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PEOPLE



Lord Boyd Orr of Brechin, 1880 - 1971

<https://www.gla.ac.uk/research/az/boydorr/>

FOOT-AND-MOUTH DISEASE CONTROL IN ENDEMIC AFRICAN SETTINGS: OPPORTUNITIES AND CHALLENGES

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Global Foot-and-Mouth Disease
Research Alliance

Epidemiology Session
Tuesday, 29th October 2019

University of Glasgow

- Tiziana Lembo
- Richard Reeve
- Alicia Davis
- Paul Johnson
- Gemma Chaters
- Divine Ekwem
- Grant Hopcraft

Sokoine University of Agriculture, Tanzania

- Rudovick Kazwala

University College Dublin

- Miriam Casey-Bryars

International Livestock Research Institute, Kenya & Tanzania

- Bernard Bett
- Amos Omore

WRL-FMD, The Pirbright Institute

- David Paton

Nelson Mandela African Institution of Science and Technology, Tanzania

- Tito Kibona

Ministry of Livestock and Fisheries, Tanzania

- Michael Madege

Directorate of Veterinary Services, Kenya

- Abraham Sangula

Ministry of Agriculture, Animal Industry and Fisheries, Uganda

- Ana Rose Ademun

University of Global Health Equity, Rwanda

- Jean-Claude
Byshimo

IZSLER

- Emiliana Brocchi
- Santina Grazioli

Onderstepoort Veterinary Institute, South Africa

- Katherine Scott

Washington State University

- Ashley Railey
- Tom Marsh

University of Minnesota

- Kim VanderWaal

University of Edinburgh

- Jess Enright

MSD Animal Health

- John Atkinson

The Role of Agriculture in the World Economy

Agriculture as Share of Total GDP (%)

GDP = Gross Domestic Product

- Developing countries rely on agriculture as a larger percentage of GDP than developed countries
- Agriculture as a share of total GDP highest in Africa and Asia
- Livestock sector contributes an average of 40% of the agricultural GDP globally and 15-80% in developing countries

Agriculture (% of GDP)

50% and More

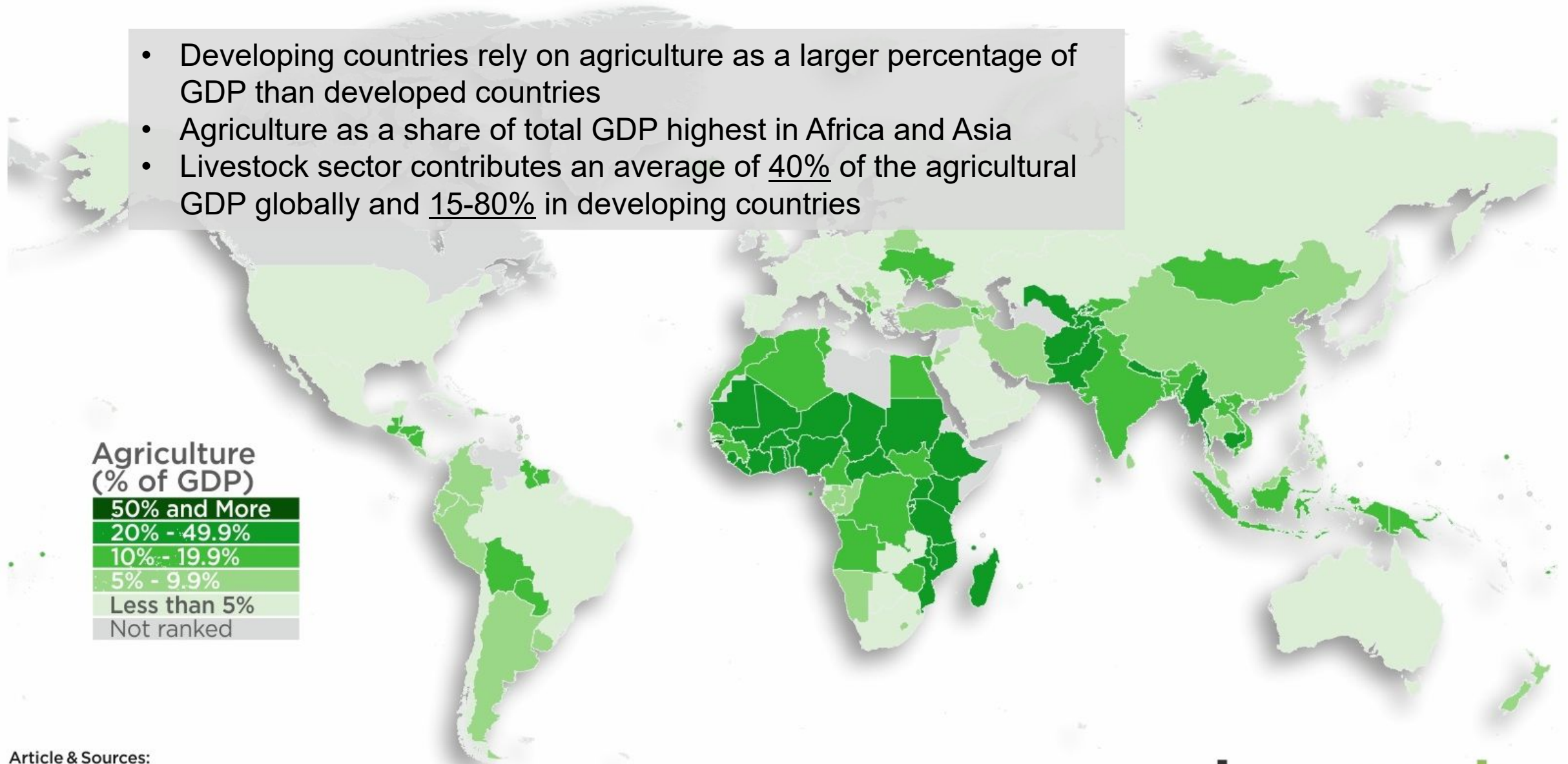
20% - 49.9%

10% - 19.9%

5% - 9.9%

Less than 5%

Not ranked



Article & Sources:

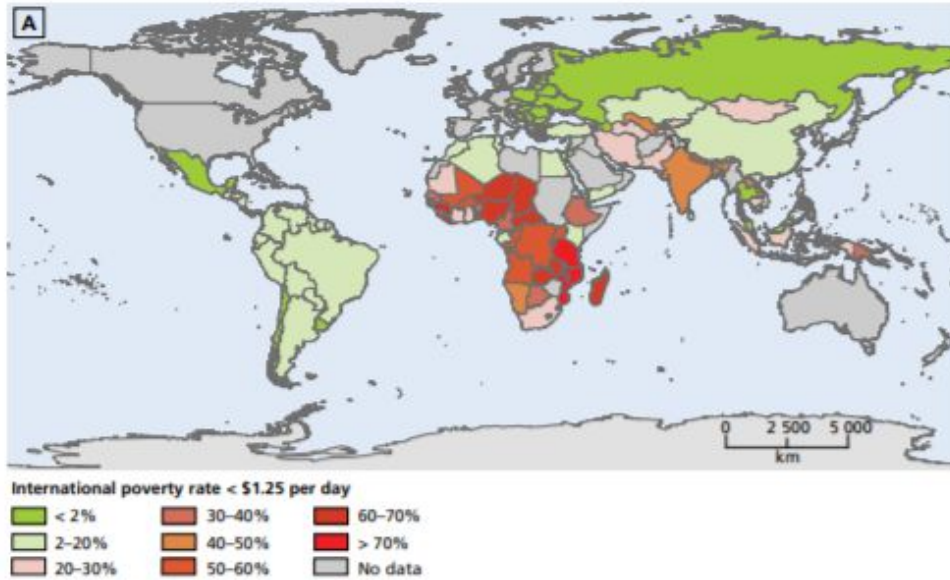
<https://howmuch.net/articles/role-agriculture-around-the-world>

