Rice and malaria in Africa

Trade-off vs. co-benefits?

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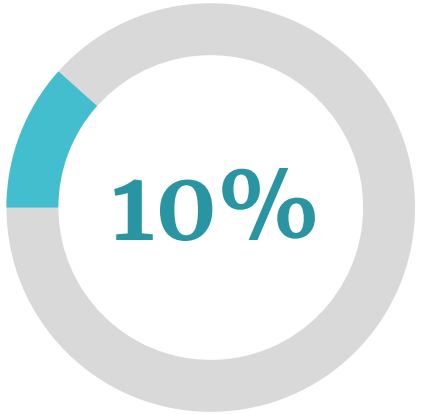
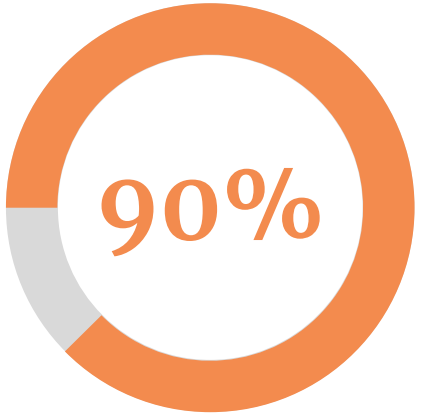
Multi-sectoral malaria control



health interventions are delivered by non-health sector businesses



Addressing man-made malaria

What is man-made malaria?

What proportion of malaria is man-made, in any given setting?

- Mainly…vector breeding in man-made landscapes
- What proportion of local vector mosquitoes are from man-made breeding sites? Consider…
  - sites created directly / indirectly by human activity
  - sites much more productive because of human activity
  - (sites inadvertently removed by human activity)

Man-made malaria

Is it time to revive this concept?

- A huge fraction of total malaria burden (in Africa and elsewhere)

- Not a new idea! recognized ~100 years ago
- But recently less profile: malaria control becomes more medicalized, less ‘hygiene’

- But in practice: its importance is growing
- Towards 100% anthropogenic landscapes

