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Regional scale biophysical assessment of the potential for sustainable intensification

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Introduction

- Climate shocks and soil degradation are driving food insecurity and threatening agricultural sustainability in Sub-Saharan Africa, including Ghana.
- Integrated Soil Fertility Management (ISFM) offers a pathway to sustainable intensification (SI) by optimizing inputs and boosting maize productivity.
- Yet, location-specific evidence on ISFM's impact on maize sustainability and risks remains limited. This study addresses this gap in northern Ghana's maize-producing zones using the SIMPLACE platform.

Materials and methods

- Assessment of the potential of ISFMs for sustainable intensification and its associated risks:

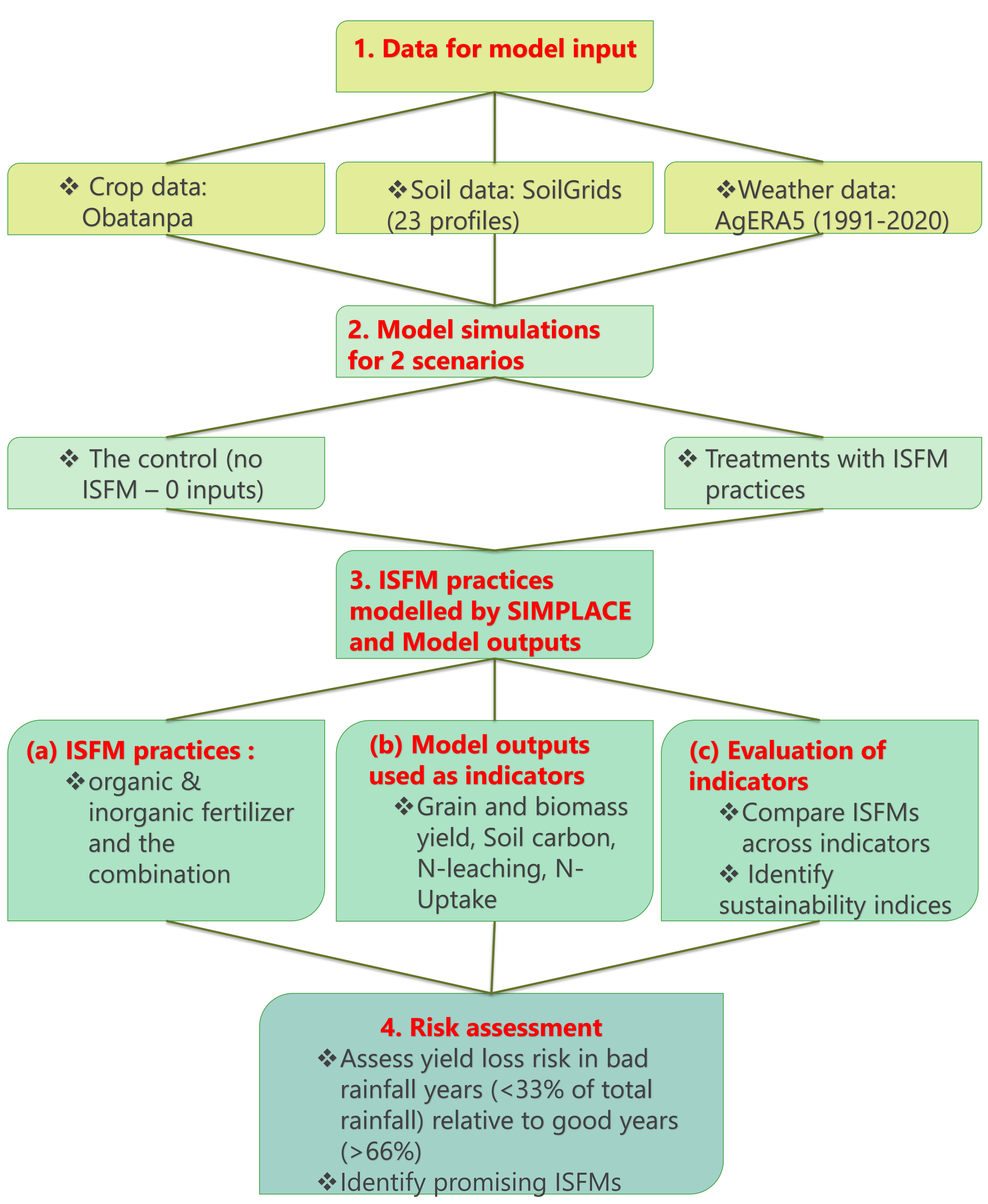

Table 1. ISFMs, application rates, and codes tested on Obatanpa maize in northern Ghana

ISFMs code	ISFM practices	Amount
1	Control	0
2	Inorganic1	90kg N/ha
3	Inorganic2	60kg N/ha
4	Inorganic2_Manure1	5t/ha +60kg N/ha
5	Inorganic2_Manure2	2.5 t/ha+ 60kg N/ha
6	Inorganic3	30kg N/ha
7	Inorganic3_Manure1	5t/ha +30kg N/ha
8	Inorganic3_Manure2	2.5 t/ha+ 30kg N/ha
9	Manure1	5t/ha
10	Manure2	2.5t/ha

