Toward Sustainable Intensification of Agriculture in East and Southern Africa: What Have We Learned?

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The Challenge:

1. Farmers are using low levels of fertilizer
2. Low crop response rates to fertilizer is a major problem contributing to low use
3. What can governments do to help farmers
   - raise their response rates to fertilizer?
   - Make fertilizer use more profitable?
   - Contribute to greater use of fertilizer?

Section 1:

Evidence on Crop Response Rates

Review of maize-fertilizer response rates on farmer-managed fields

Study	country	Agronomic response rate (kgs maize per kg N)
Morris et al (2007)	W/E/S Africa	10-14
Sheahan et al (2013)	Kenya	14-21
Marenya and Barrett (2009)	Kenya	17.6
Liverpool-Tasie (2015)	Nigeria	8.0
Burke (2012)	Zambia	9.6
Minten et al (2013)	Ethiopia	11.7
Pan and Christiaensen (2012)	Tanzania	11.8
Mather et al (2015)	Tanzania	5.7 to 7.8
Snapp et al (2013)	Malawi	7.1 to 11.0
Holden and Lunduka (2011)	Malawi	11.3
Ricker Gilbert and Jayne (2011, 2012)	Malawi	6.6 to 11.5
Dorward and Chirwa (2013)	Malawi	negative to 9.0

Distinction between farmer-managed and researcher-managed fields

1. trials often non-randomly select farmers known to extension agents, often “master farmer” types
2. Trials often instruct farmers to follow strict protocols that most farmers cannot adhere to on their own plots
3. “observer effect”
4. Trials results often toss out observations in which the plot incurred damage due to water stress, insects, disease, pests, flooding, etc.

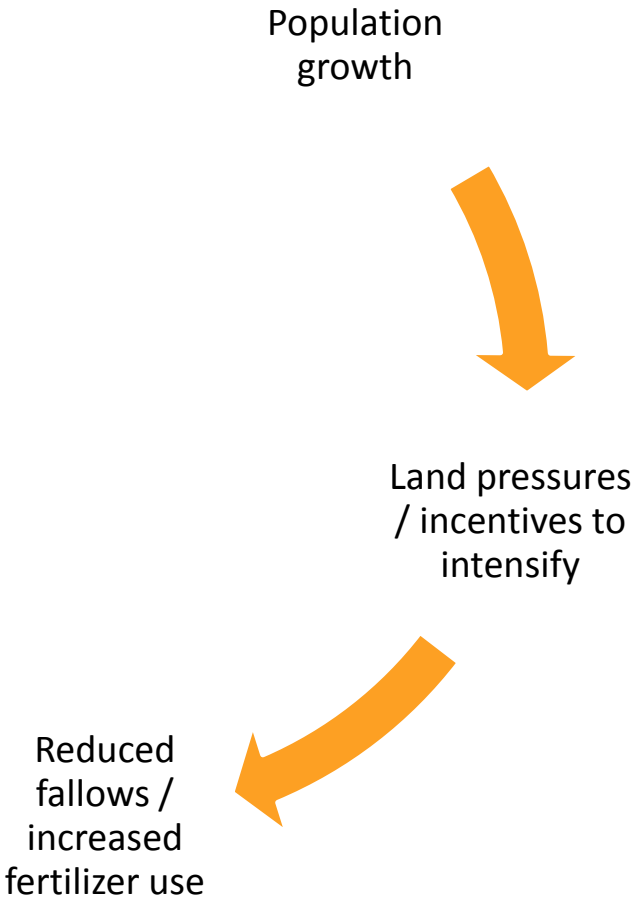
Result: researcher-managed trials tend to show 2-3 times higher NUE than in farmer-managed survey data.

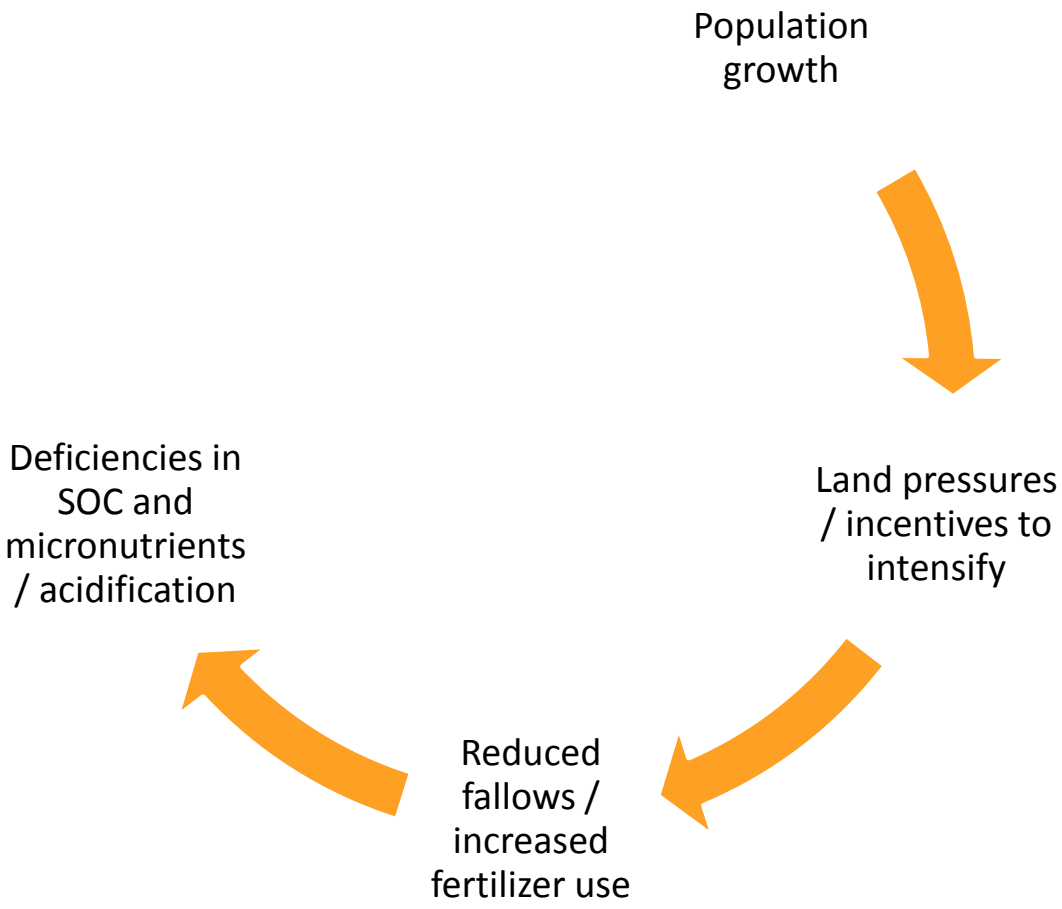
Section 2:

