Rice and malaria in Africa

Trade-off vs. co-benefits?

Jo Lines & Kallista Chan

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RESILIENCE AGAINST FUTURE THREATS

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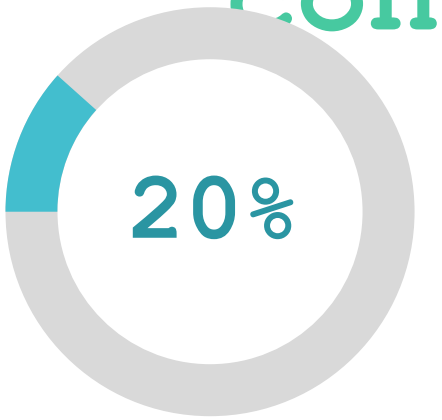
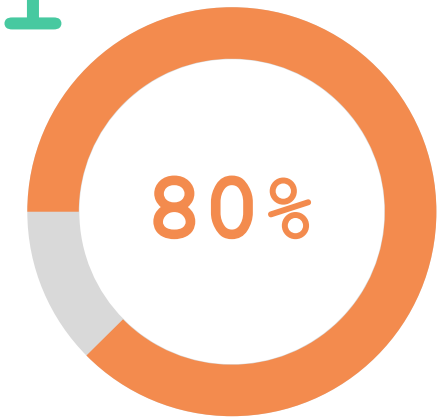
Multi-sectoral malaria control



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)

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Man-made malaria

Is it time to revive this concept?

- Big fraction of total malaria burden especially in Africa
- Not a new idea!
- Recently less profile…. but growing importance …
- …as landscapes become 100% anthropogenic

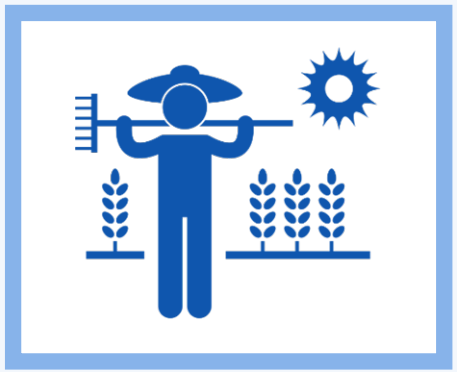
Where we are

The state of the evidence

1900-2005: paddies paradox

Nowadays: rice and malaria situation has changed

But... Just 1 paper

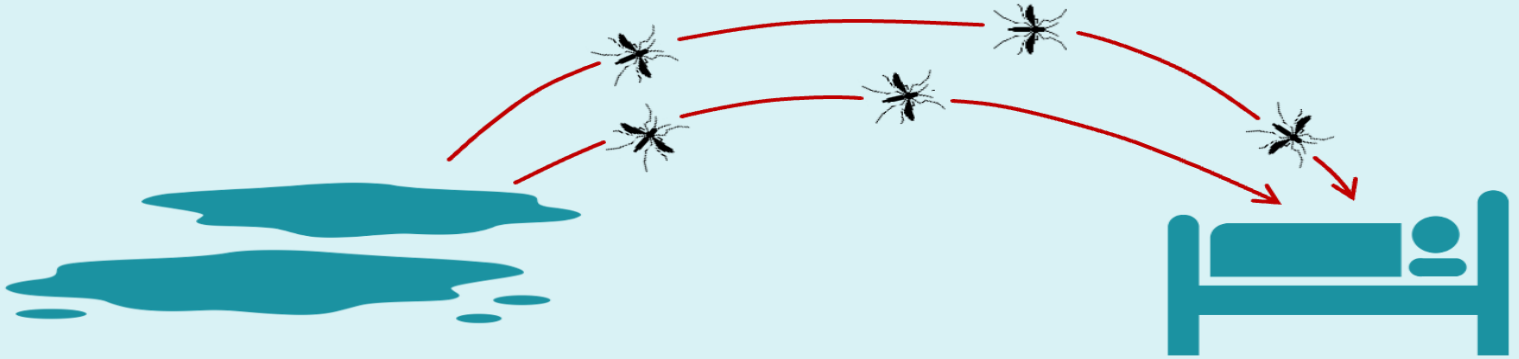


VS.