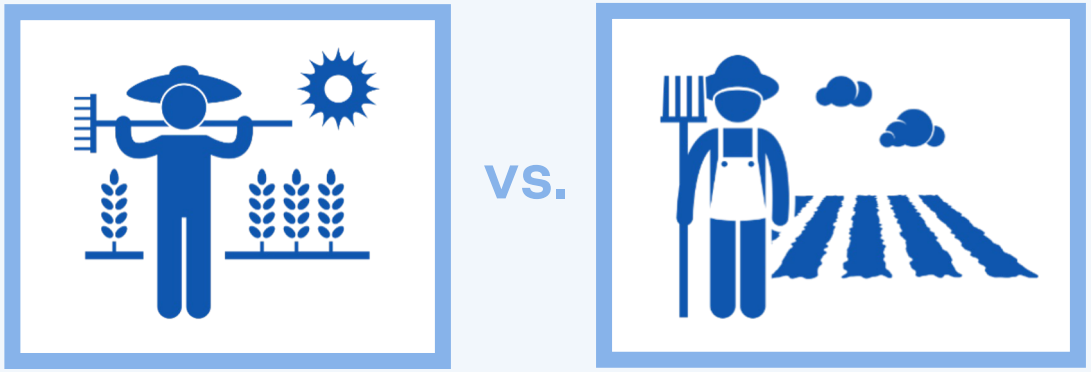
Where we are

The state of the evidence

1900-2005: paddies paradox

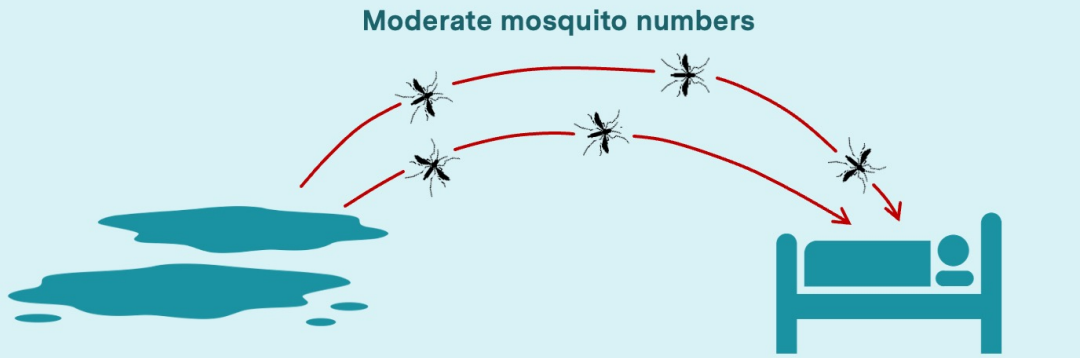
Nowadays: rice and malaria situation has changed

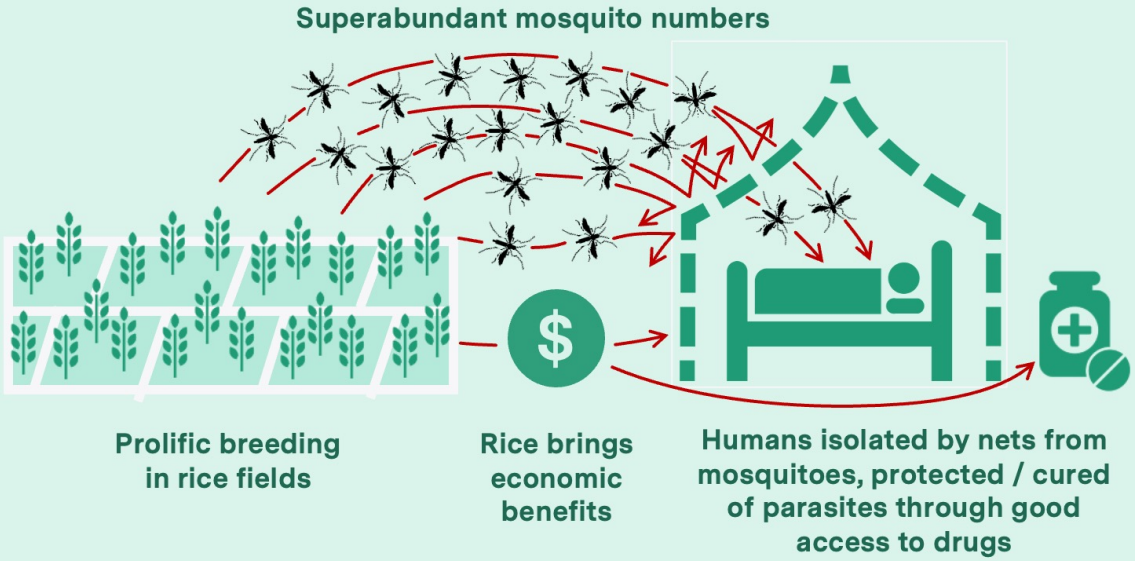
But… Just 1 paper



1990s: A series of studies in Africa compared malaria in *rice vs. non-rice communities*

Paddies paradox: rice fields produce **VERY MANY EXTRA** malaria vectors but the malaria in rice villages was (at the time) similar or a bit less


Moderate mosquito numbers
Ordinary breeding sites: sunlit, temporary puddles
Humans without nets and poor access to drugs exposed to mosquitoes and parasites


Superabundant mosquito numbers
$
Prolific breeding in rice fields
Rice brings economic benefits
Humans isolated by nets from mosquitoes, protected / cured of parasites through good access to drugs