World Bank - <https://worldbank.org>

Global poverty rates

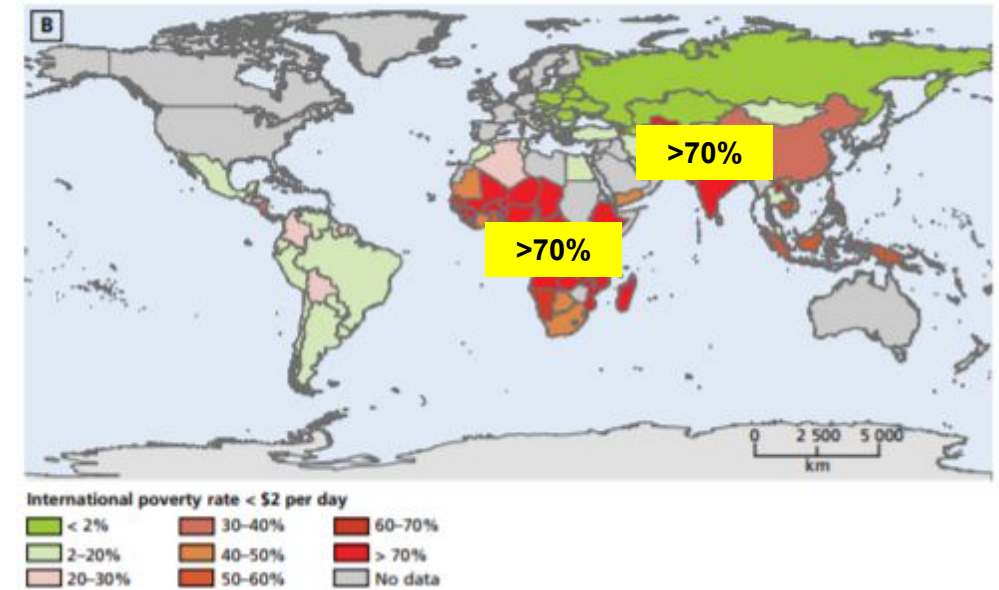
1.4 billion
extremely
poor people

Poverty line of \$1.25/day



2.6 billion
poor
people

Poverty line of \$2/day



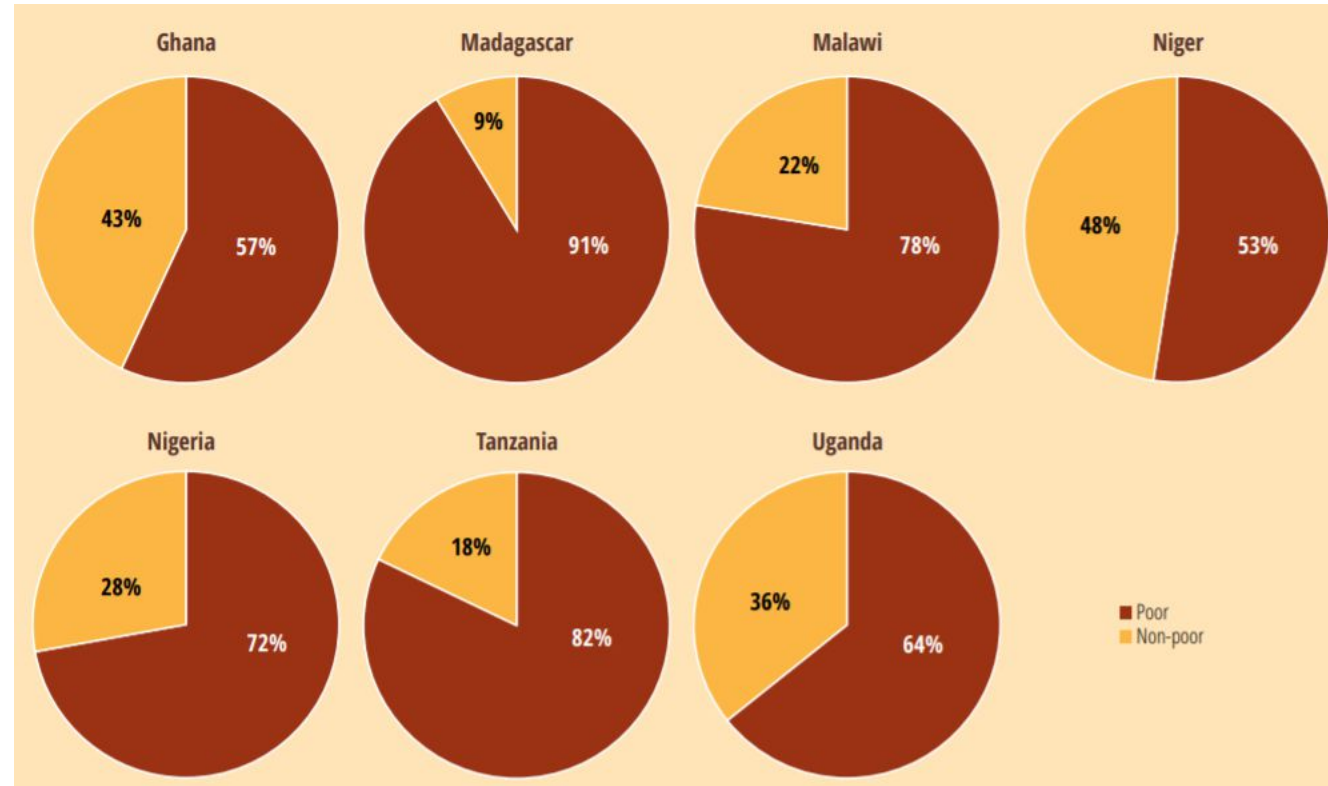
Data – World Bank 2008

- Areas where reliance on agricultural is the highest also those where the extremely poor people reside
- South Asia and sub-Saharan Africa dominate the depth of poverty

FAO. 2011. *Mapping supply and demand for animal-source foods to 2030*, by T.P. Robinson & F. Pozzi. *Animal Production and Health Working Paper. No. 2*. Rome.

FAO. 2012 *Livestock sector development for poverty reduction: an economic and policy perspective – Livestock's many virtues*, by J. Otte, A. Costales, J. Dijkman, U. Pica-Ciamarra, T. Robinson, V. Ahuja, C. Ly and D. Roland-Holst. Rome, pp. 161.

One billion extremely poor people live in rural areas



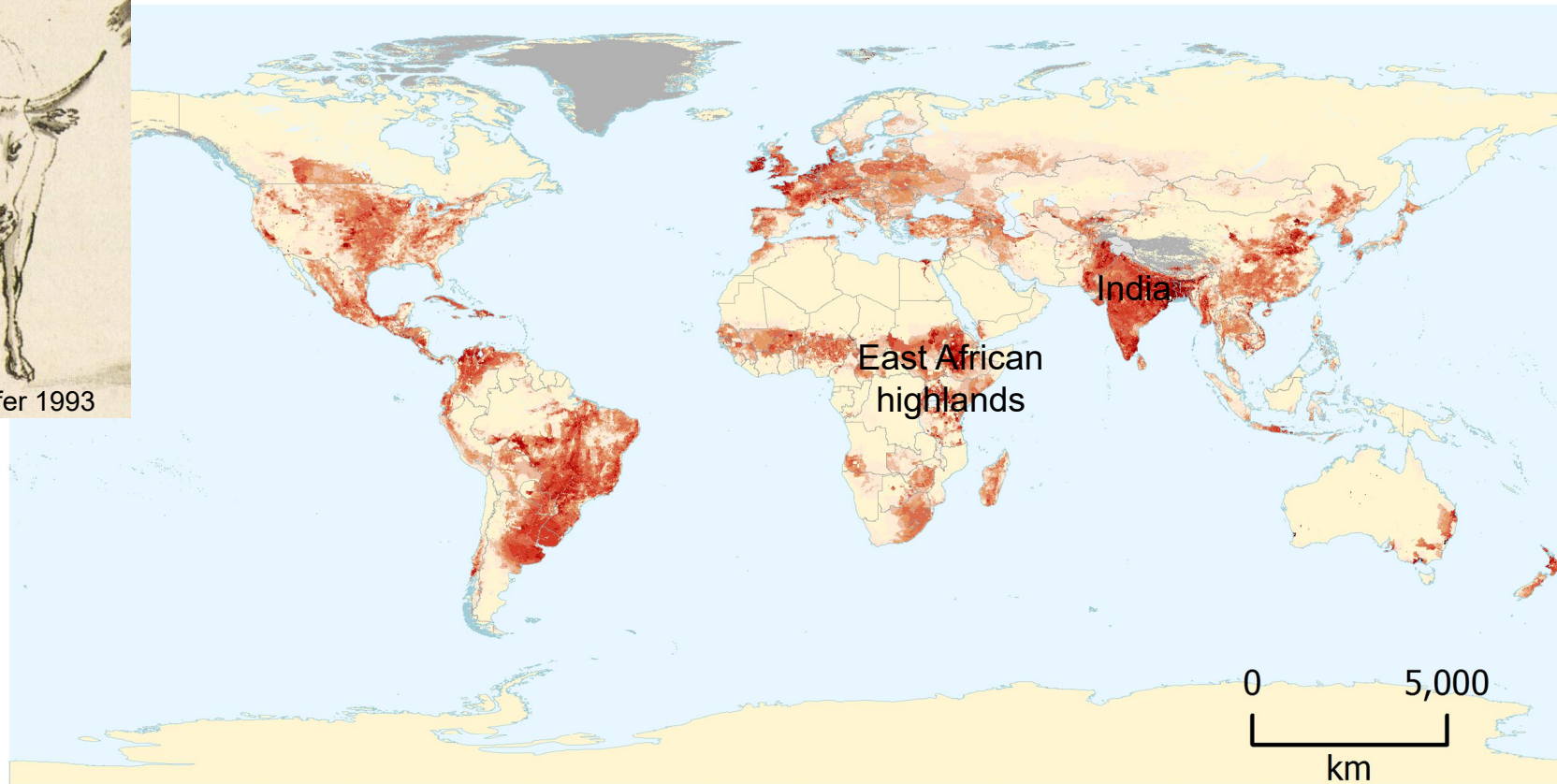
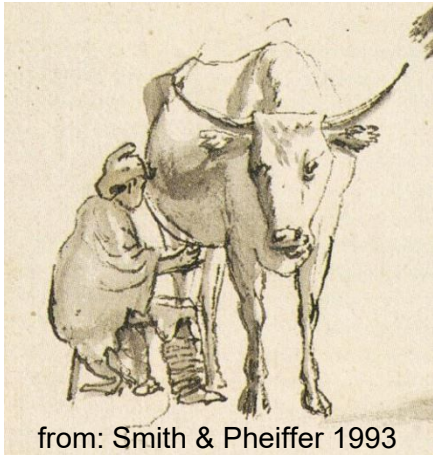
- Three quarters of the extremely poor live in rural areas and more than half will reside in rural areas until about 2035
- Over 85% of poor people in rural sub-Saharan Africa

FAO. 2011. *Mapping supply and demand for animal-source foods to 2030*, by T.P. Robinson & F. Pozzi. *Animal Production and Health Working Paper. No. 2*. Rome.

World Bank. 2014. *Business and Livelihoods in African Livestock : Investments to Overcome Information Gaps*. Washington, DC. © World Bank.
<https://openknowledge.worldbank.org/handle/10986/17801> License: CC BY 3.0 IGO.

Global distribution of cattle

- Estimated >1.4 billion cattle and >1.8 billion small ruminants
- ~1.3 billion in developing countries
- Expected increase by 40%