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

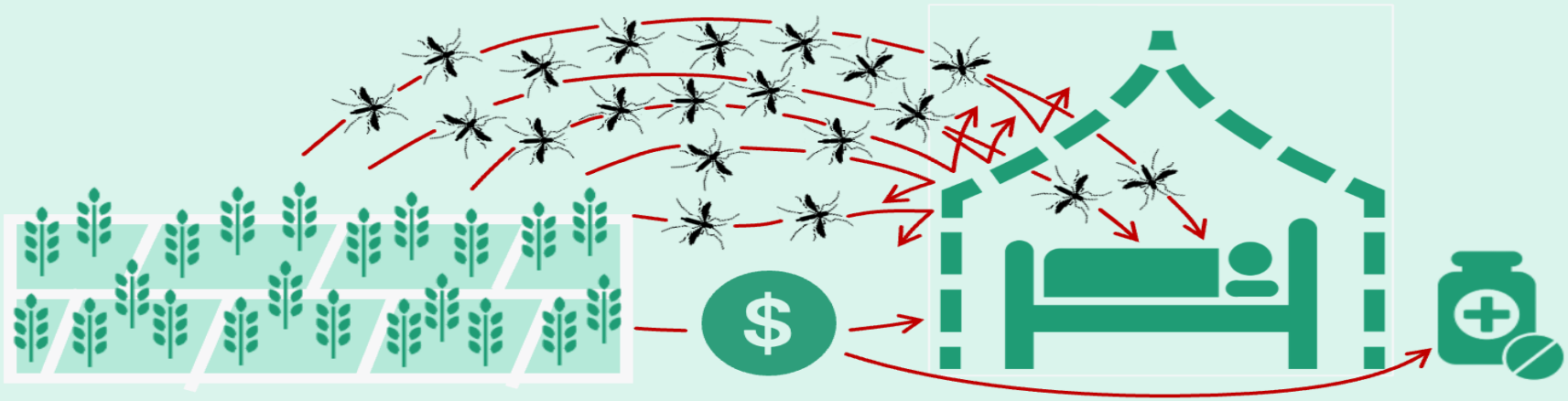
Moderate mosquito numbers



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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Addressing insecticide resistance and emerging mosquito-borne disease thr
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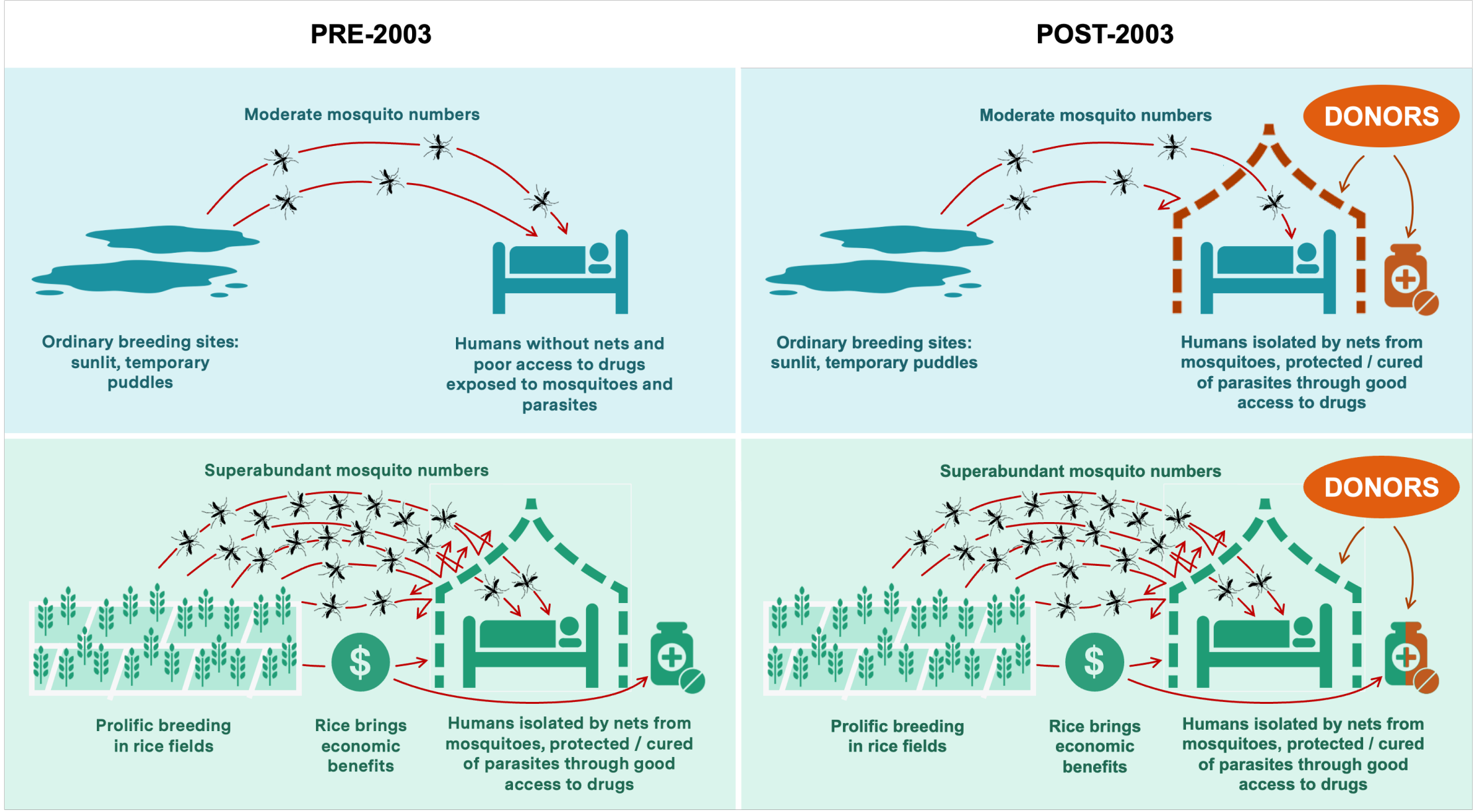
Intervention coverage has changed

Malaria in Africa has changed = pathway to elimination


PRE-2003
POST-2003
Moderate mosquito numbers