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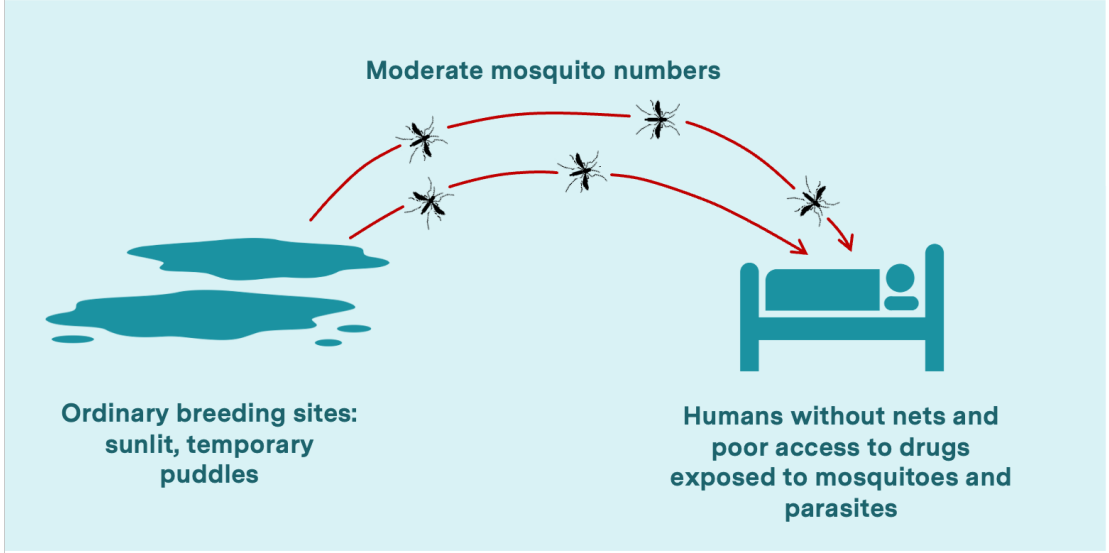
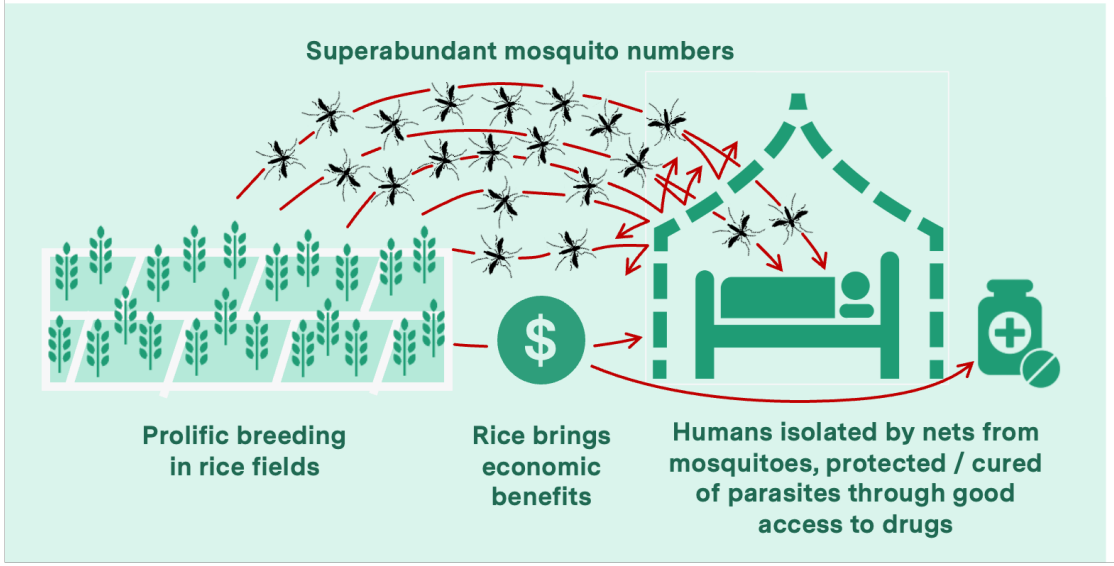
Intervention coverage has changed