Head per km²

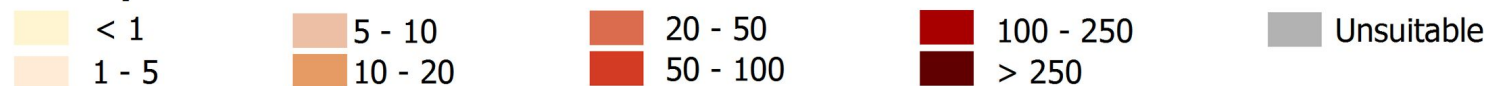
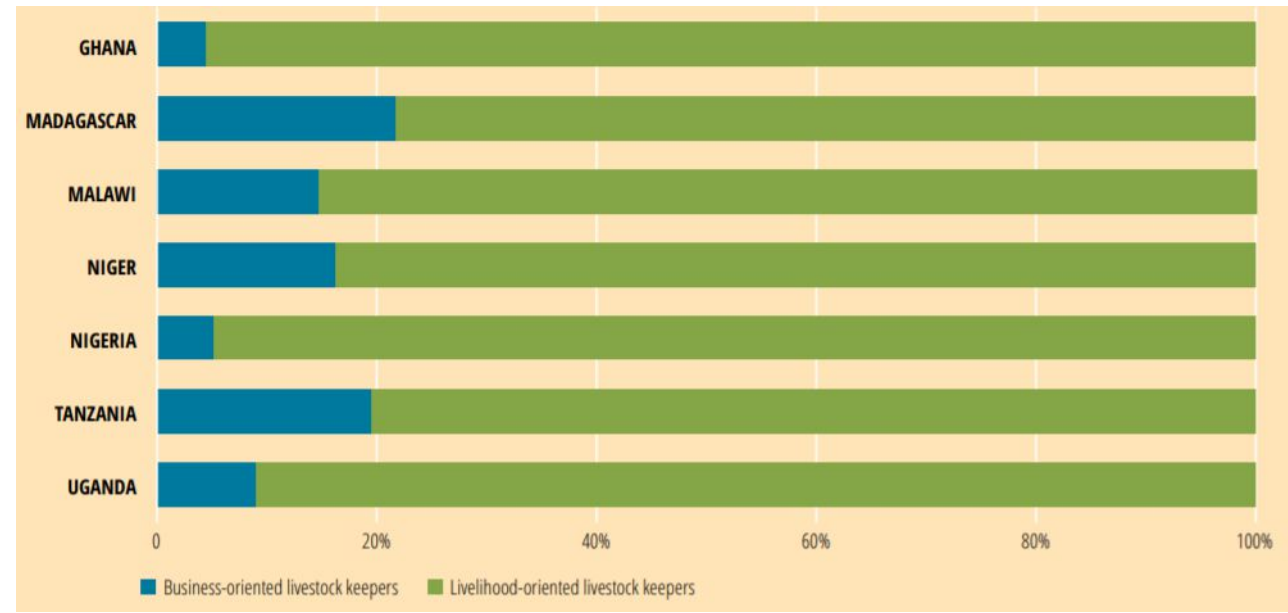
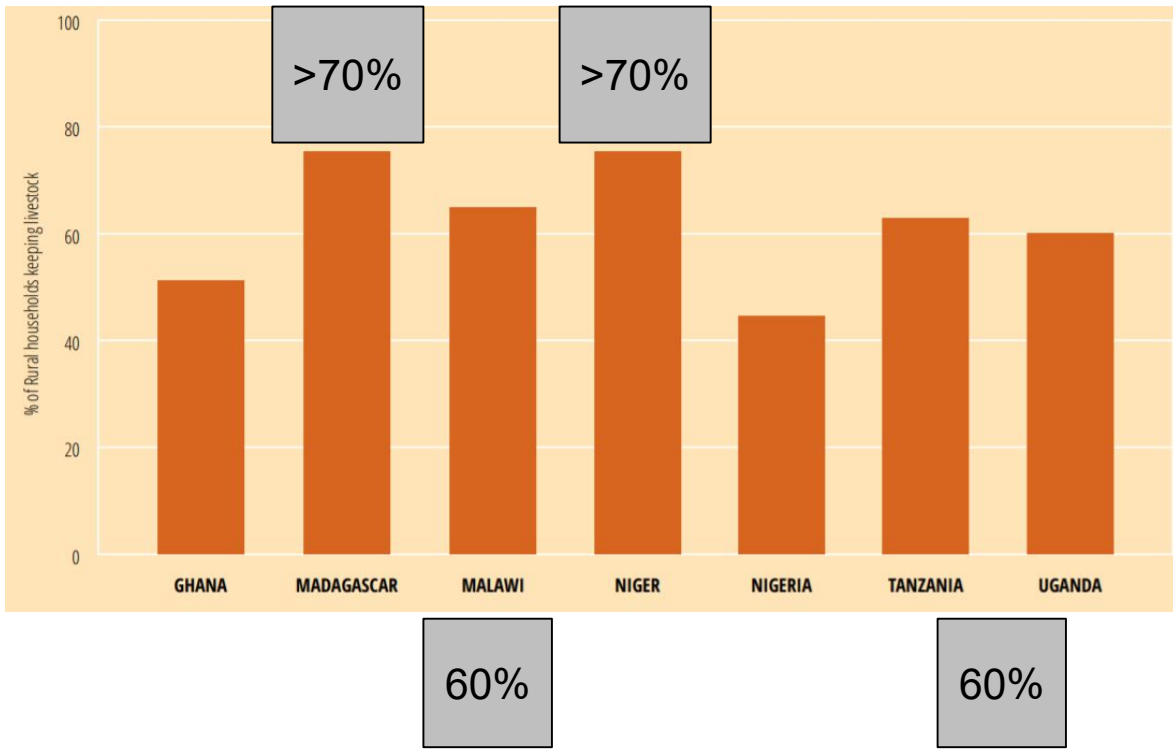




IMAGE ID: 457800904
www.shutterstock.com

Over two thirds of households keep livestock...

...largely as a source of livelihoods



Proportional consumption of protein from animal-source foods in sub-Saharan Africa



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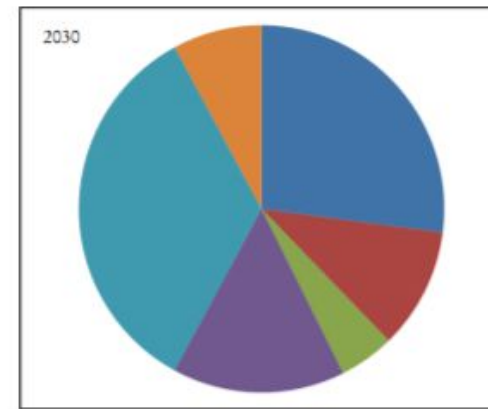
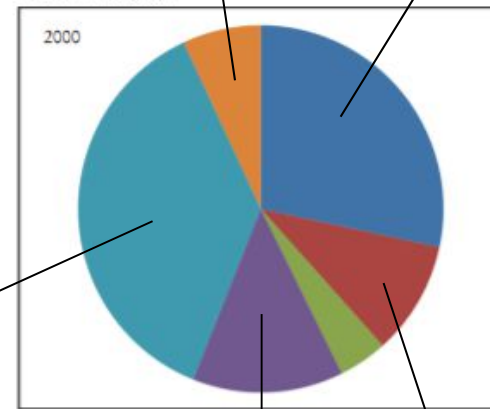


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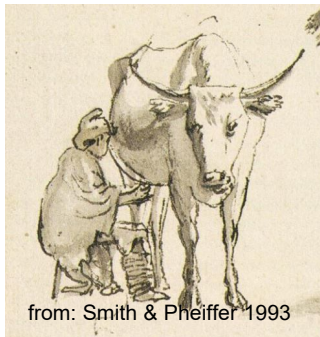


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Sub-Saharan Africa



■ Beef ■ Mutton ■ Pork ■ Poultry ■ Milk ■ Eggs



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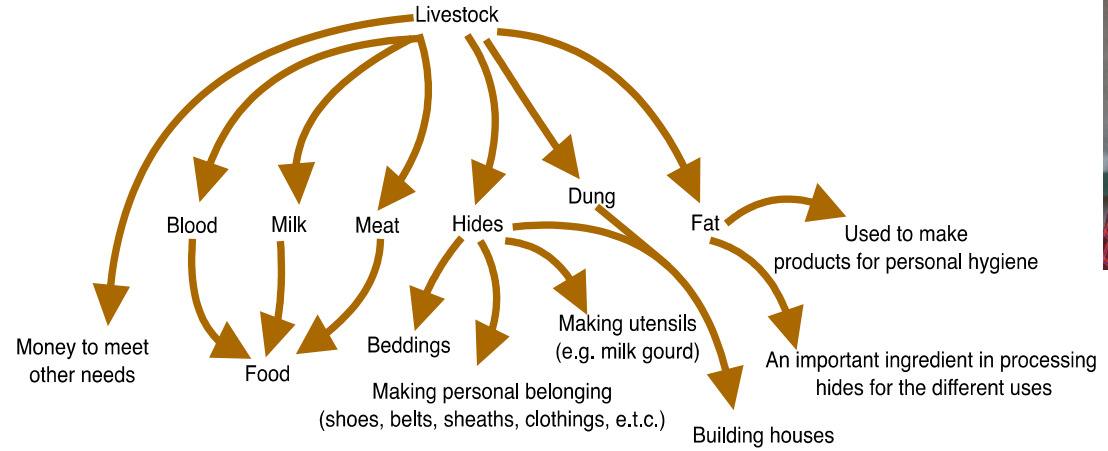
- Three of the top ten agricultural commodities provided by domestic animals
- Projected changes to 2030 very small



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Many other uses

Rhoda Aminu

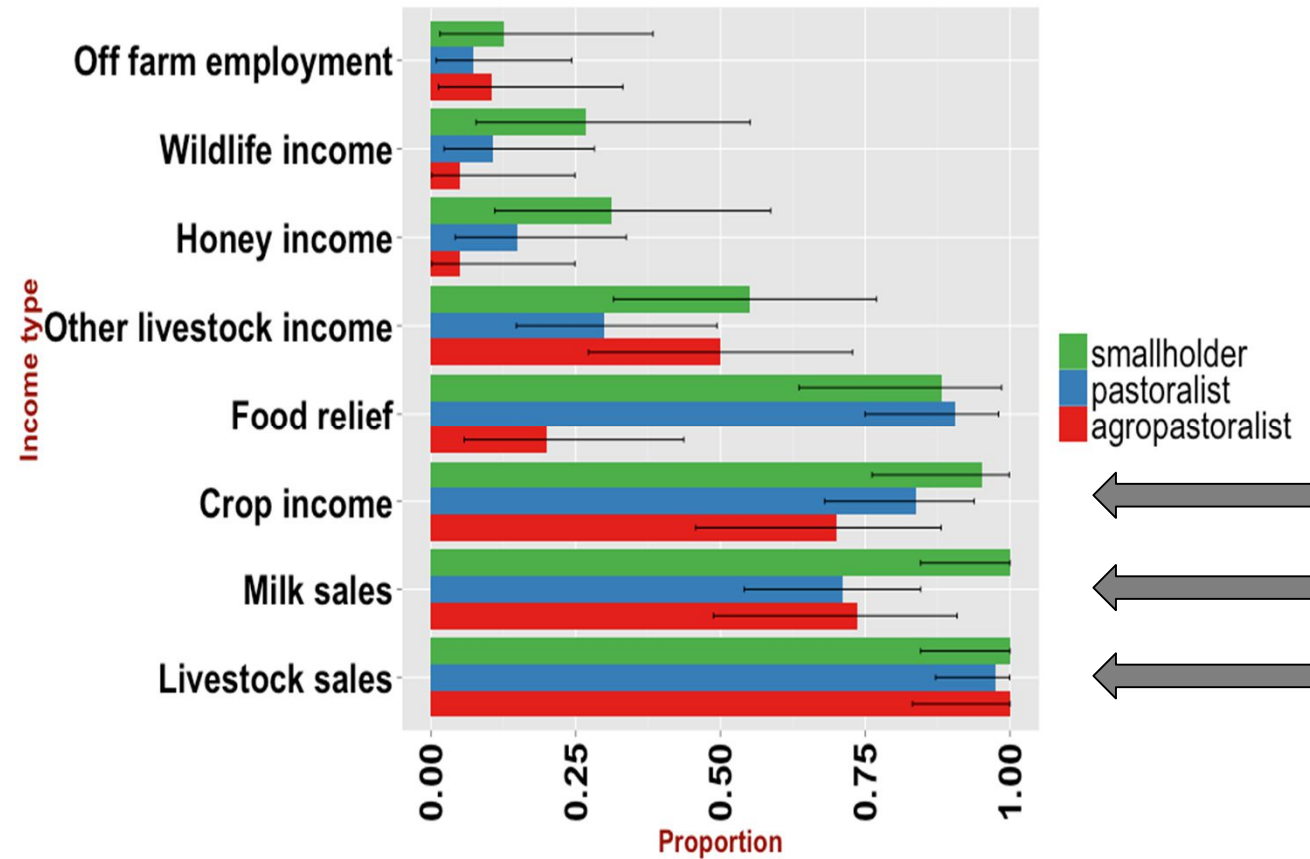


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Photos: T. Lembo



Importance of agriculture-related income in traditional livestock-keeping systems of northern Tanzania



n = 100 respondents

Livestock health and productivity important role in poverty reduction





ANIMAL “health”

General wellbeing/”social” dimension

- Able to breath normally, graze, drink, walk, “work” (e.g. ploughing and carrying luggage), reproduce and produce (e.g. milk and eggs), and provide labour
- Acting healthy (not isolating themselves from the rest)