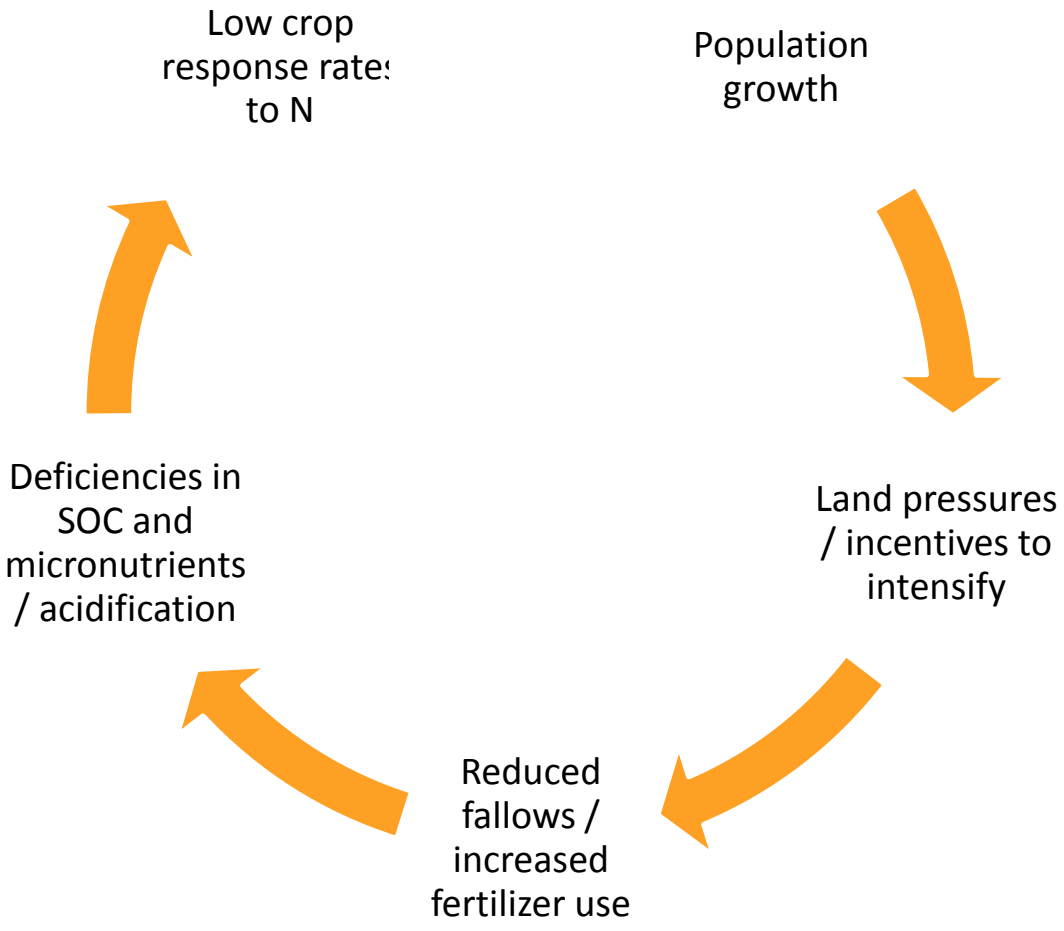
Reasons why smallholders exhibit low fertilizer use efficiency

Population growth

Land pressures / incentives to intensify


Population growth
Land pressures / incentives to intensify
Reduced fallows / increased fertilizer use


Population growth
Land pressures / incentives to intensify
Reduced fallows / increased fertilizer use
Deficiencies in SOC and micronutrients / acidification