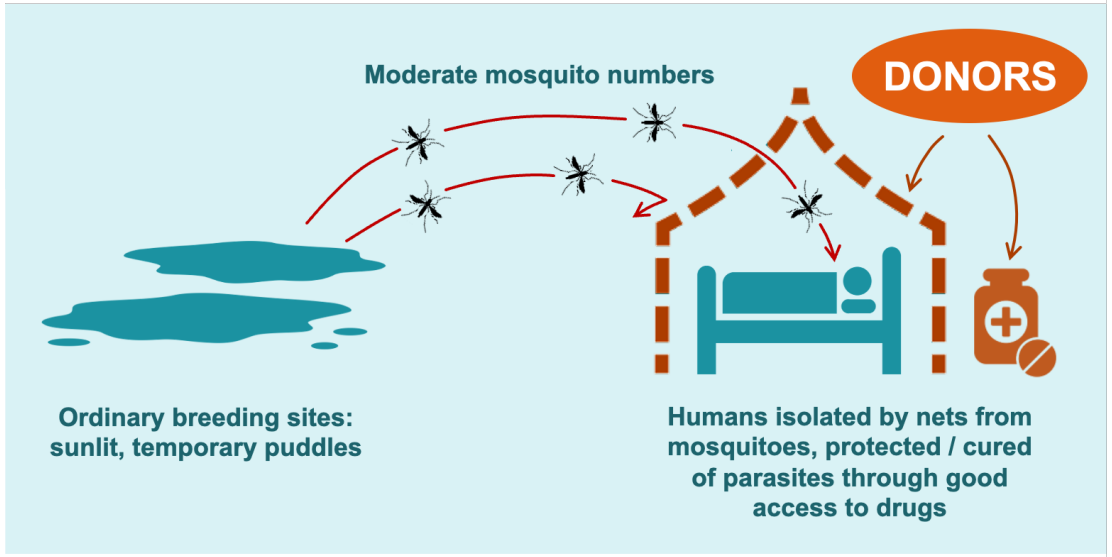
Malaria in Africa has changed = pathway to elimination