Biomedical dimension

- No signs of disease (e.g. no profuse salivation or nasal discharge, diarrhoea or constipation, swollen “neck”, skin or mouth lesions, dry nose, coughing, shivering, blindness)
- “Testing”/acting and looking healthy (e.g. size, body conditions, coat)



Photo: A. Davis

Data from 9 focus group discussions and 2 in-depth interviews in northern Tanzania

Mary Nthambi



Alicia Davis



Edna Mutua



Endemic diseases in rural Africa major barriers to animal health and productivity



@ Emmanuel Baliyanga

Top priority livestock diseases		Communities	Health providers
1	Contagious Bovine Pleuropneumonia (CBPP)	1 FGD	3 FGDs
2	Contagious Caprine Pleuropneumonia (CCPP)	1 FGD	1 FGD
3	Foot-and-mouth Disease	2 FGDs	2 FGDs
4	East Coast Fever	2 FGDs	3 FGDs
5	“Ormilo” (Theileria spp)	1 FGD	1 FGD
6	Worms	2 FGDs	1 FGD
7	Peste des Petits Ruminants	1 FGD	1 FGD
8	Newcastle disease	1 FGD	2 FGDs

FGD = Focus Group Discussion

Why these diseases matter

Farmers

- Persistent threats (e.g. FMD, CBPP)
- Higher workload (e.g. FMD – inability to walk means farmers need to feed their livestock)
- No disease prevention measures (e.g. CBPP/CCPP, Ormilo, FMD)
- Severity/high morbidity/mortality (e.g. FMD, ECF, CBPP/CCPP, PPR and Newcastle)
- Immunocompromising (e.g. worms)
- Prolonged illness (e.g. Ormilo)

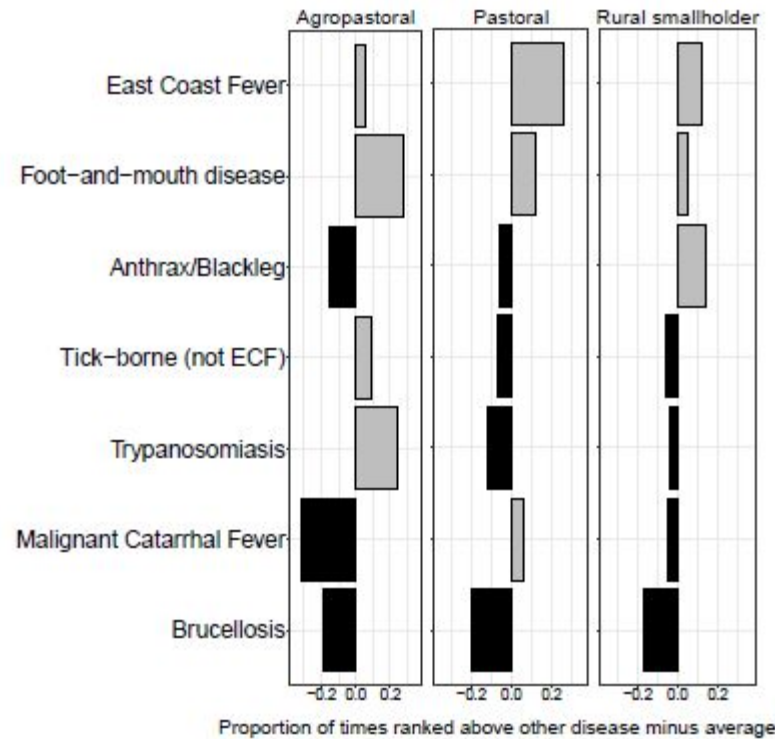
Health providers

- Persistent threats (e.g. FMD, CBPP)
- Ability to spread fast (e.g. FMD, CBPP, PPR)
- No disease prevention measures (e.g. CBPP/CCPP, Ormilo, FMD)
- Farmers not applying measures when available (e.g. ECF)
- Severity/high proportion of animals affected (e.g. Newcastle disease)





Photos: T. Lembo



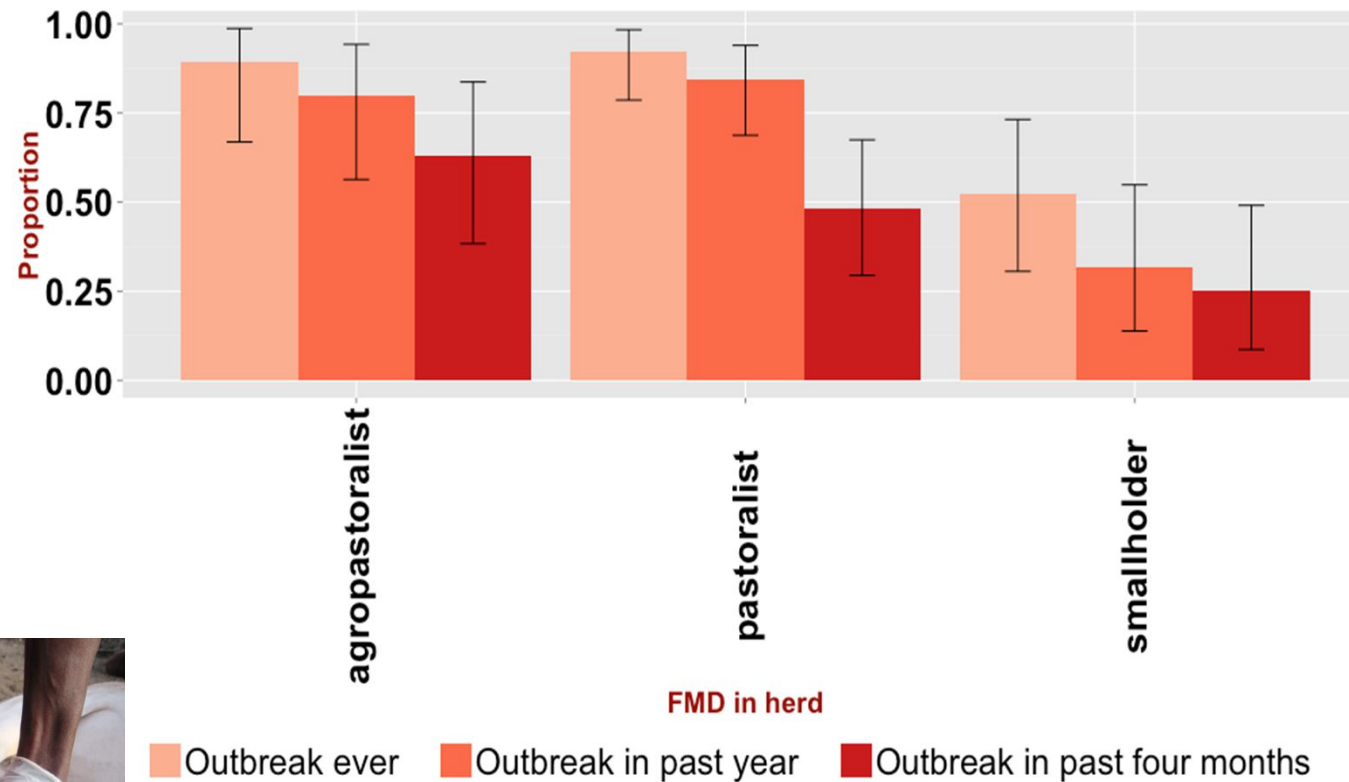
n = 99 respondents

FMD of great concern to agro-pastoralists and pastoralists

Casey-Bryars M, Reeve R, Bastola U, Knowles NJ, Auty H, Bachanek-Bankowska K, Fowler VL, Fyumagwa R, Kazwala R, Kibona T, King A, King DP, Lankester F, Ludi AB, Lugelo A, Maree FF, Mshanga D, Ndhlovu G, Parekh K, Paton DJ, Perry B, Wadsworth J, Parida S, Haydon DT, Marsh TL, Cleaveland S and Lembo T (2018). Waves of endemic foot-and-mouth disease in eastern Africa suggest feasibility of proactive vaccination approaches. *Nature Ecology & Evolution* 2: 1449–1457.

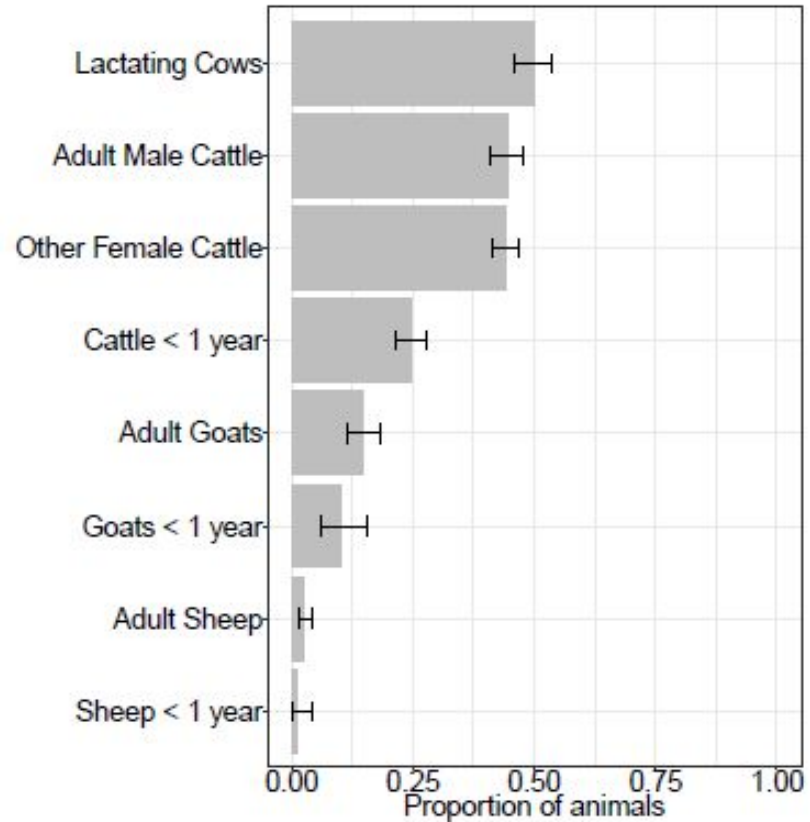
Greatest frequency of outbreaks in pastoralist and agro-pastoralist households

Multiple outbreaks each year (80 – 90% in the past year, up to 63% in the past four months)



