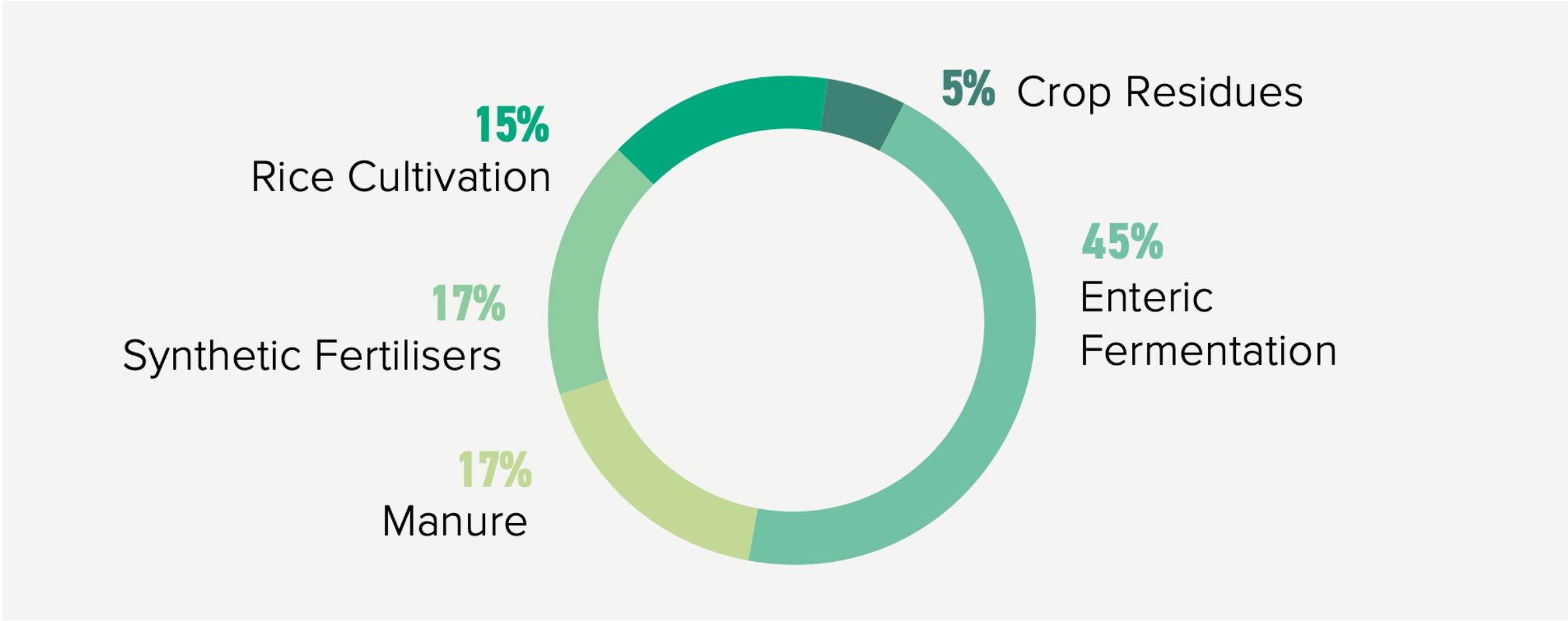
Emissions from smallholder farming systems

- Responsible for approximately one-third of emissions from the agricultural sector
- India's agricultural sector is the largest emitter (719.82 $MtCO_2e$), and emissions are steadily increasing through time