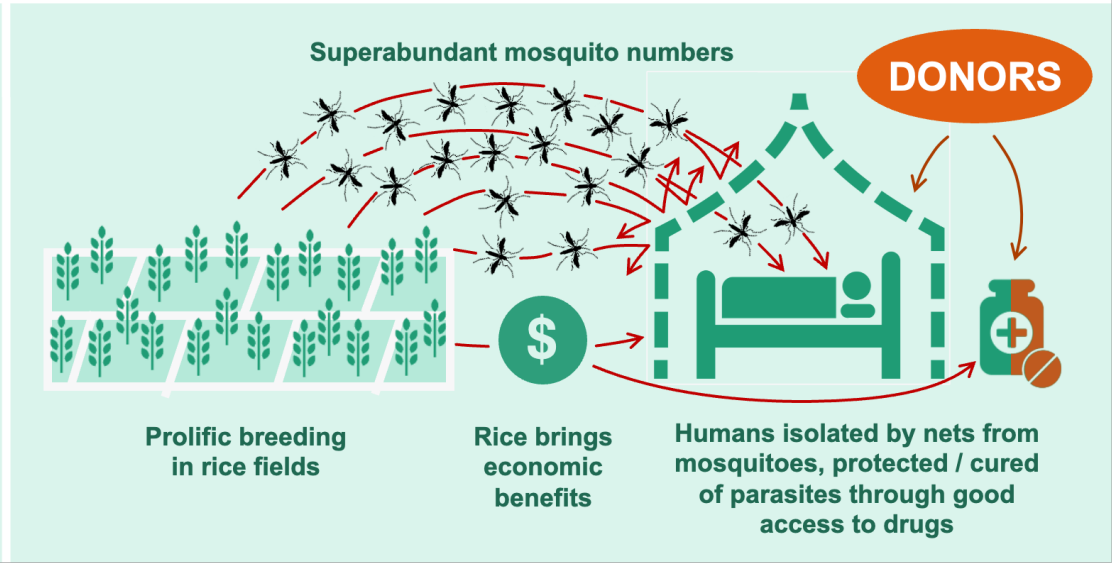
PRE-2003





POST-2003





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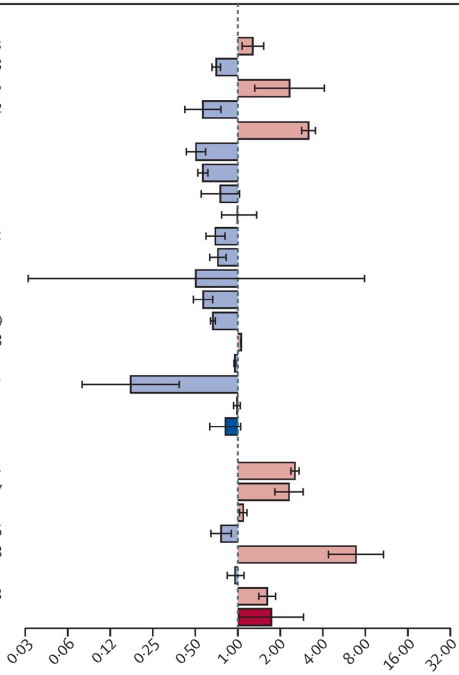
A

	Country	Year	Control areas		Rice-growing areas		Risk ratio (95% CI)
			Total participants	PfPR$_{2-10}$	Total participants	PfPR$_{2-10}$	
Pre-2003 studies							
Audibert et al (1990)[26]	Cameroon	1979	1470	19·4558	491	24·8473	1·28 (1·06–1·54)
Robert et al (1987)[27]	Burkina Faso	1980	817	62·4235	1505	43·8538	0·70 (0·65–0·76)
Couprié et al (1985)[29]	Cameroon	1981	554	3·2491	370	7·5676	2·33 (1·31–4·15)
Audibert et al (1990)[26]	Cameroon	1981	775	12·5161	864	7·0602	0·56 (0·42–0·77)
Coosemans (1985)[29]	Burundi	1982	1335	17·2045	2357	54·7553	3·18 (2·81–3·60)
Josse et al (1987)[32]	Cameroon	1985	966	26·9151	1409	13·5557	0·50 (0·43–0·60)
Boudin et al (1992)[33]	Burkina Faso	1985	1033	62·8359	1087	35·4221	0·56 (0·51–0·62)
Audibert et al (1990)[26]	Cameroon	1985	469	14·7122	542	11·0701	0·75 (0·54–1·04)
Faye et al (1993)[37]	Senegal	1990	685	9·6825	1035	9·7871	1·01 (0·75–1·36)
Thomson et al (1994)[39]	The Gambia	1991	1167	50·3844	298	35·0622	0·69 (0·59–0·82)
Gbakima (1994)[38]	Sierra Leone	1991	105	68·9089	1001	49·5132	0·72 (0·63–0·83)
Faye et al (1995)[40]	Senegal	1992	329	0·3180	656	0·1595	0·50 (0·03–7·99)
Ijumba et al (2002)[43]	Tanzania	1994	1483	21·4820	1468	12·2114	0·57 (0·48–0·67)
Sissoko et al (2004)[47]	Mali	1995	3308	51·0108	5826	33·9839	0·67 (0·63–0·70)
Henry et al (2003)[49]	Côte d'Ivoire	1997	11 951	83·2694	24 266	88·0288	1·06 (1·05–1·07)
Assi et al (2013)[52]	Côte d'Ivoire	1998	8189	50·7864	21 141	48·5513	0·96 (0·93–0·98)
Mutero et al (2004)[55]	Kenya	2001	116	38·9543	90	7·0057	0·17 (0·08–0·38)
Koudou et al (2009)[58]	Côte d'Ivoire	2002	245	90·9072	171	90·1236	0·99 (0·93–1·05)
Pooled effect estimate							0·82 (0·63–1·06)
Post-2003 studies							
Rumisha et al (2019)[64]	Tanzania	2004	3283	18·7713	4605	47·8074	2·55 (2·36–2·75)
Mboera et al (2011)[66]	Tanzania	2005	289	22·6452	289	51·8647	2·31 (1·81–2·94)
Koudou et al (2009)[58]	Côte d'Ivoire	2005	795	63·7318	714	69·6313	1·09 (1·02–1·17)
Touré et al (2016)[70]	Mali	2010	417	34·7716	728	26·5096	0·76 (0·64–0·91)
Mboera et al (2015)[73]	Tanzania	2012	1016	1·9322	1022	13·6478	6·91 (4·36–10·95)
Hien et al (2017)[74]	Burkina Faso	2014	329	55·6231	285	53·3333	0·96 (0·83–1·11)
Babamale et al (2020)[75]	Nigeria	2018	137	58·9749	93	95·9538	1·62 (1·40–1·87)
Pooled effect estimate							1·73 (1·01–2·96)



