion of wheat area under organic fertilizer	-	0.03	Khurana and Kumar, 2022
41	Proportion of rice area under organic fertilizer	-	0.03	Khurana and Kumar, 2022
42	N rate applied to maize from synthetic sources	kg ha^{-1}	104.2	Ludemann et al., 2022
43	N rate applied to wheat from synthetic sources	kg ha^{-1}	112.3	Ludemann et al., 2022
44	N rate applied to rice from synthetic sources	kg ha^{-1}	135.4	Ludemann et al., 2022
45	Proposed Manure application rate - maize	t ha^{-1}	2.5	Expert opinion
46	Proposed Manure application rate - wheat	t ha^{-1}	2.5	Expert opinion
47	Proposed Manure application rate - rice	t ha^{-1}	2.5	Expert opinion
48	N content of manure	%	1.50 (0.5-2%)	Aryal et al., 2021

All countries				
49	Maize grain N concentration	%	1.58	Feliciano et al., 2017
50	Wheat grain N concentration	%	1.99	Feliciano et al., 2017
51	Rice grain N concentration	%	1.24	Feliciano et al., 2017
53	Mean N derived from atmospheric N_2 by grain legumes	kg ha^{-1}	51.0	Ladha et al., 2022

*M ha = million hectares; MT = metric tons

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Supplementary Information 2 – Ex ante estimation

Ex ante estimation framework

To estimate the potential reduction in urea fertilizer due the projected increase in urea price by 55%, this study starts with the total nitrogen applied to wheat and maize in the sampled countries. Let N denotes the total nitrogen fertilizer applied to agriculture. The nitrogen applied to crop c (c= wheat, maize) then can be calculated as:

Total nitrogen applied to wheat (tons)= $tN_c = sN_c \times N$ (1)

where sN_c is the share (%) of nitrogen to crop c, which is collected from Heffer et al., (2017).

Per ha fertilizer use in crop c = $phN_c = (tN_c)/(\text{Crop area (ha)})$ (2)

The reduction in nitrogen application to crop c per ha is = $Nr_{cph} = phN_c \times (\%\ \text{increase in urea price} \times \varepsilon_p)$ (3)

Where ε_p is the own price elasticity of urea fertilizer in a country sampled. In this ex ante study, we relied on the World Bank's (2022) projection is that by the first quarter of 2023, the urea price will increase by 55% from US$482 in 2021 to US$750 in 2023.

The total national level potential reduction of urea application to a crop sampled is calculated as $TNr_c = Nr_{cph} \times \text{Total crop area (ha)}$ (4)

The monetary value (million US$) of the total potential reduction of urea application to crop c is calculated as: $TNr_w = Nr_{wph} \times \text{Urea price (US\$/ton)}$ (5)

The World Bank's (2022) projection is that by the first quarter of 2023, the urea price will increase by 55% from US$482 to US$850 in 2023. In Eq.(5), we set the urea price at US$850/ton for all three sampled countries.

The per ha loss in crop production is calculated as $lCph = Nr_{cph} \times Yieldc \times \varepsilon_{ny}$ (6)

Where Nr_{cph} is defined in Eq.(3); Yieldc is the yield of crop c, and ε_{ny} yield response of crop to nitrogen.

National level potential aggregated reduction of crop c is calculated as

$tCr = lCph \times \text{Total crop area (ha)}$ (7)

Parameters used for ex ante estimation

Country	Price elasticity of fertilizer, maize	Price elasticity of fertilizer, wheat	Yield response to urea, maize	Yield response to urea, wheat	Source
India	-0.38	-0.38	+0.42	+0.256	Dholakia & Majumdar, 1995
Ethiopia	-0.0625	-0.1275	+0.265	+0.215	Rashid et al., 2013
Malawi	-0.92	–	+0.0884	–	Komarek et al., 2017; Snapp et al., 2014

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