@ T. Lembo

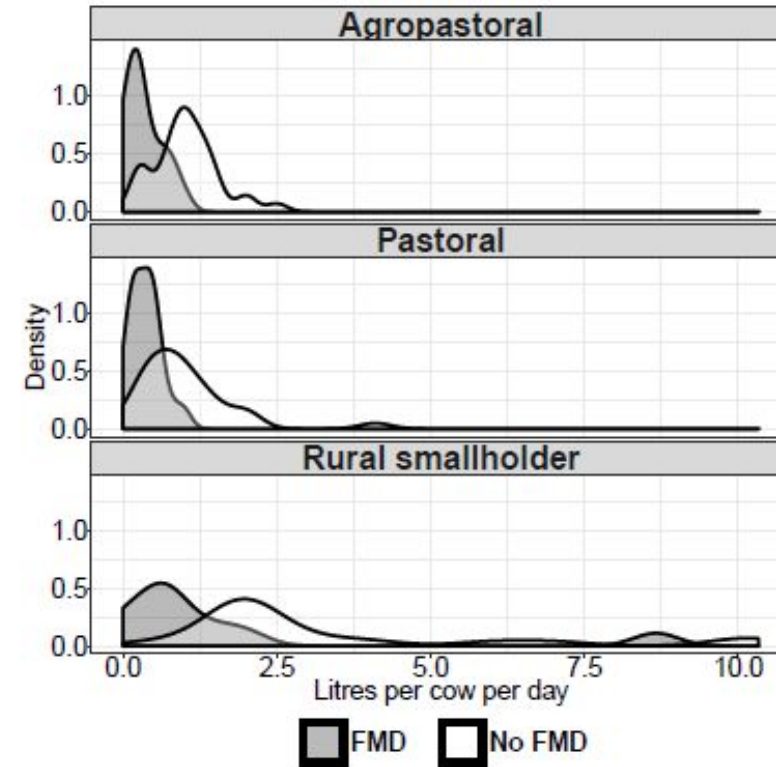
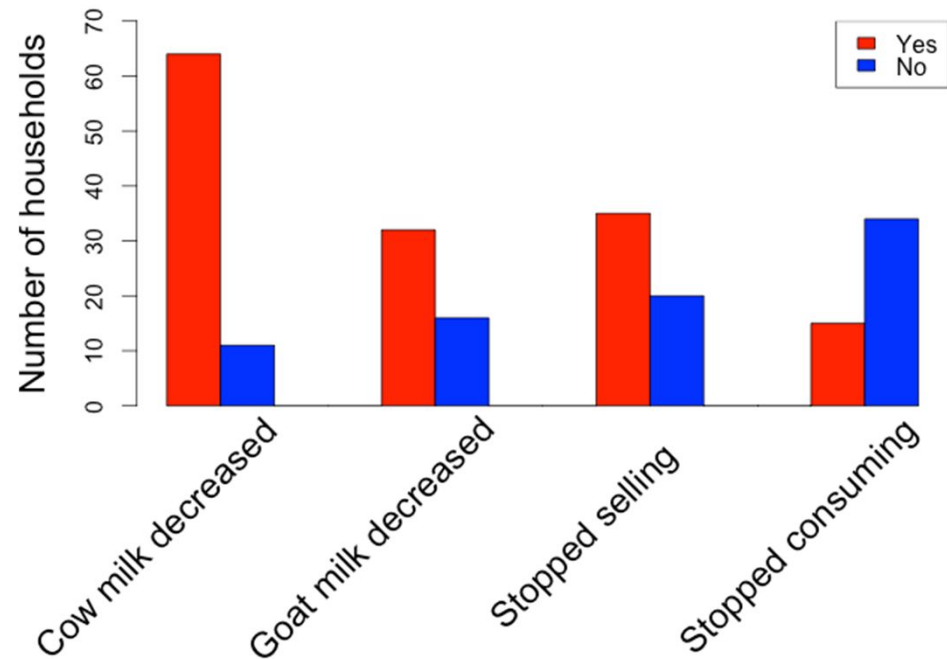
Morbidity impacts



n = 4,852 animals belonging to 45 households that had FMD outbreaks



Impacts on milk production, consumption and sale



Mean percentage decrease in milk yield of 67% of great concern due to the reliance on milk for child nutrition

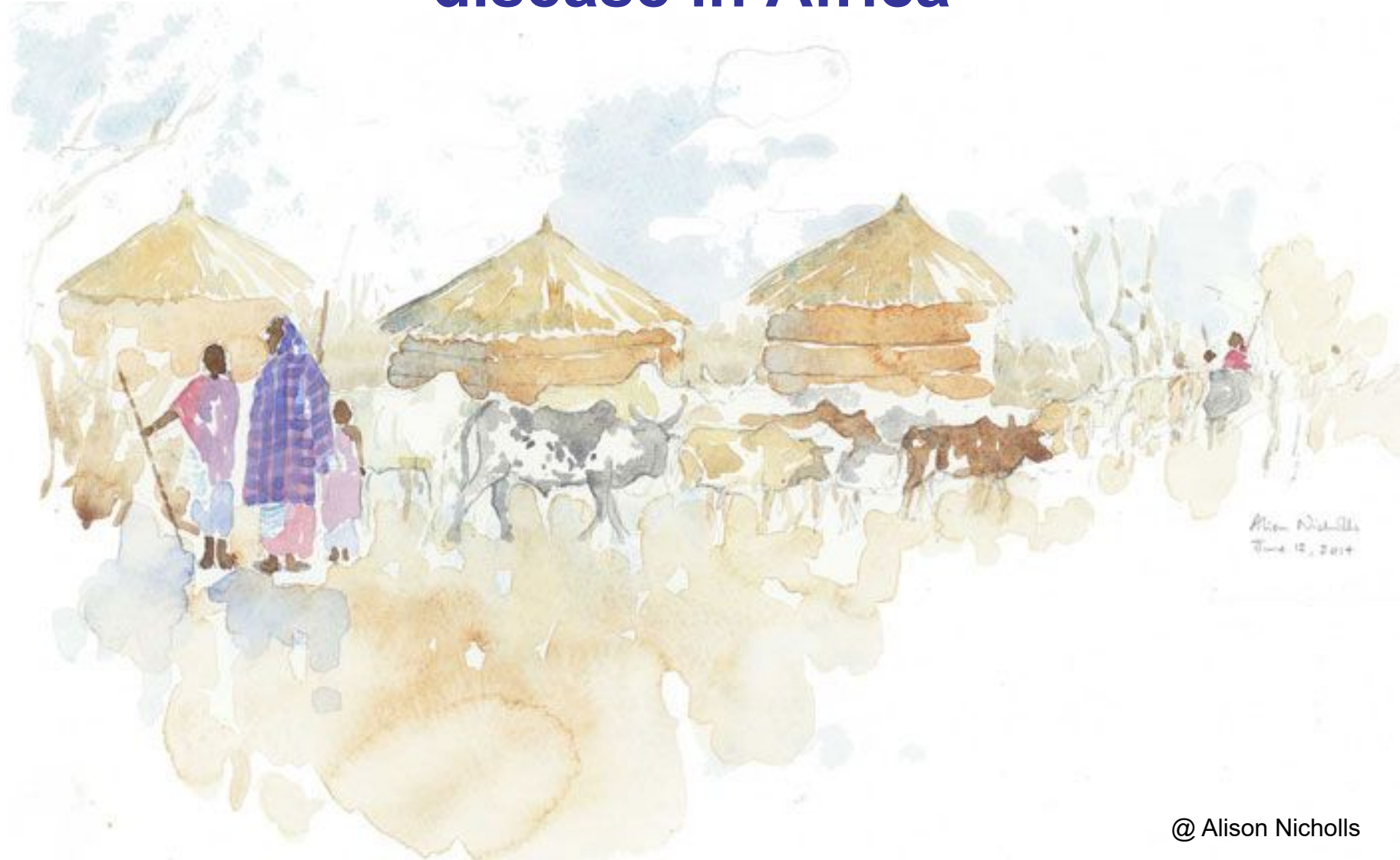
n = 86 respondents

Impacts on traction capacity and livestock sales

- A loss of traction capacity affects 73% of households, with 65% reporting negative impacts on crop production
- Cash generation from livestock sales decreased by 27% (US\$234/household) with consequences for human health (reduced expenditure by 25%)



Opportunities and challenges for control of endemic foot-and-mouth disease in Africa



Foot-and-mouth disease epidemiology in multi-host environments



Casey-Bryars M, Reeve R, Bastola U, Knowles NJ, Auty H, Bachanek-Bankowska K, Fowler VL, Fyumagwa R, Kazwala R, Kibona T, King A, King DP, Lankester F, Ludi AB, Lugelo A, Maree FF, Mshanga D, Ndhlovu G, Parekh K, Paton DJ, Perry B, Wadsworth J, Parida S, Haydon DT, Marsh TL, Cleaveland S and Lembo T (2018). Waves of endemic foot-and-mouth disease in eastern Africa suggest feasibility of proactive vaccination approaches. *Nature Ecology & Evolution* 2: 1449–1457.

Risk factors for livestock seropositivity

- Age ✓
- Species (cattle) ✓
- Livestock practice (agropastoral and pastoral) ✓
- Cattle herd size ✗
- Time to grazing/watering ✗
- Buffalo sighting ✗
- Distance to buffalo areas ✗
- Livestock acquisitions ✗



n = 84 households, 2694 livestock serum sampled



Risk factors for cattle outbreaks

- New acquisitions ✓
- Number cattle in herd ✓
- Buffalo sighting ✗
- Different grazing/watering ✗
- Livestock contact during grazing/watering ✗
- Visitors ✗



n = 69 households

Circulating serotypes and serotype dominance in cattle and buffalo

- Four serotypes in cattle (O, A, SAT1 and SAT2)
- Cattle O  SAT2
- Buffalo SAT1, SAT2  A
- No close genetic relationship between cattle and buffalo sequences for SAT serotypes, but small sample of buffalo sequences
- Low seroprevalence of serotypes O and A in buffalo possibly due to occasional spillover or cross-reactivity
- Consistent with data from Kenya:
 - Cattle to buffalo ✓
 - Buffalo to cattle ✗



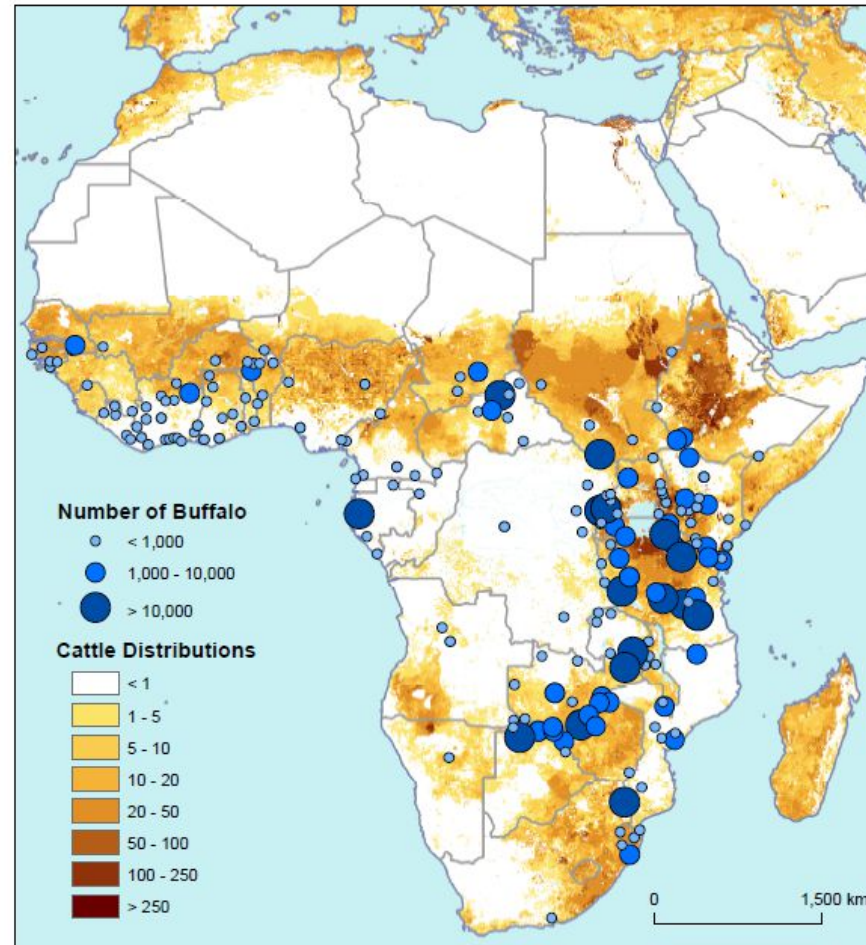
© kathrynochorney.com



Casey-Bryars M et al. (2018). Waves of endemic foot-and-mouth disease in eastern Africa suggest feasibility of proactive vaccination approaches. *Nature Ecology & Evolution* 2: 1449–1457.