Growing rice w/o growing mosquitoes: feasibility

	Does it work? (% effectiveness)	No. of studies (no. in SSA)
Monomolecular surface films	-57.2 (-69.4, -40.3) / -91.6 (-99.9, +486.3)	3 (3)
Biological larvicides	-60.0 (-71.8, -43.1)	10 (2)
Synthetic organic chemicals	-73.1 (-83.8, -55.4) / -72.3 (-89.5, -26.9)	6 (2)
Fish	-81.5 (-91.4, -60.2) / -87.1 (-93.9, -72.7)	6 (1)
Copepods		1 (0)
Azolla		1 (0)
Neem		1 (0)
Intermittent irrigation	-[illegible]	7 (2)
Rice variety	+150.0 (-66.1, +1745.1)	1 (0)
Rice variety & plant spacing	-66.3 (-90.0, +13.4)	1 (0)
Weed control (herbiciding)	+77.4 (+65.7, +89.9)	1 (0)
Agricultural insecticide	-76.4 (-88.8, -50.2)	1 (0)
Land preparation: tillage	-64.7 (-85.5, -14.1)	1 (1)
Land preparation: levelling	-12.8 (-65.2, +118.5)	1 (1)

It is possible!

Growing rice w/o growing mosquitoes: approach

- No point in interventions being developed by entomologists
- Entomologists have done it – successfully – but no attention (except in China)
- Win-win solutions (with agriculture-health [and environmental] co-benefits)