Vermeulen and Wollenberg, 2017
Global Carbon Project

Most emissions come from livestock, rice production, and fertilizer use

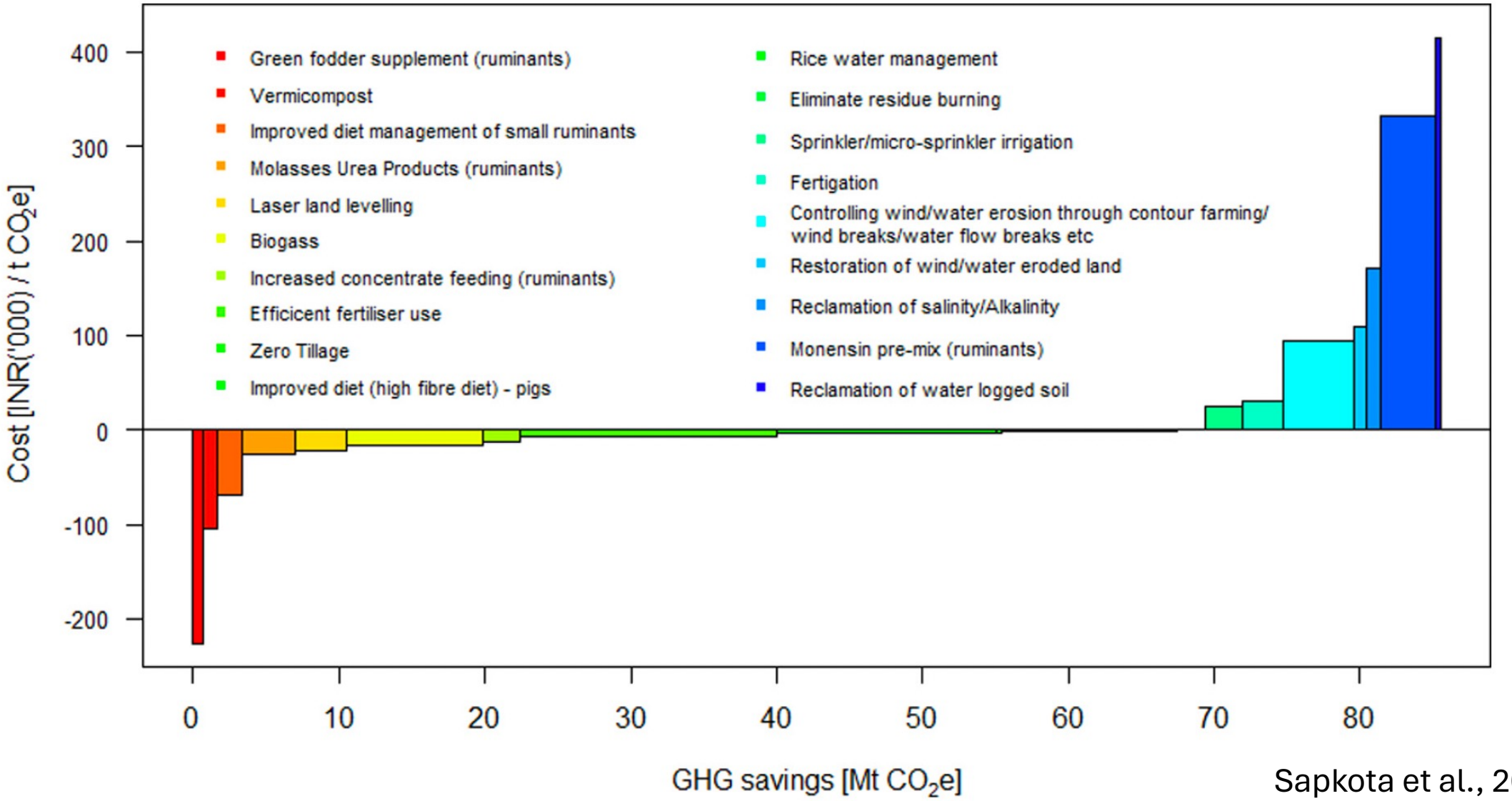


Climate Transparency Report 2020

Possible mitigation strategies

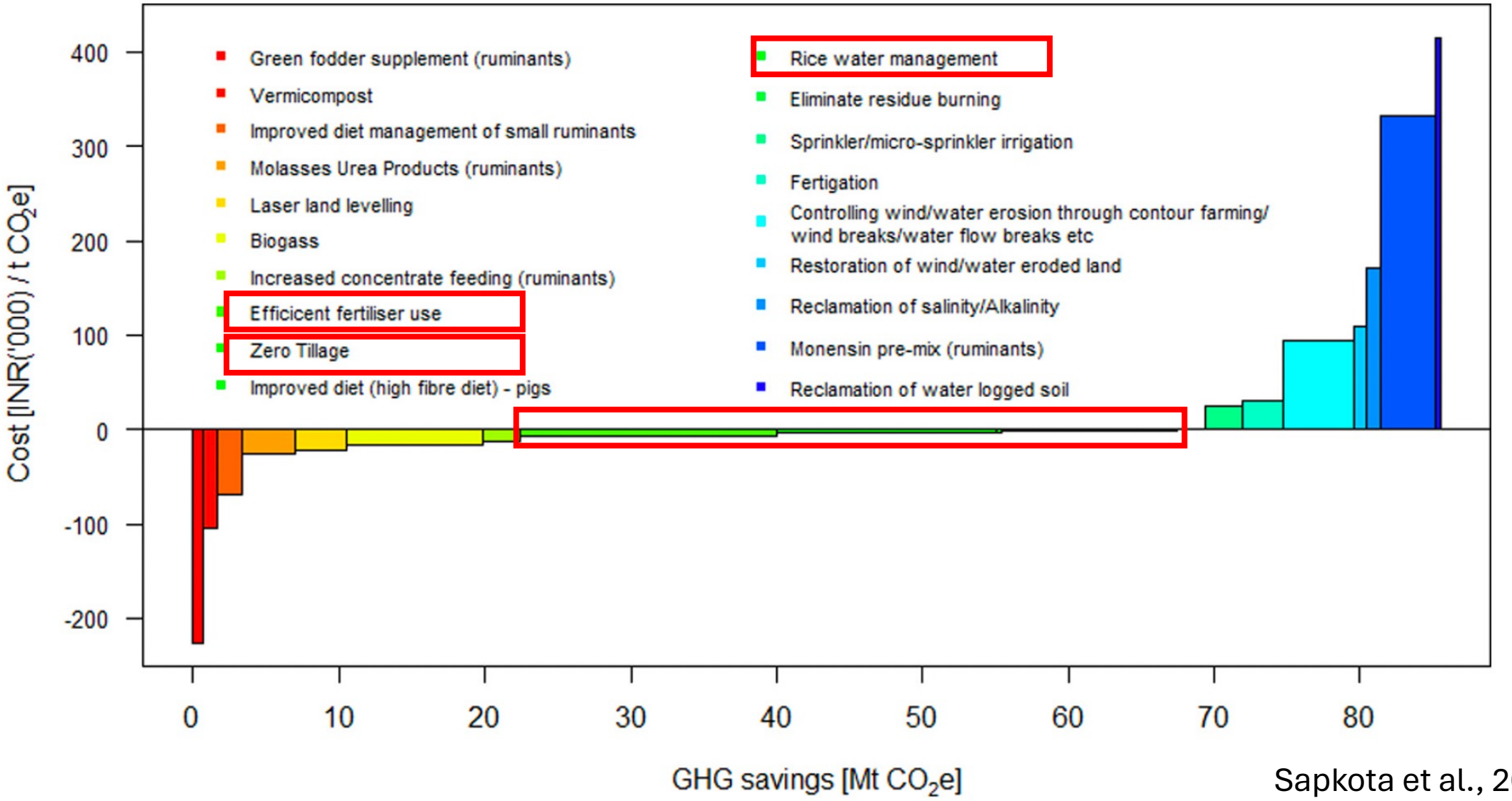
- Reclaim degraded agricultural lands
- Increase input use efficiency and yields
- Alter livestock feed
- Improve rice water management
- Adopt zero tillage
- Eliminate residue burning
- Use solar irrigation

80% of strategies are cost effective, could lead to 18% reduction in agricultural emissions