Results

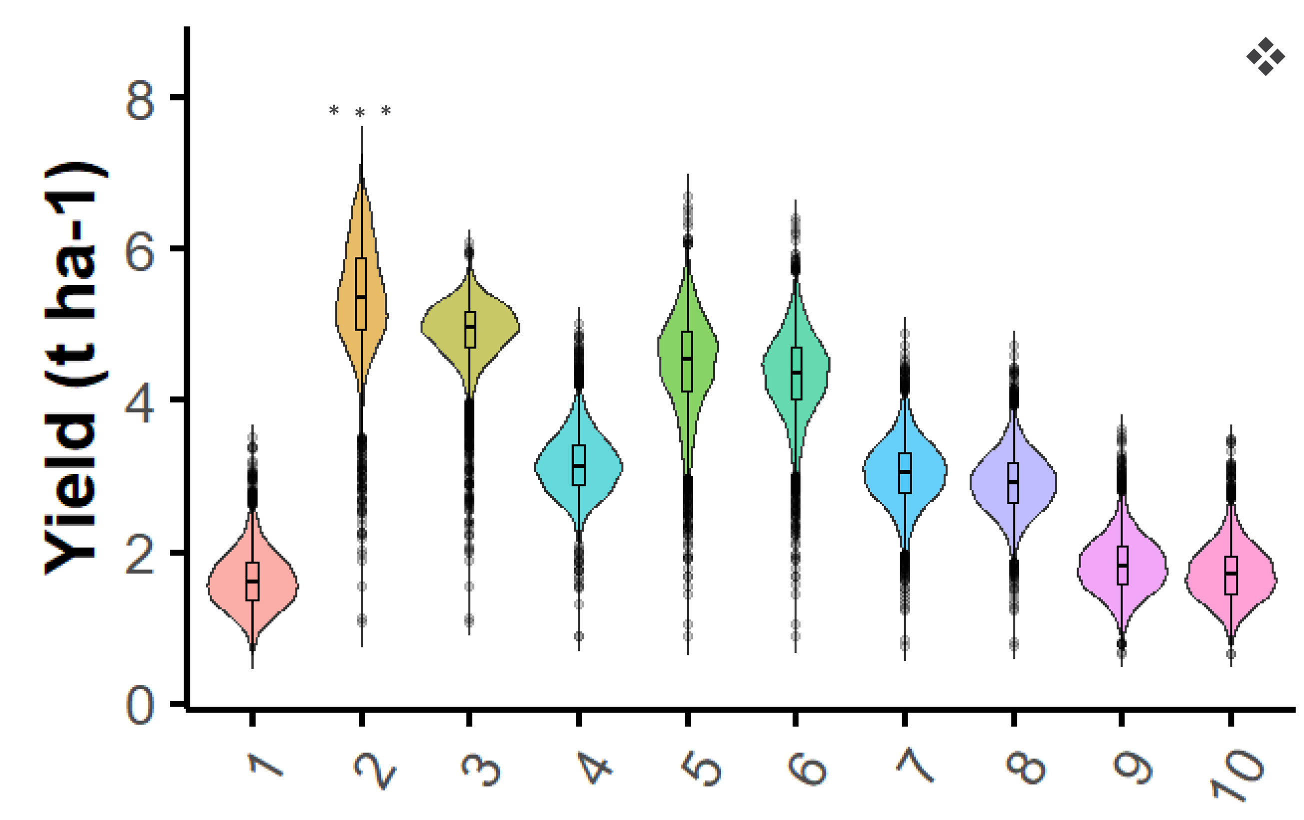

Figure 1. Yield distribution across ISFM practices

- Applying 90 kg N/ha produced the highest grain yield, which was significantly greater than all other treatments.

Table 2. Assessment of ISFMs in bad (332 mm) versus good (1100 mm) years. Grain (mean, sd and cv of grain yield), red color: lowest CV (%), S-sustainability

Year type	Outputs	1	2	3	4	5	6	7	8	9	10
Bad	Biomass	1.7	4.4	4.1	**4.6**	4.5	3.2	3.6	3.4	2.2	2
	Grain	0.6	2.2	1.9	1.8	1.7	1.2	1.2	1.1	0.7	0.6
	sd	0.3	**0.8**	0.5	0.7	0.6	0.4	0.4	0.4	0.3	0.3
	cv	**21**	15.6	**11.2**	15.2	14.2	12.3	14.5	13.8	19.5	**20.4**
	N-Leaching	135	242	160	183	172	135	158	151	143	139
	SOC	577	667	642	666	646	601	647	630	627	612
Good	Biomass	2.9	6.5	6.3	**7**	6.9	5.1	5.5	5.3	3.5	3.2
	Grain	1.1	3.2	3	2.7	2.6	2	1.9	1.8	1.2	1.1
	sd_Grain	0.4	0.6	0.4	0.6	0.5	0.4	0.4	0.4	0.4	0.4
	cv_Grain	**22**	11.1	**7.3**	13.4	12.2	12.8	13.5	13.3	19.4	**21**
	N-Leaching	238	399	280	317	301	238	277	265	252	245
	SOC	574	650	633	649	632	596	634	620	616	605
S- indices		0	**3.8**	2.5	**2.8**	2.7	1.1	1.	1.4	0.6	0.4

- 5 t/ha manure + 60 kg N/ha improved biomass and SOC but produced lower grain yields than Inorganic 1 and 2.
- It enhanced yield stability, with lower CVs in both bad (11.2%) and good (7.3%) years with higher sustainability index (2.8).
- Risk of yield loss was highest with no fertilizer (45%) and higher with manure than inorganic fertilizer: 43% vs. 32%.

Conclusion

- ISFM enhance maize productivity in northern Ghana.
- Highest yields occur at 90 kg N/ha, but with higher nitrogen leaching risks.
- Integrated inorganic–organic inputs (Inorganic2_Manure1) ensure more stable yields under low rainfall.
- No-input systems are highly vulnerable, with severe yield loss in dry years.
- Balanced ISFM strategies are critical to enhance yields, limit environmental risks, and build resilience.

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