Ordinary breeding sites: sunlit, temporary puddles
Humans without nets and poor access to drugs exposed to mosquitoes and parasites
Moderate mosquito numbers
DONORS
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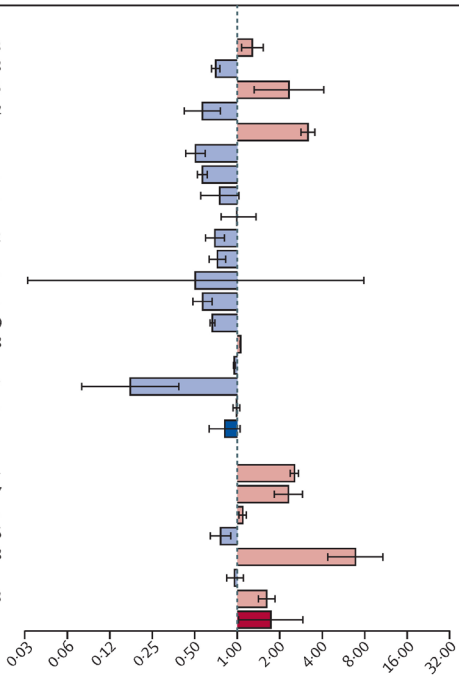
A

	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	11951	83·2694	24266	88·0288	1·06 (1·05–1·07)
Assi et al (2013)[52]	Côte d'Ivoire	1998	8189	50·7864	21141	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		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!