Sapkota et al., 2019, *STOTEN*

3 strategies contribute to 50% of potential savings



Sapkota et al., 2019, *STOTEN*

Yet strategies have not been widely adopted

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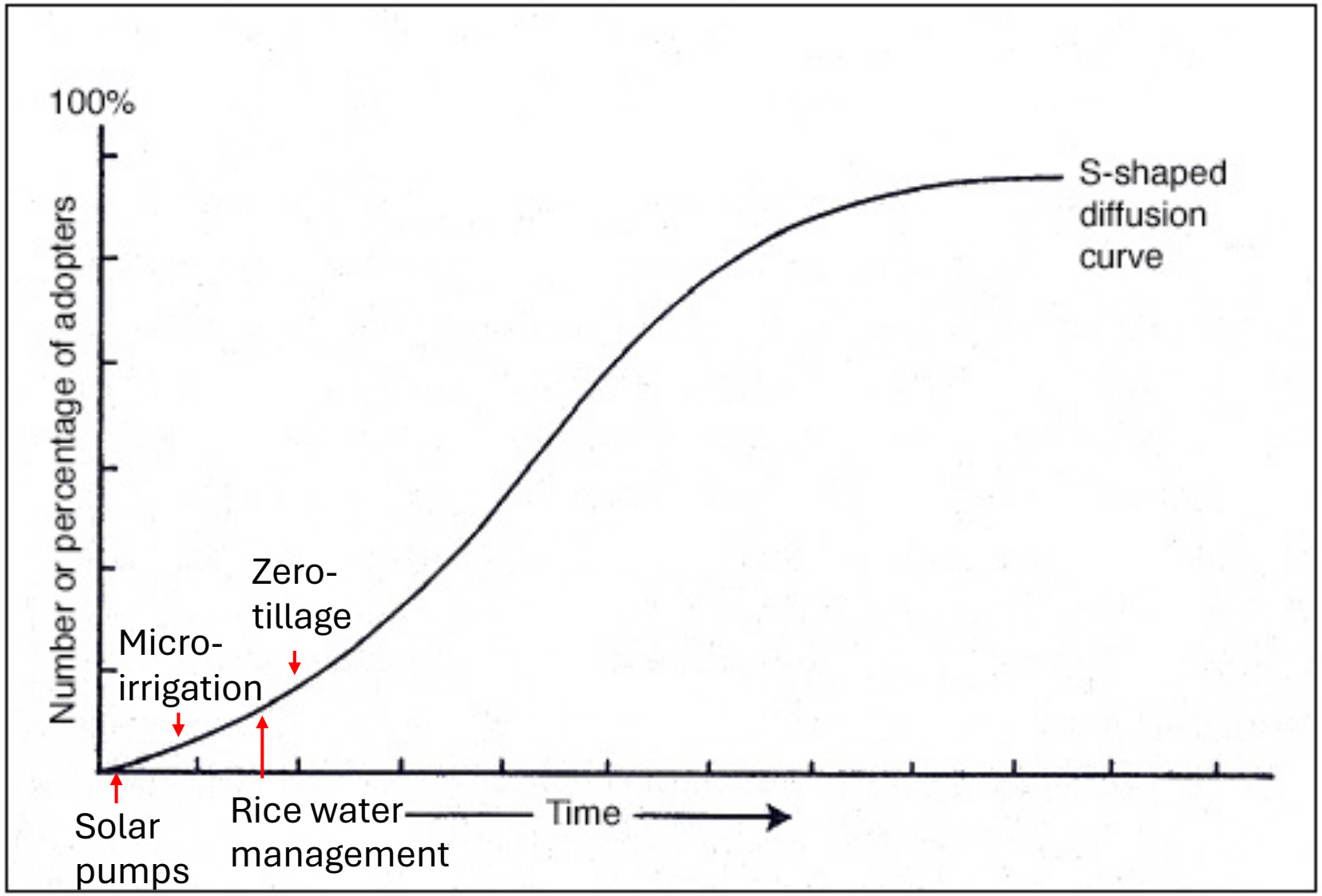
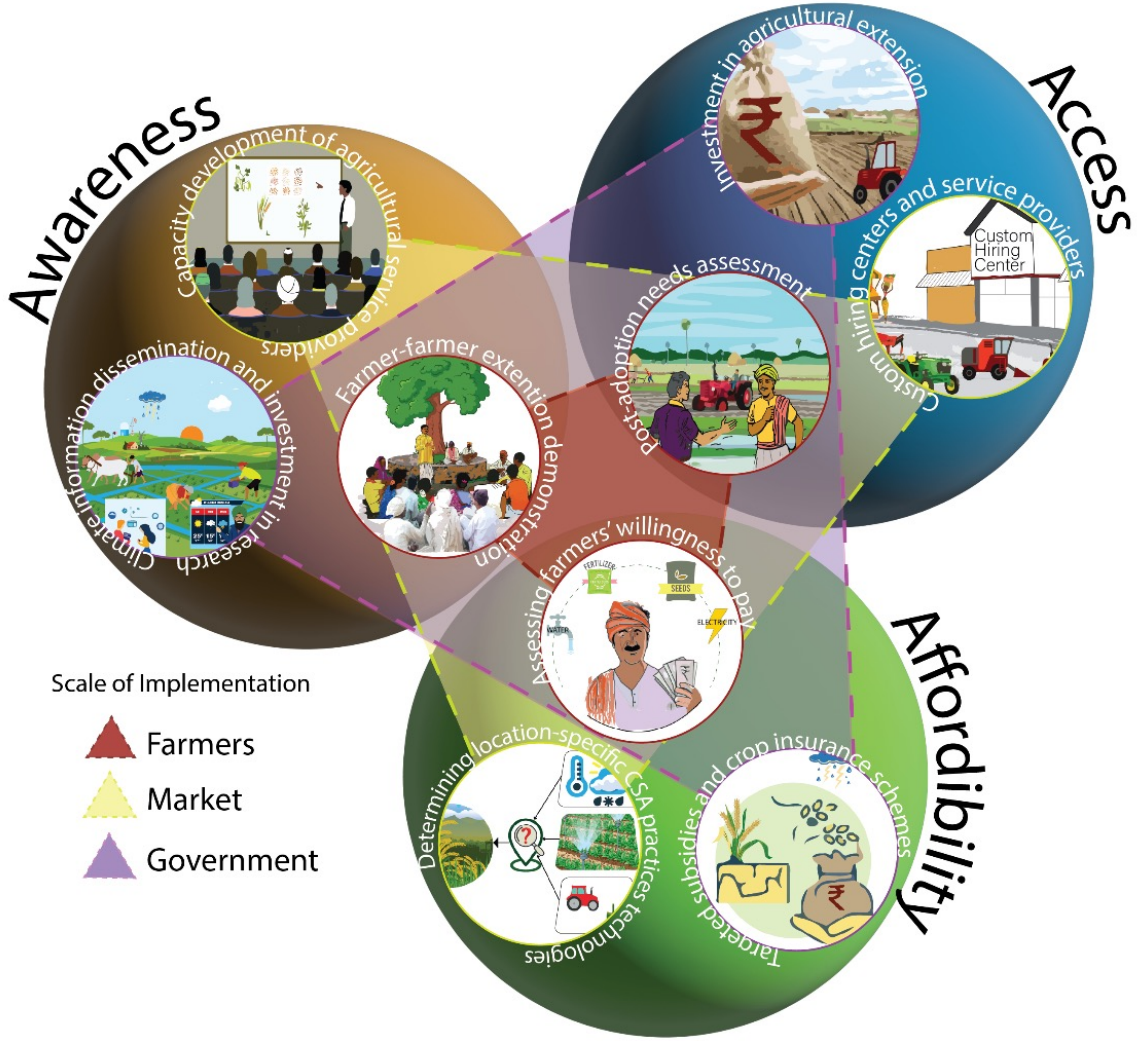