Water use:
Reduction

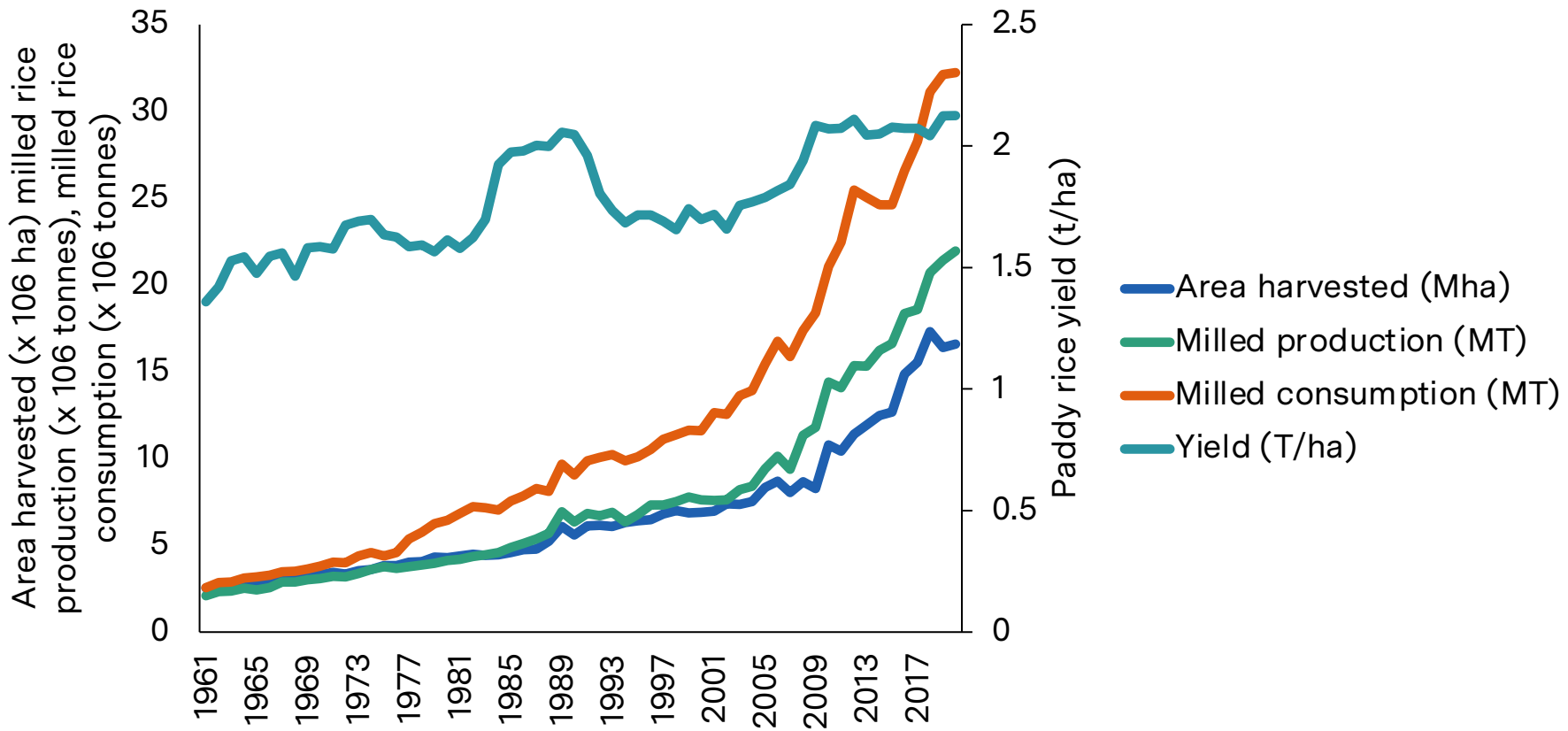
Methane emissions:
Reduction

Rice yield:
Increase

Vector production:
Reduction

Growing rice w/o growing mosquitoes: approach

Asking rice experts to change the way rice is grown in Africa = **BIG ASK!**



Agenda

If the big R&D job must be led by the agricultural sector…

Q: What is there for us health people to do?

A: Convince them it is an **avoidable problem**

1. It is a problem
2. It is avoidable

Suggestions?

1. How to strengthen the epidemiological evidence that it is a problem?
2. How to strengthen the evidence that it is avoidable?

The research agenda: next steps for malaria entomologists

Q: So if the big R&D job must be done by Agriculture Research, what is there for us health people to do?

A: convince them it is an avoidable problem: (a) it is a problem and (b) it is avoidable

1. Strengthen the epidemiological evidence that rice brings malaria:

HOW? Before-and-after studies

Risk factor studies - case control?

Estimate the rice-attributable fraction?

what proportion of malaria burden comes from mosquitoes from ricefields

Need geo-referenced surveys without the random error of DHS/MIS

WHO? national cross-sectoral development plans: office of the PM; AU, donors and broad development community, cross-sectoral multi-laterals … now CIF countries?

2. Show that is is possible to grow rice with only a few mosquitoes

Lots of promising ideas begging for research

AWD, levelling, direct-sowing, weeding methods, rice varieties

Fish & ducks

Bti in fertilizer