Omondi & Alkhamis et al. 2019, *Molecular Ecology*

Representative of the situation in east Africa

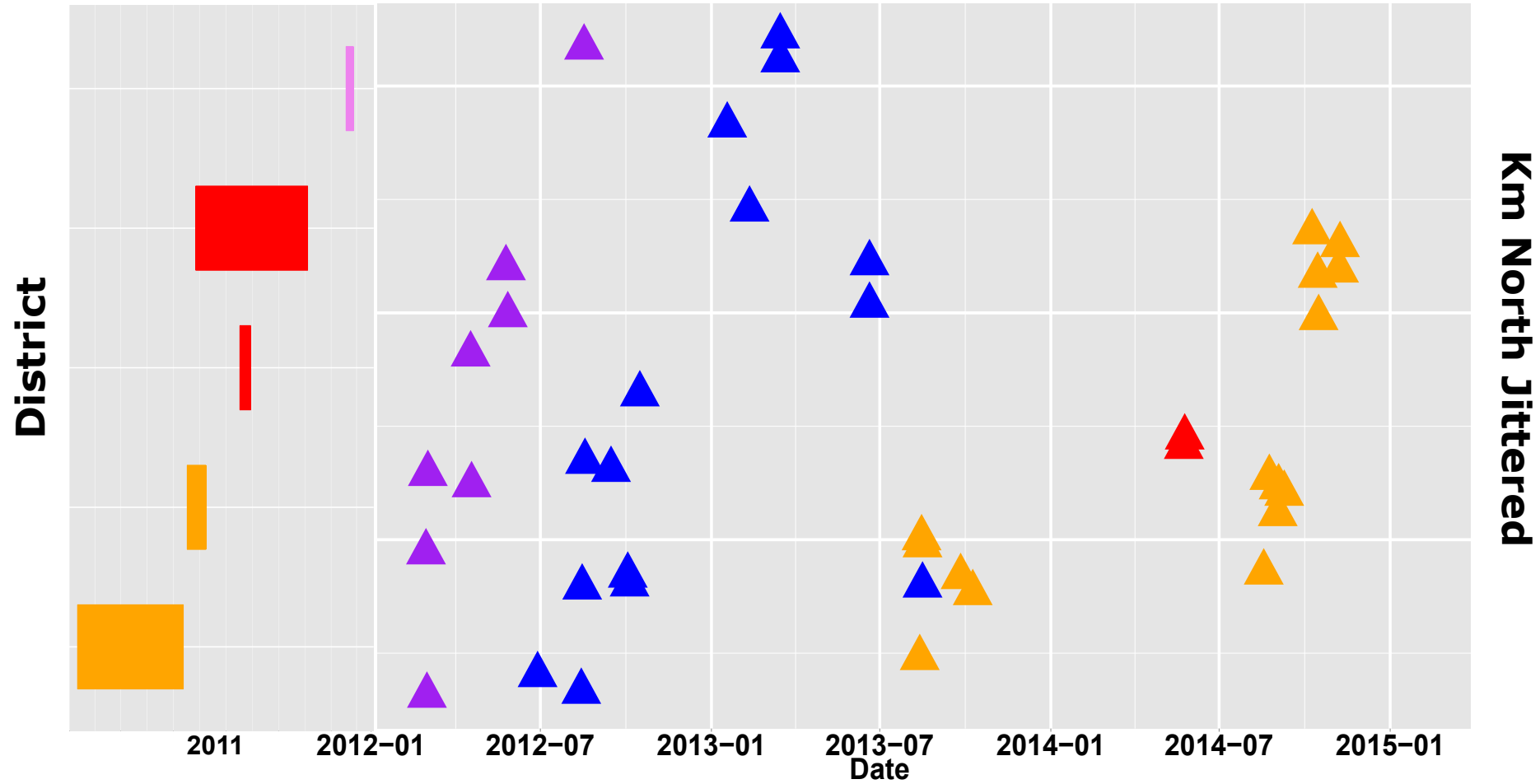


Casey-Bryars M, Reeve R, Bastola U, Knowles NJ, Auty H, Bachanek-Bankowska K, Fowler VL, Fyumagwa R, Kazwala R, Kibona T, King A, King DP, Lankester F, Ludi AB, Lugelo A, Maree FF, Mshanga D, Ndhlovu G, Parekh K, Paton DJ, Perry B, Wadsworth J, Parida S, Haydon DT, Marsh TL, Cleaveland S and Lembo T (2018). Waves of endemic foot-and-mouth disease in eastern Africa suggest feasibility of proactive vaccination approaches. *Nature Ecology & Evolution* 2: 1449–1457.

Serotype frequency in cattle (2011 - 2015)

Bayesian model
inference from SPCE
results

Virus isolation results



N
63 herds

▲ SAT2 ▲ A ▲ SAT1 ▲ O

N
38 outbreaks
in 27 herds

Implications for control through vaccination

- Temporal patterns of antigenic dominance offer opportunities for targeted vaccination through existing (monovalent) high-quality vaccines:
 - O and SAT2 vaccines provide $r1 \geq 0.3$ against Tanzanian isolates
 - Also for A and SAT1 $r1$ matching or consistent with protection



@ thecattlesite.com



<http://marketresearchtime.com/2019/07/29>

Major international initiatives to broaden access to high-quality vaccines

AgResults to launch FMD vaccine project for East Africa

15 Mar 2019 | NEWS



by **Joseph Harvey**

@JHJournalist | joseph.harvey@informa.com

AgResults is going to follow up the success of its ongoing brucellosis vaccine development competition with a project focused on developing a vaccine for foot-and-mouth disease (FMD).



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ANIMAL HEALTH

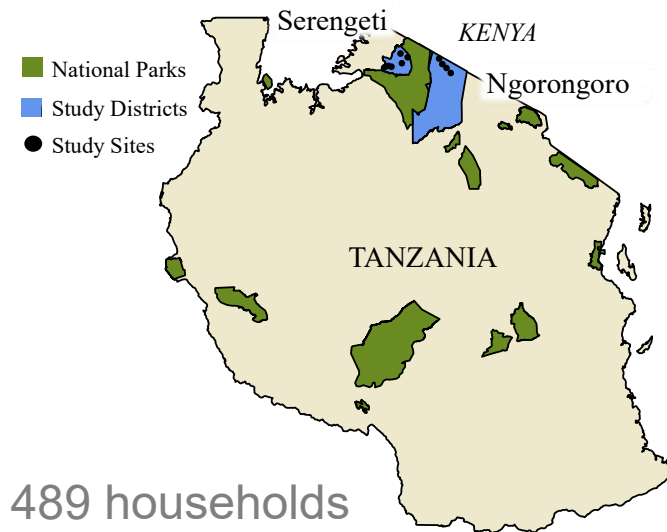
- > Product
- > Vaccines
- > Sector
- > Food Animals
- > Disease
- > Foot and mouth disease

What to read next

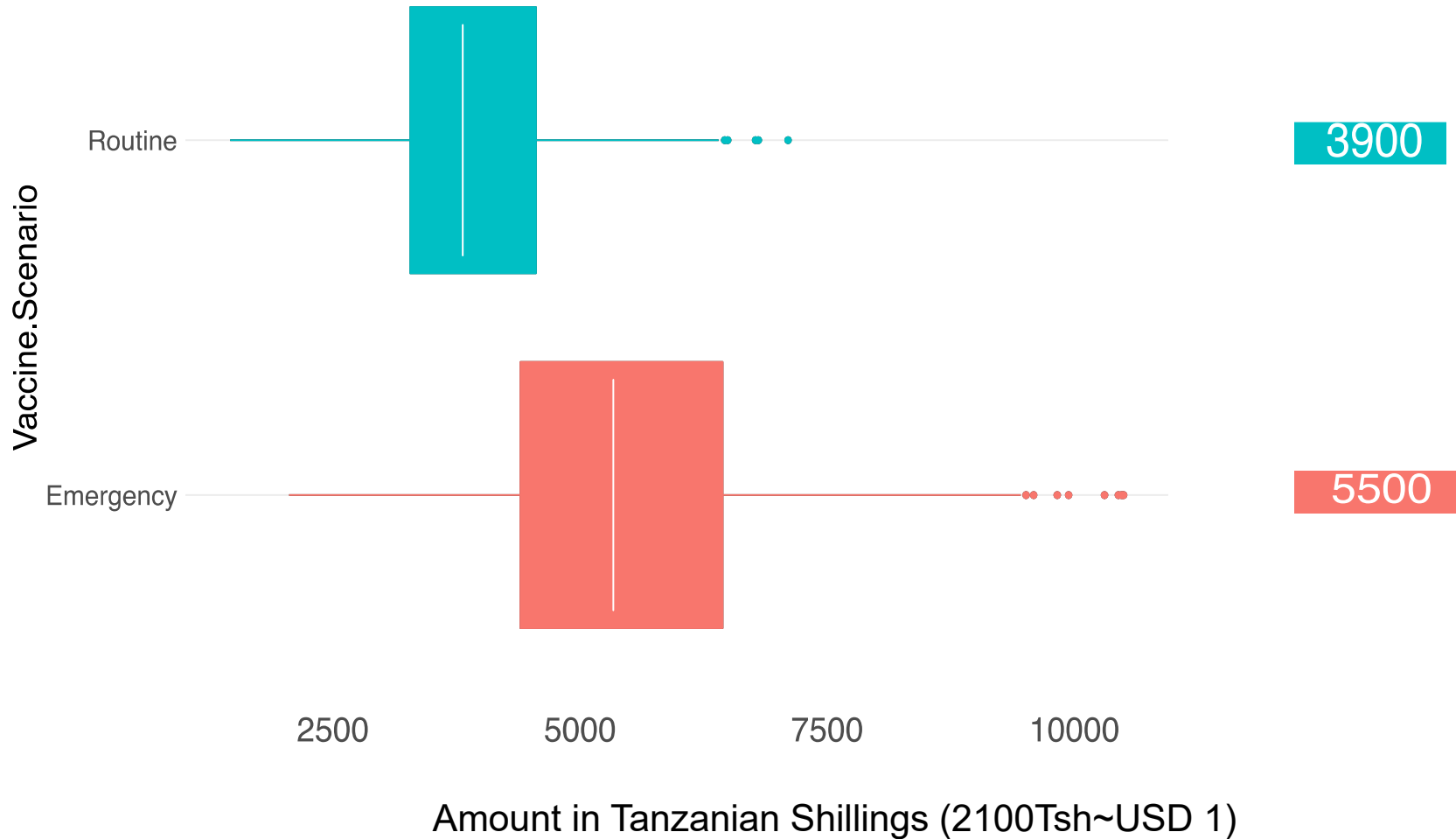


But vaccine quality not the only issue

- Uptake of preventative measures generally low in East Africa
- Only 19% of households in northern Tanzania vaccinate for any disease (reduced price or free), less than 5% vaccinate against FMD
- Farmers prefer to treat rather than prevent
- Negative past experience with FMD vaccines might explain the...