Low crop response rates to N
Population growth
Land pressures / incentives to intensify
Reduced fallows / increased fertilizer use
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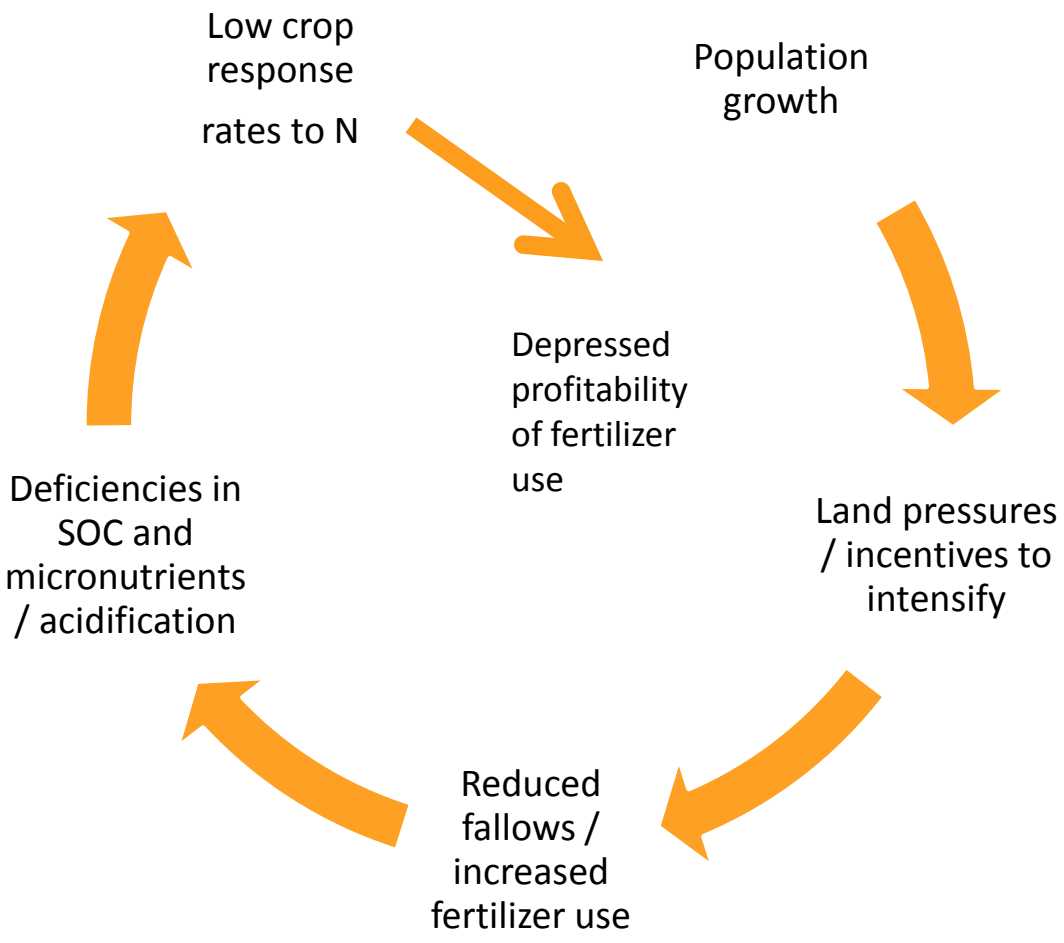
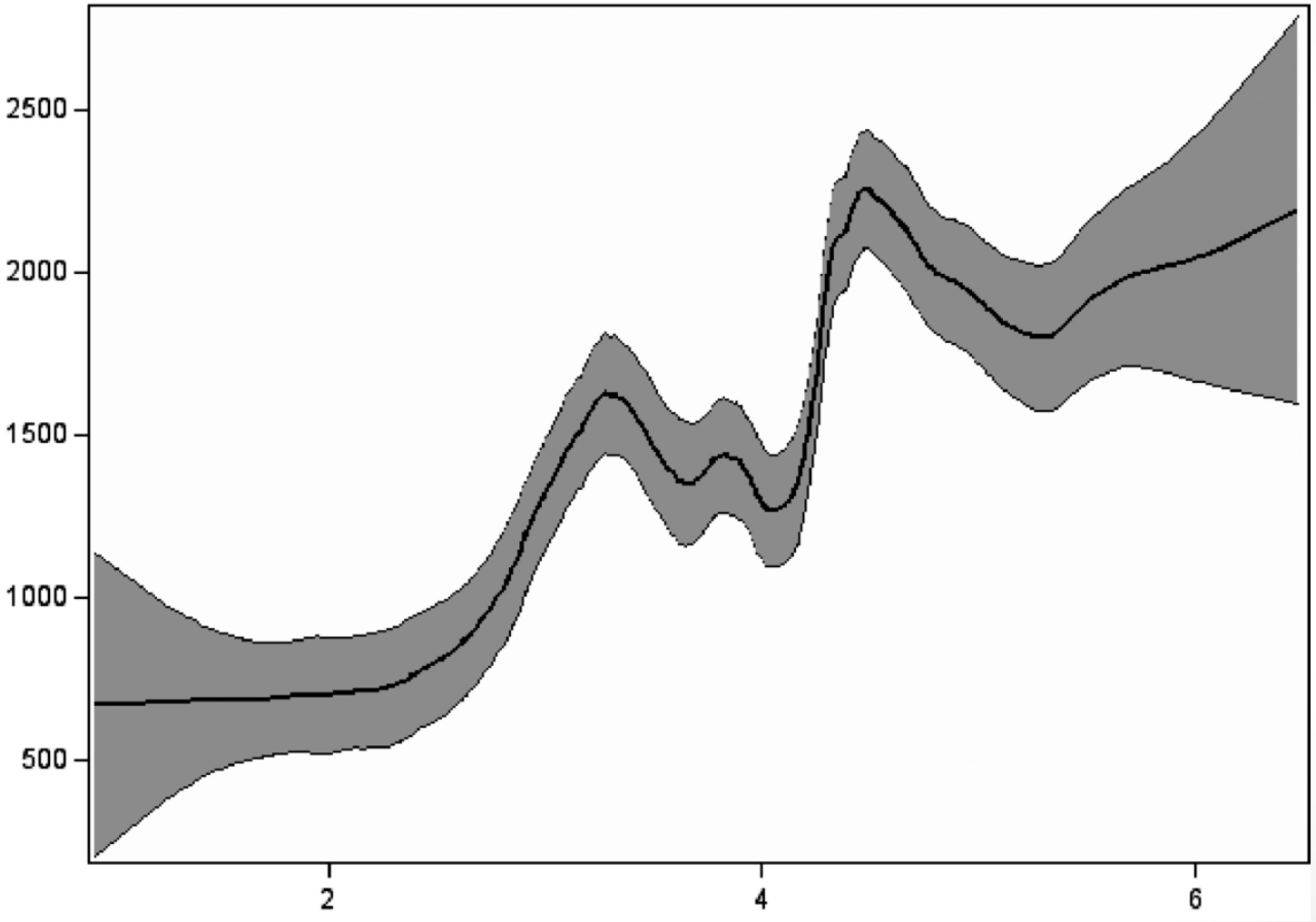
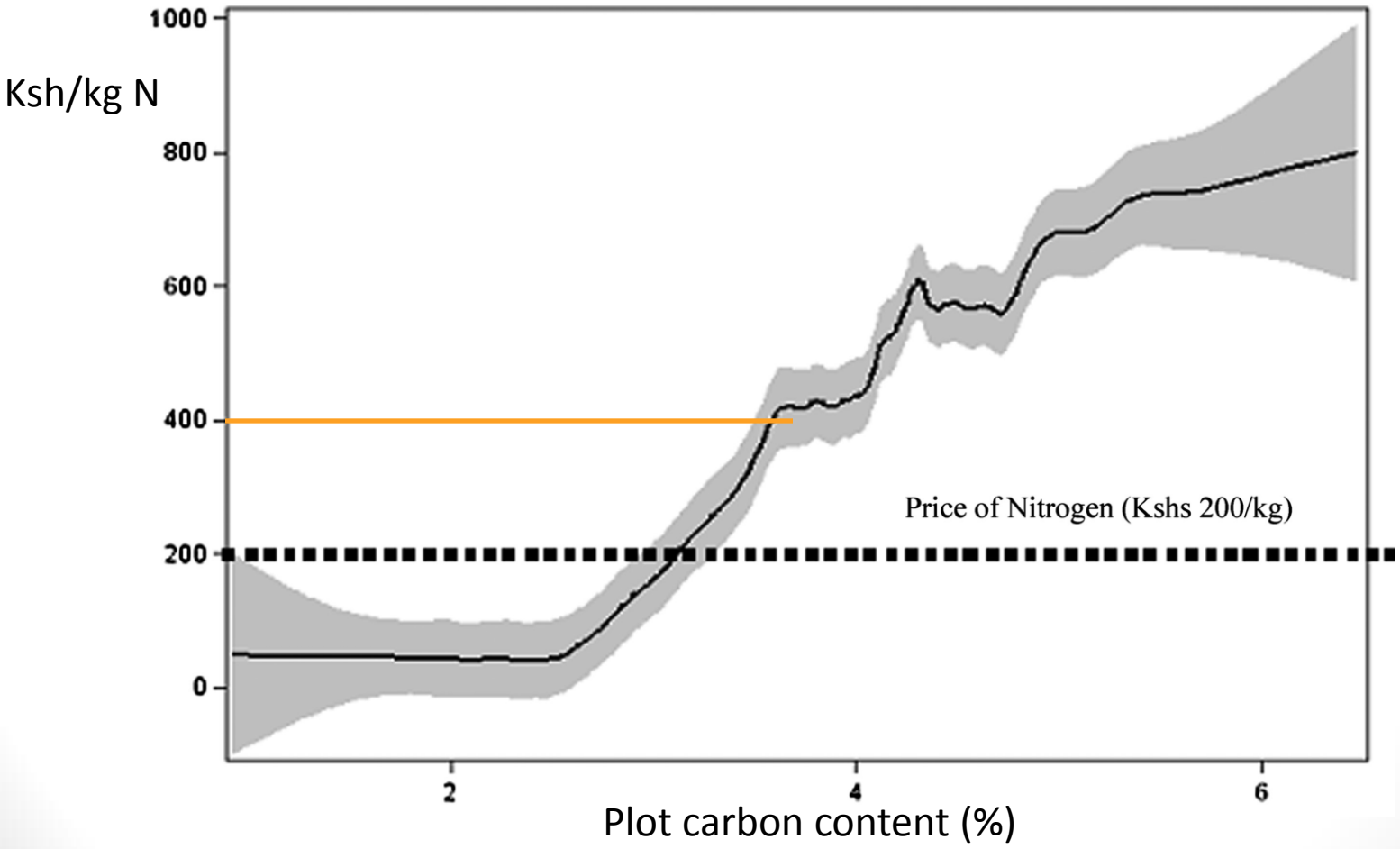