But needs more detailed research

Growing rice w/o growing mosquitoes: approach

- No point in interventions being developed only 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

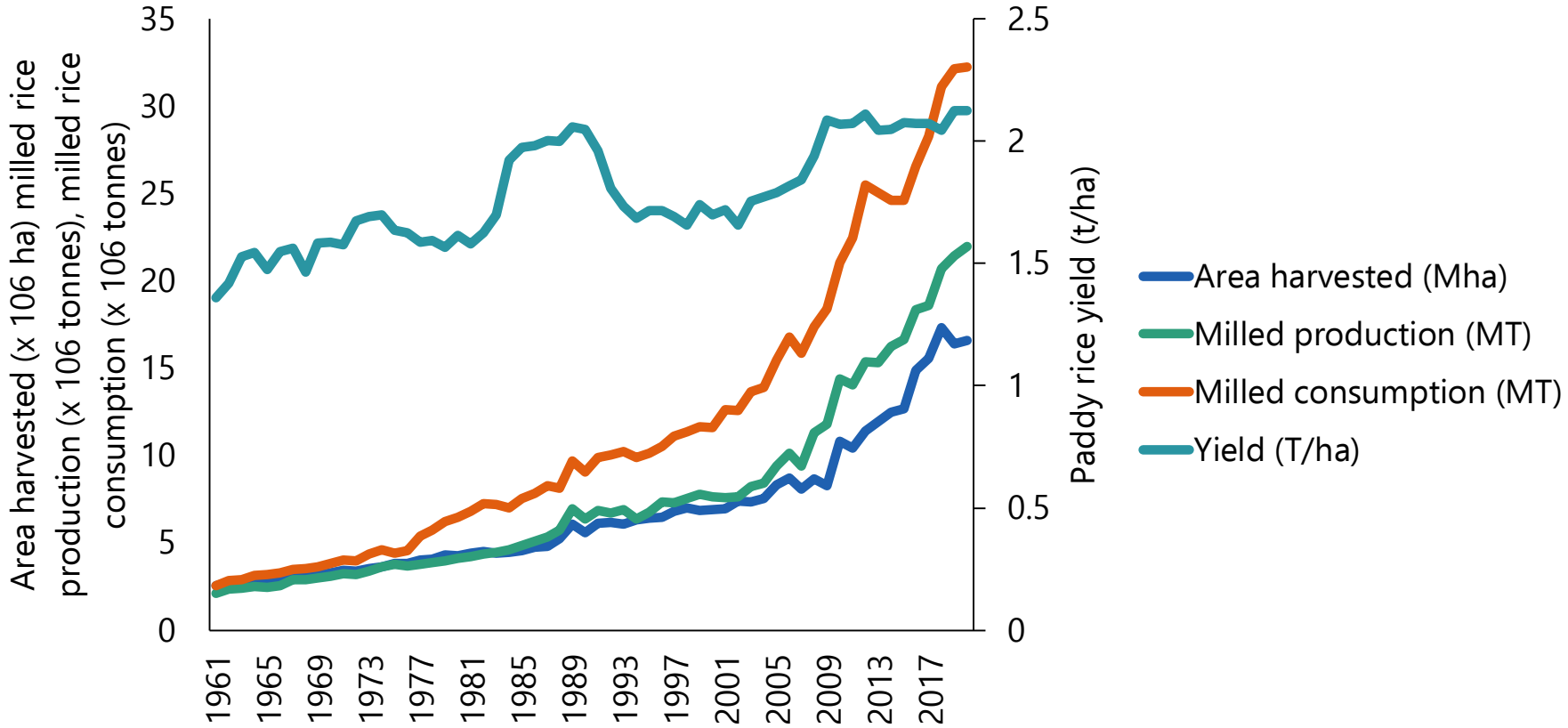
Vector production:
Reduction

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:**

- **problem**
- **avoidable**

Suggestions?

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

1. How to strengthen the evidence that it is avoidable?

The research agenda: next steps for malaria entomologists

1. Strengthen the epidemiological evidence that rice brings malaria:

HOW?

- Before-and-after studies -- routine data?
- Risk factor studies - case control?
- Estimate the rice-attributable fraction? We've started…
  - what proportion of malaria burden comes from mosquitoes from rice-fields?
- Need geo-referenced prevalence *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?

The research agenda: next steps for malaria entomologists

2. Show that is is possible to grow rice without mosquitoes

- Lots of promising ideas begging for research

    AWD & Intermittent irrigation

    Levelling/tilling, direct-sowing, weeding methods, rice varieties

    Fish ? Even ducks ?

    Bti in fertilizer for initial peak of productivity