...low (23%) willingness to pay for FMD vaccination, but higher value if immediate threat of disease



Railey AF, Lembo T, Palmer GH, Shirima GM and Marsh TL (2018). Spatial and temporal risk as drivers for adoption of foot-and-mouth disease vaccination. *Vaccine* 36 (33): 5077-5083


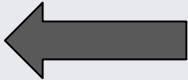
Use of veterinary services also generally low

- **Formal/conventional** sources - doctors, experts, pharmacists, and local government authorities:
 - Only 35% of households use of a public veterinarian for livestock information
- **Informal/traditional** sources - family, friends, village elders and traditional leaders
- One critical and widespread source of health services is **SELF-TREATMENT**:
 - Almost 80% of households reported using antibiotics (oxytetracycline, penicillin, or streptomycin)
 - For antibiotic treatment, 23 – 34% of households consult a veterinarian
 - For vaccination, only 6% of households use a veterinarian



Data from 9 focus group discussions
and 2 in-depth interviews in northern
Tanzania

n = 489 households

	Livestock disease	Options	Traditional
1	Foot-and-mouth disease	Aspirin (Misugwi) <u>Trimycin</u> <u>Tylosin</u> Vaccination*** 	Sisal "Makonge", ash is rubbed in the mouths of infected animals (Misugwi), give the animal salty water
2	East Coast Fever	Injection offered by veterinary officer*** <u>Trimycin</u> Clarkson*** Vaccine*** Acaricides 	Use palm oil or sweet potato vines to ease bowel movement Olchani oibor" "Osusuyian"
3	CBPP/CCPP	<u>Adamycin</u> <u>Tylosin</u> <u>Trimycin</u> <u>Penstrep</u> Vaccine***	None
4	"Urinating blood"	Unidentified medicine that comes in a pack	None
5	Intestinal worms	Wormsid Unspecified injections and tablets	"Magembya" mixed with drinking water, salty water, neem tree extracts mixed with drinking water
6	The disease of "being confused/rotating"- "Ormilo"	Medicine used is unspecified	Slaughter or sale of animal
7	Diarrhoea	Unspecified medicine for curing intestinal worms	None
8	Lack of minerals	Calcium drip	Feeding the animal well
9	PPR	Ivermectine Albendazole Vaccine***	None
10	Newcastle	None, just vaccinating the animals	None

90% of households treat FMD secondary infections with antibiotics

Drivers of self-treatment



Data from 9 focus group discussions
and 2 in-depth interviews in northern
Tanzania

Previous knowledge/experience/beliefs

Unavailability/shortage of animal health
providers

Severity of disease, i.e. professionals
consulted only in severe cases

Prompt availability of veterinary drugs that
can be stored at home (“first-aid kit”)

Costs associated with veterinary care
(service, transport)

Drivers and dynamics of livestock movements



Divine Ekwem

Motivations for movements – livestock survival and health

Watering points



Grazing locations



Dipping points

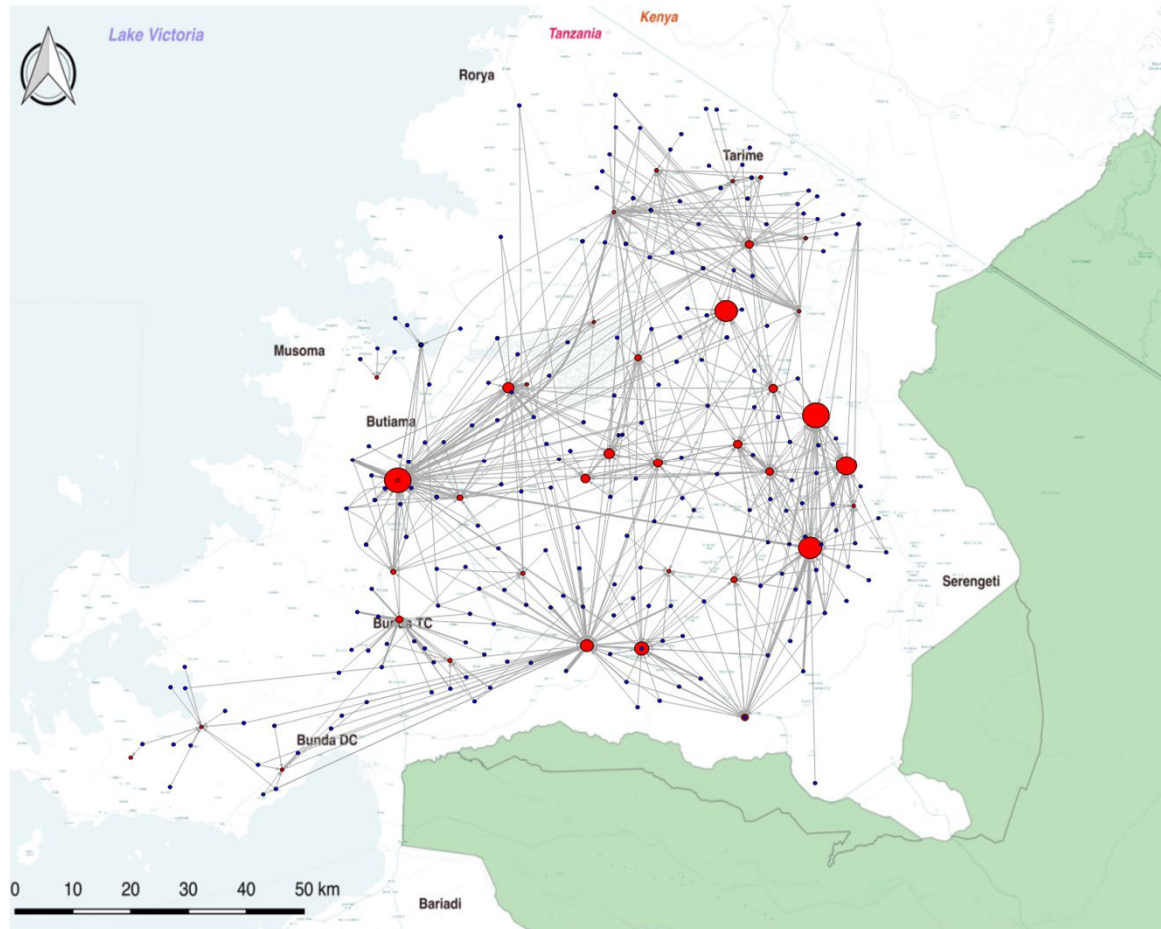


Salting points



Motivations for movements – economic

Network of livestock market and village connectivity in northern Tanzania



- Local, national, international
- Livestock trade – influenced by market value
- As a compensation mechanism to offset shocks (e.g. drought, high mortality)

Motivations for movements – social, cultural, others



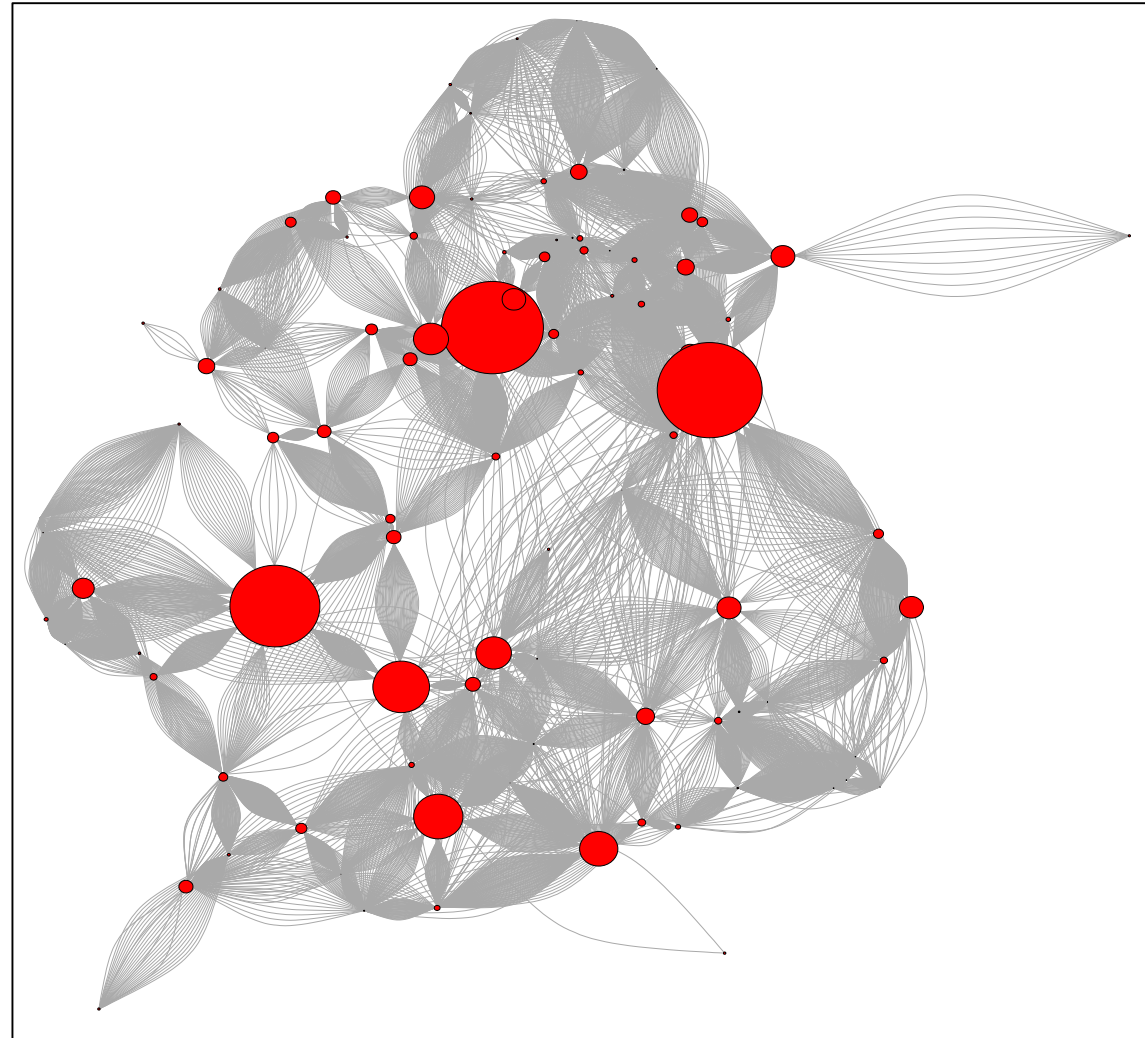
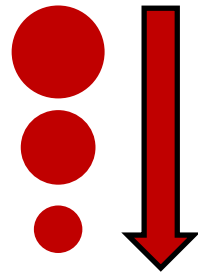
- Local, national, international
- Festivities (especially religious)
- Social interactions (e.g. dowries) including cross-border intermarrying
- Illegal (theft)