Low crop response rates to N
Population growth
Depressed profitability of fertilizer use
Land pressures / incentives to intensify
Reduced fallows / increased fertilizer use
Deficiencies in SOC and micronutrients / acidification

Maize yields as a function of plot soil carbon content



Source: Marenya & Barrett 2009

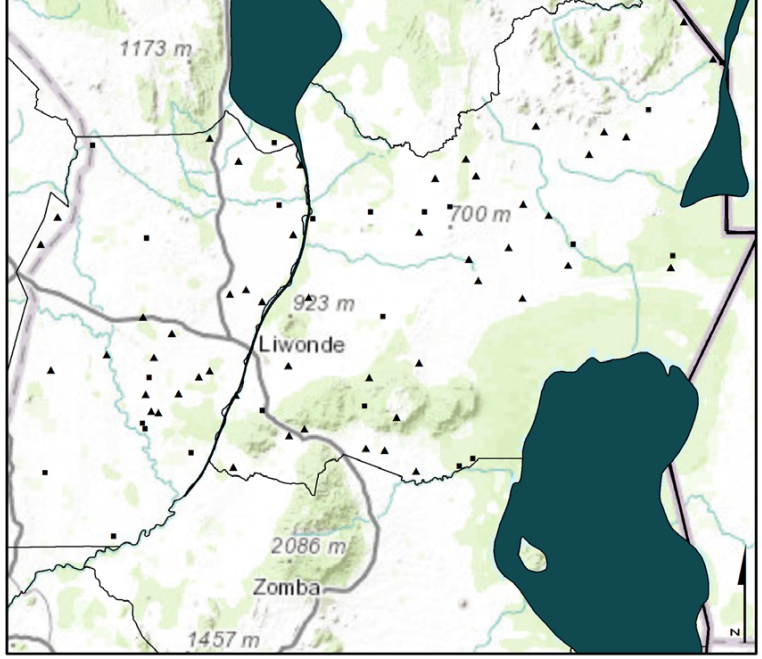
Estimated marginal value product of nitrogen fertilizer conditional on plot soil carbon content

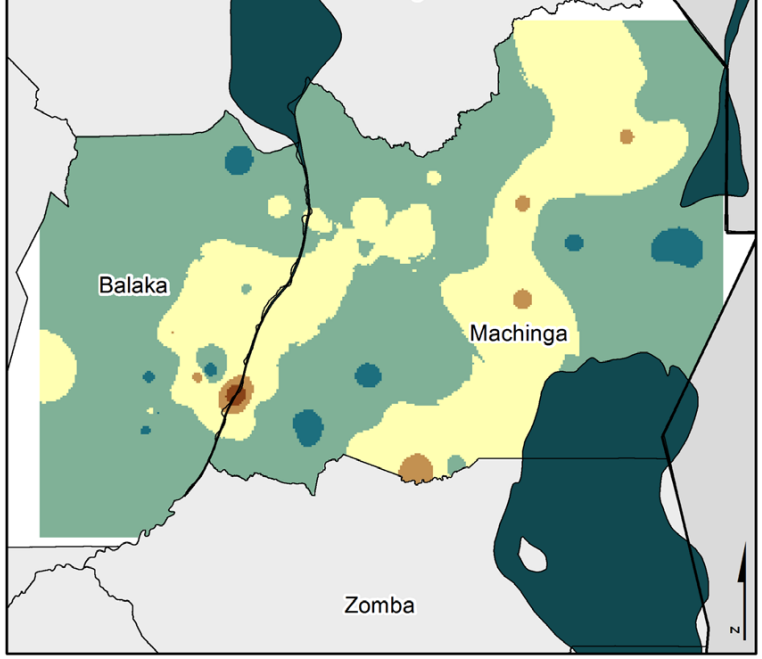


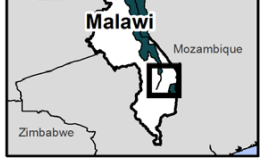
Source: Marenya & Barrett 2009

Evidence of land degradation

1. Loss of soil organic matter
   - significant decline in SOM over past 20 years in Malawi (Mpeketula and Snapp)







- Sample (Ag)
- Sample (Other)

Difference (2015 - 1990)