Why have strategies not been widely adopted even though they are cost-effective?

This is because of a suite of awareness, access, and affordability constraints



Ishtiaque et al., In Review

Zero tillage as an example

Affordability of zero-tillage

- It is possible that real-world savings on farm do not align with modeled savings based on field trials

Jain, Barrett, Solomon, and Kopel (2023) *ARER*

Affordability of zero-tillage

- It is possible that real-world savings on farm do not align with modeled savings based on field trials
- Causal inference studies on where farmers implemented the technology independently on real-world fields show significant cost savings and yield gains (4-30%)

Jain, Barrett, Solomon, and Kopel (2023) *ARER*

Krishna, Keil, Jain et al. (2022) *Front. Agron.*

Awareness of zero-tillage

- Awareness of ZT varies across Northern India, ranging from 2% to 80% of farmers depending on the region

Krishna, Keil, Jain et al. (2022) *Front. Agron.*

Awareness of zero-tillage

- Awareness of ZT varies across Northern India, ranging from 2% to 80% of farmers depending on the region
- When farmers are aware of the technology, 68% of large-scale and 35% of small-scale farmers adopt ZT

Krishna, Keil, Jain et al. (2022) *Front. Agron.*

Accessibility of zero-tillage

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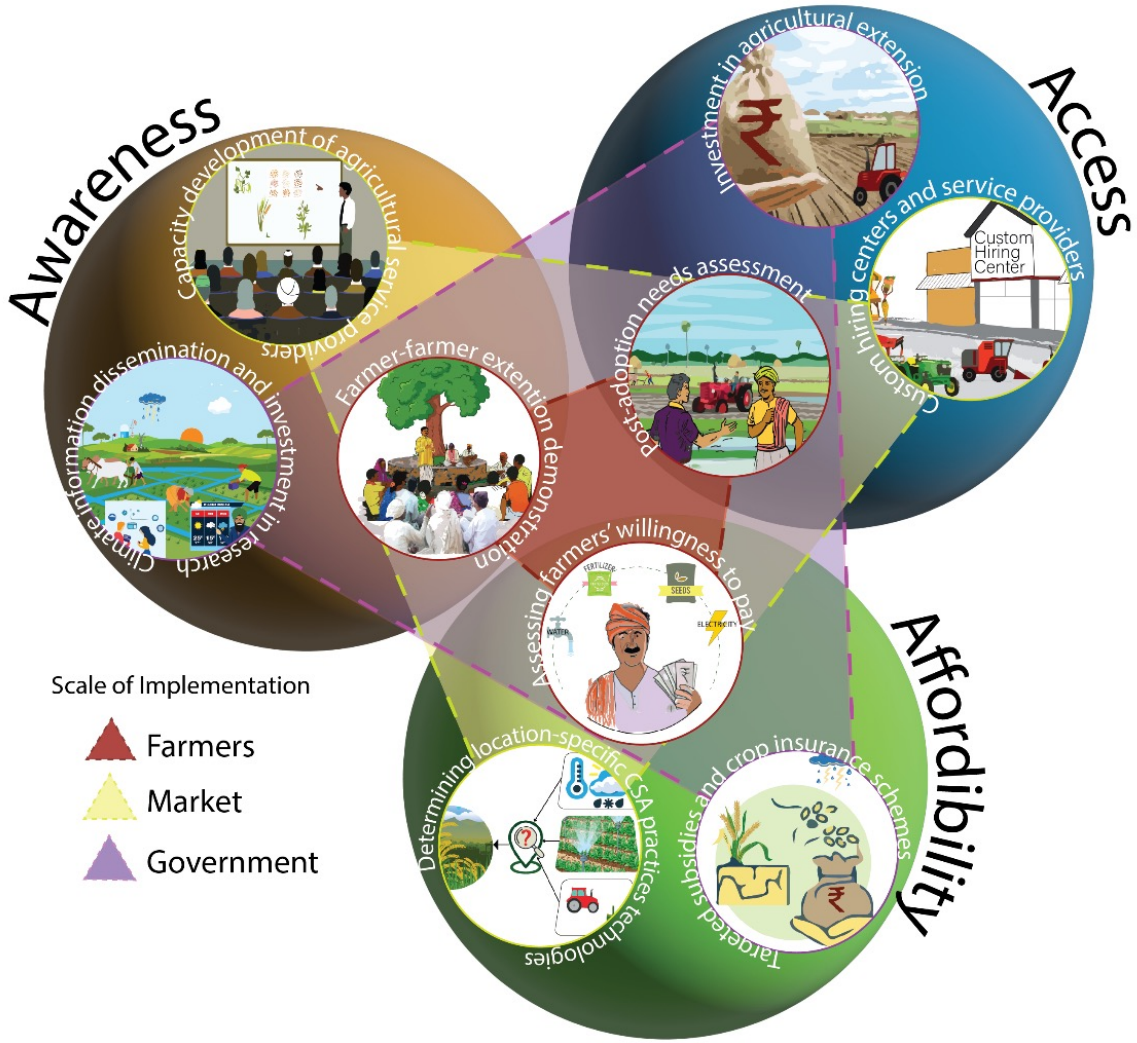
- Service provider model, where machinery-owning farmers hire out ZT use to other farmers
- Service providers are unable to meet demand, and there is scale bias in where they choose to go (returns and social networks). This is particularly true in NE India

Krishna, Keil, Jain et al. (2022) *Front. Agron.*

Need appropriate enabling environment



Ishtiaque et al., In Review

Food for thought for discussion

- Best case scenario in the medium-term is ~ 20% reduction in India's agricultural emissions (85-130 $MtCO_2e$ – 0.35% global emissions)

- Significant R&D will be needed to ensure these strategies scale and reach the full target population, which can be challenging given the heterogeneity in smallholder farmers, regions, and technologies

- How much is it worth investing in scaling out these technologies (for mitigation)?