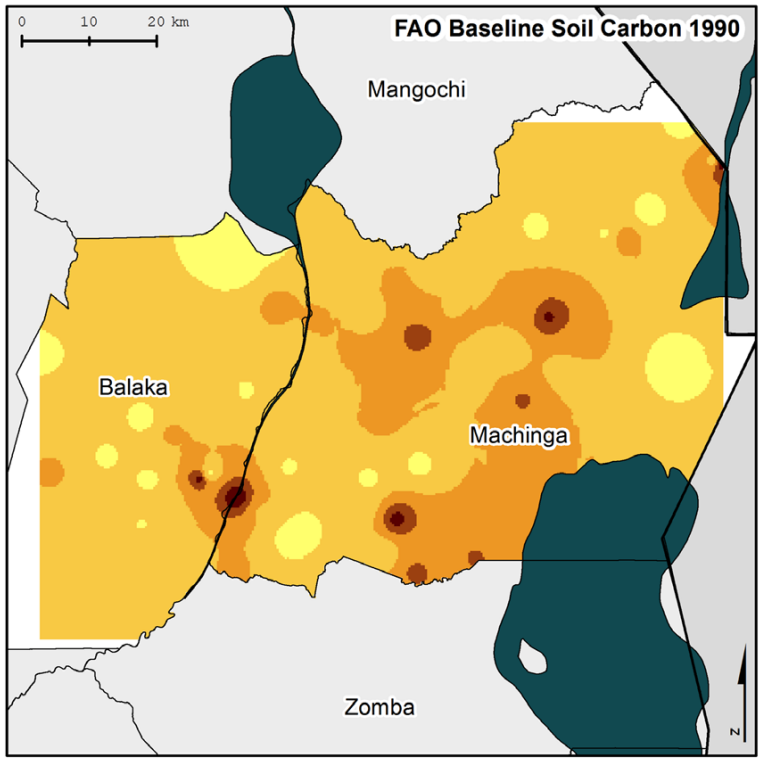
g C / 100g soil

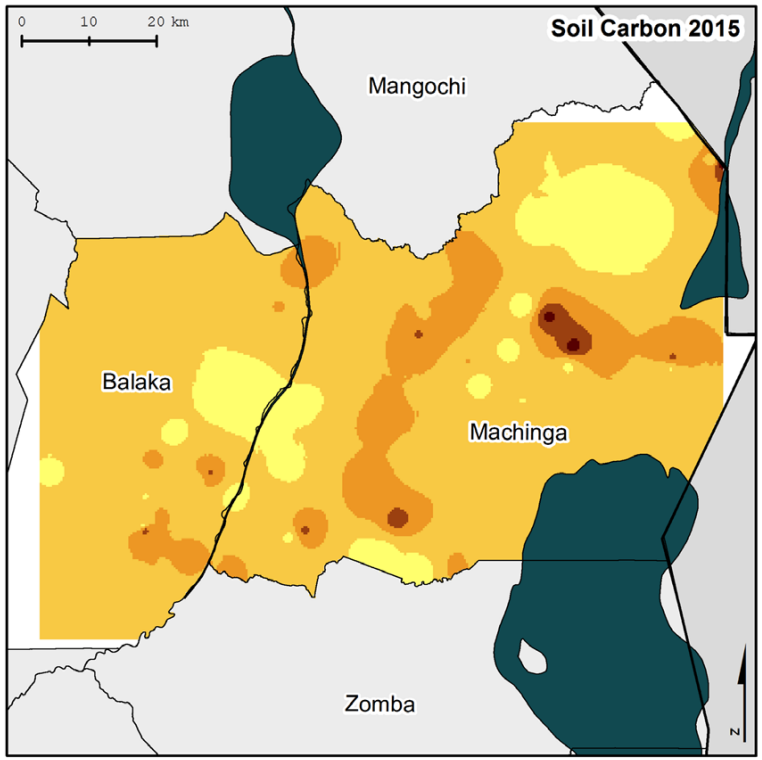
- -2.30 - -1.60
- -1.59 - -0.88
- -0.87 - -0.17
- -0.16 - 0.55
- 0.56 - 1.30

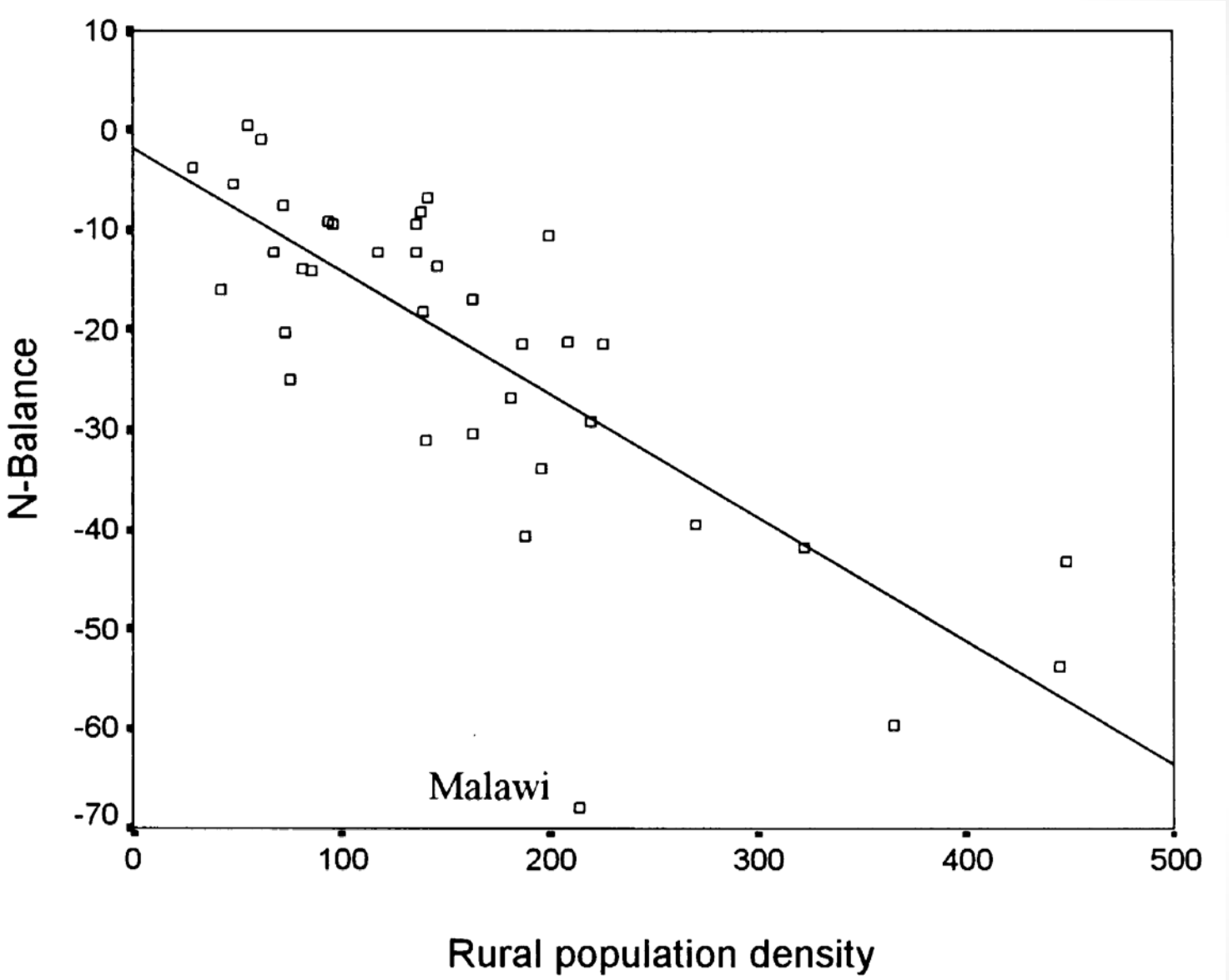
Soil Carbon

g C / 100g soil

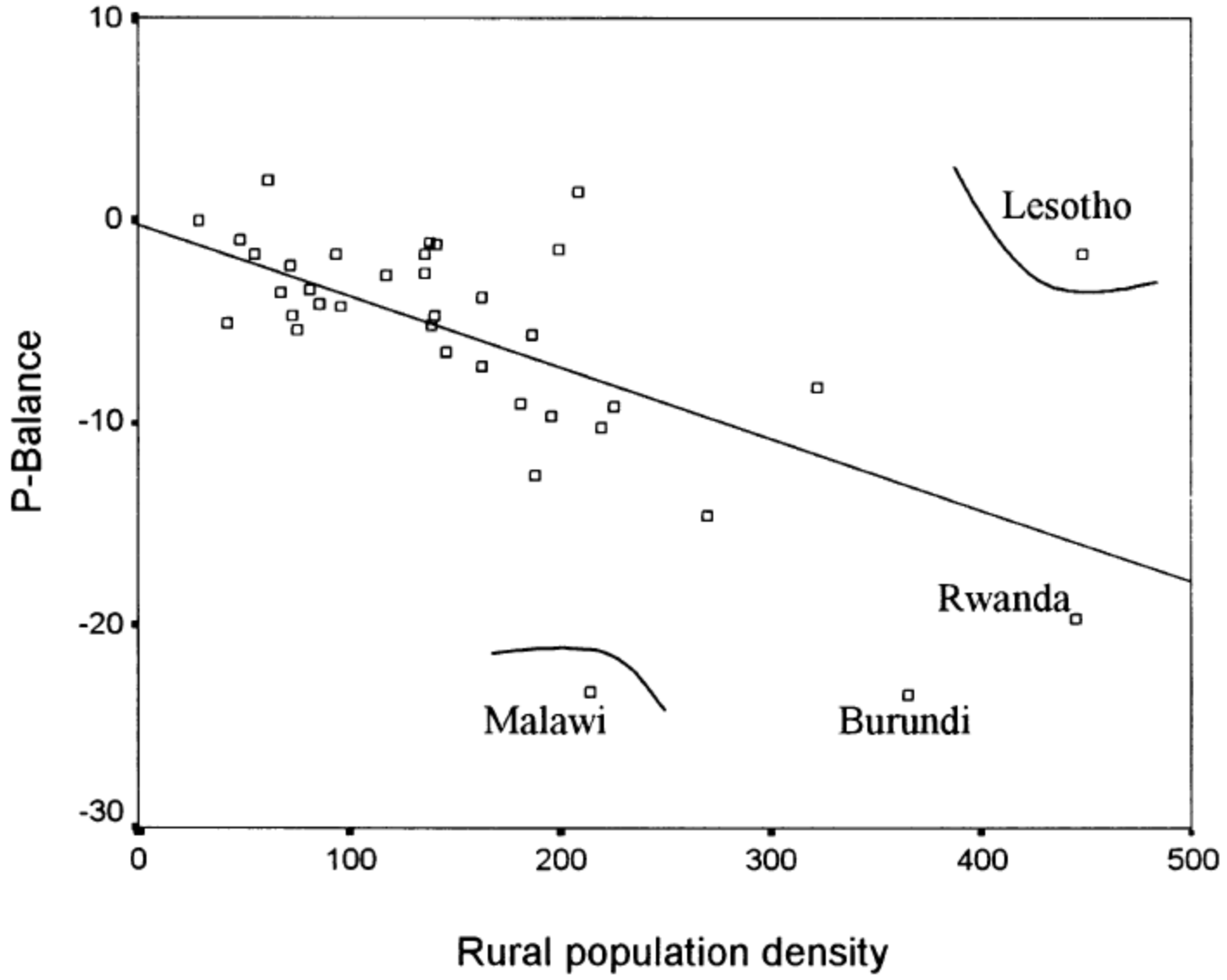
- 0.07 - 0.56
- 0.57 - 1.04
- 1.05 - 1.52
- 1.53 - 2.00
- 2.01 - 2.48







P. Drechsel et al. / Ecological Economics 38 (2001) 251–258



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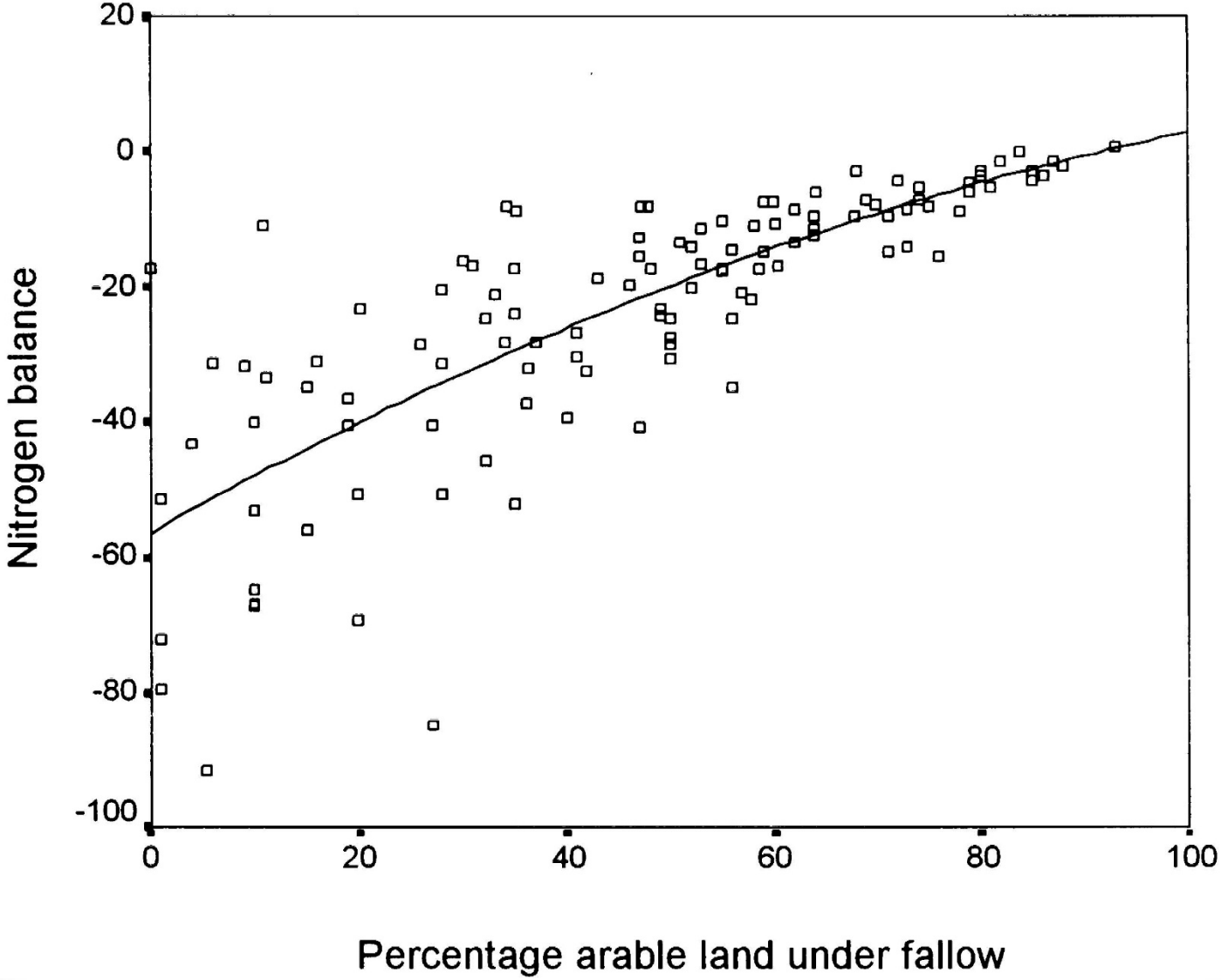

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Factors depressing NUE of inorganic fertilizer use:

1. Low soil organic matter
    - significant decline in SOM over past 20 years in Malawi (Mpeketula and Snapp)
2. Acidification


From Larson and Oldham,
Mississippi State University Extension Service, 2008.
4.3
5.3
Source: Burke, 2012

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2. Acidification
3. Late delivery

Photo courtesy of Dingi Banda,
Lusaka Province, Zambia

Factors affecting N use efficiency

1. Soil organic carbon
2. Acidification (pH) – mainly affects basal
3. Timely and sufficient weeding
4. Micronutrients
5. Soil moisture – N response on irrigated > rainfed fields
6. Timing of fertilizer application
7. Rotation of crops on a given plot
8. Contours / ridging to prevent erosion on sloped fields

- → FISP would be more effective if it were part of a more holistic approach to raise crop yields, focusing on soil fertility management

Section 3: What to do?

Elements of a holistic strategy:

1. R&D (national ag research systems)
2. Extension programs / soil testing
3. Programs to help farmers restore soil quality
4. Conservation agricultural practices
5. Physical infrastructure
6. Reducing costs in input supply chains
7. More appropriate fertilizer use recommendations

Public investments to raise crop response to fertilizer

Proposal 1: Raise public investment in agronomic research and extension programs to enable farmers to use fertilizer more efficiently

1. Adaptive research stations
2. Soil labs
3. Bi-directional learning

Overarching conclusions

1. FISP is a powerful tool to quickly raise food production….
2. FISP could be more effective if crop response to fertilizer could be raised
3. Rural pop density rising till 2050
4. Failure to restore soil fertility will cause long-term decline in ag productivity and ever smaller contributions to crop yield from fertilizer

Overarching conclusions

1. FISP is a powerful tool to quickly raise food production….
2. FISP could be more effective if crop response to fertilizer could be raised
3. Rural pop density rising till 2050
4. Failure to restore soil fertility will cause long-term decline in ag productivity and ever smaller contributions to crop yield from fertilizer
5. Sustained and serious commitment to public ag R&D can put Malawian farmers back on a upward trajectory, but with a 5-year lag…. so no time to waste!

Thank you