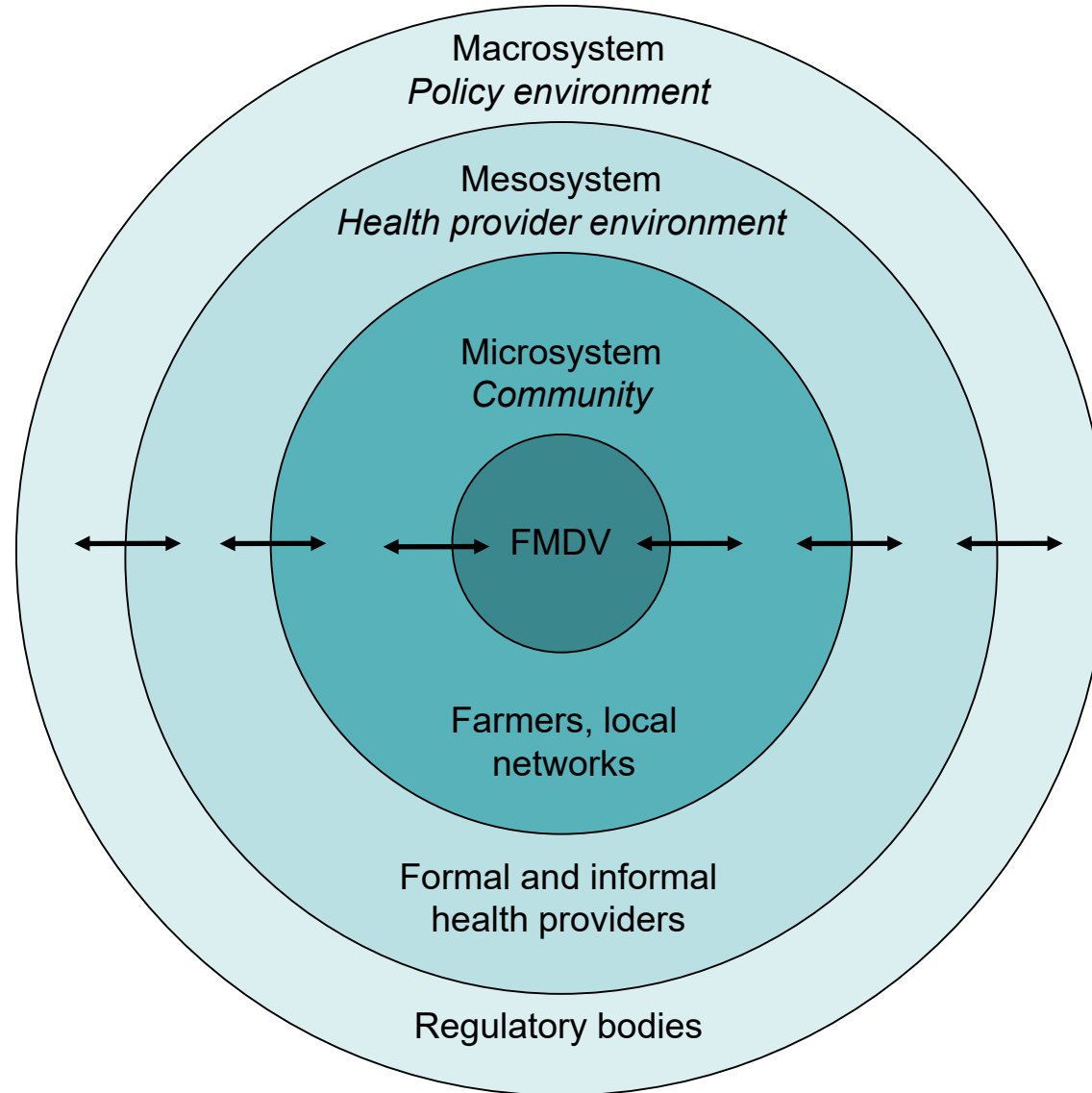
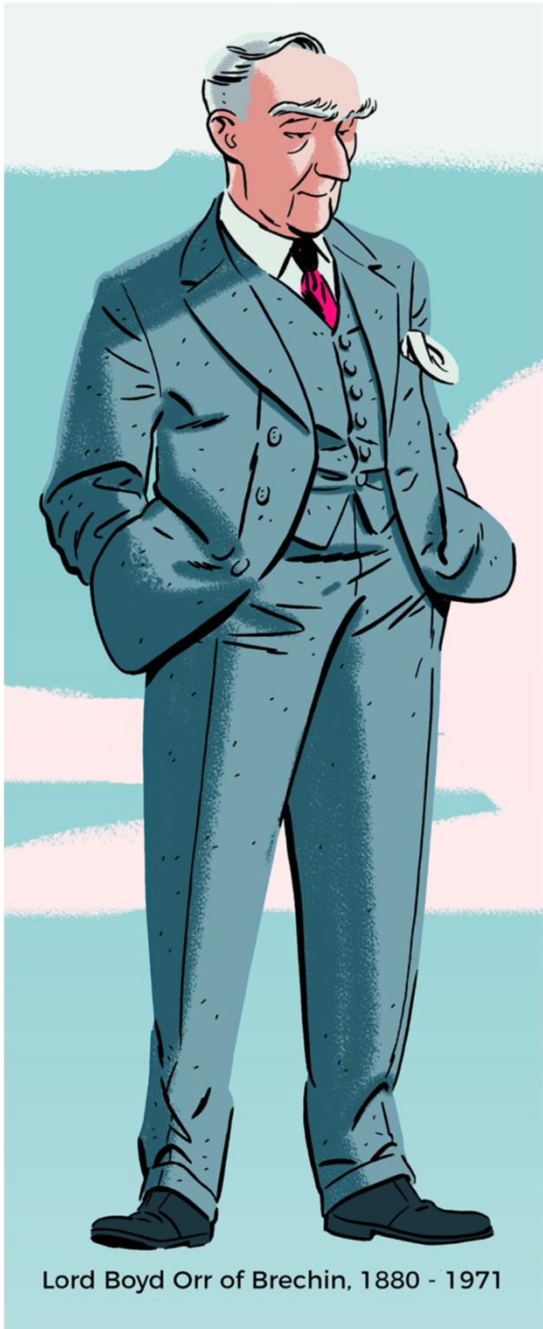
Photo credits: T. Lembo

Identifying most connected nodes

Using centrality measures based on the number of links held by each node to find very connected nodes that could be targeted



Working synergistically across levels

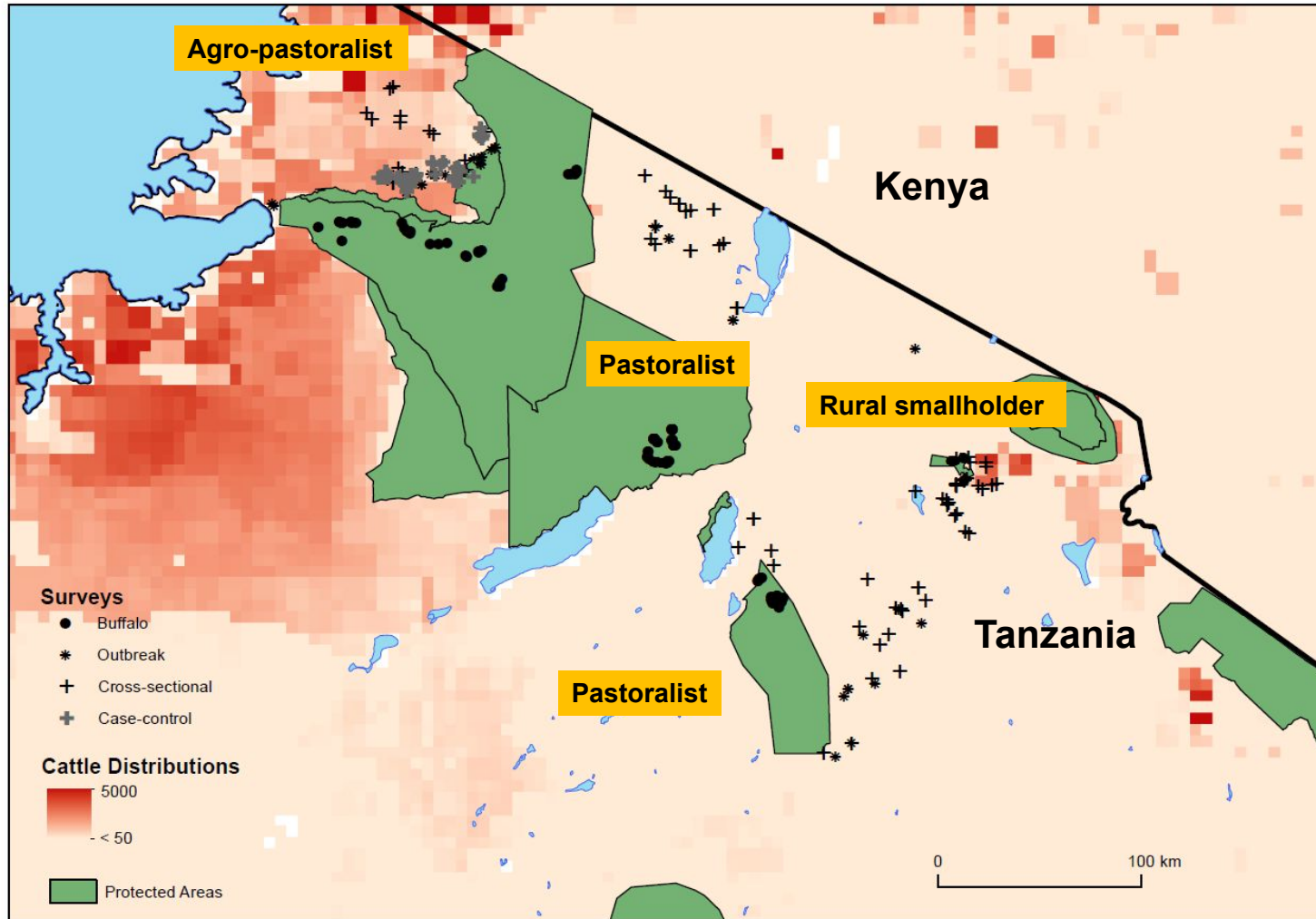


Microsystem – Individual farmers protecting the health of the animals they depend upon for their livelihoods

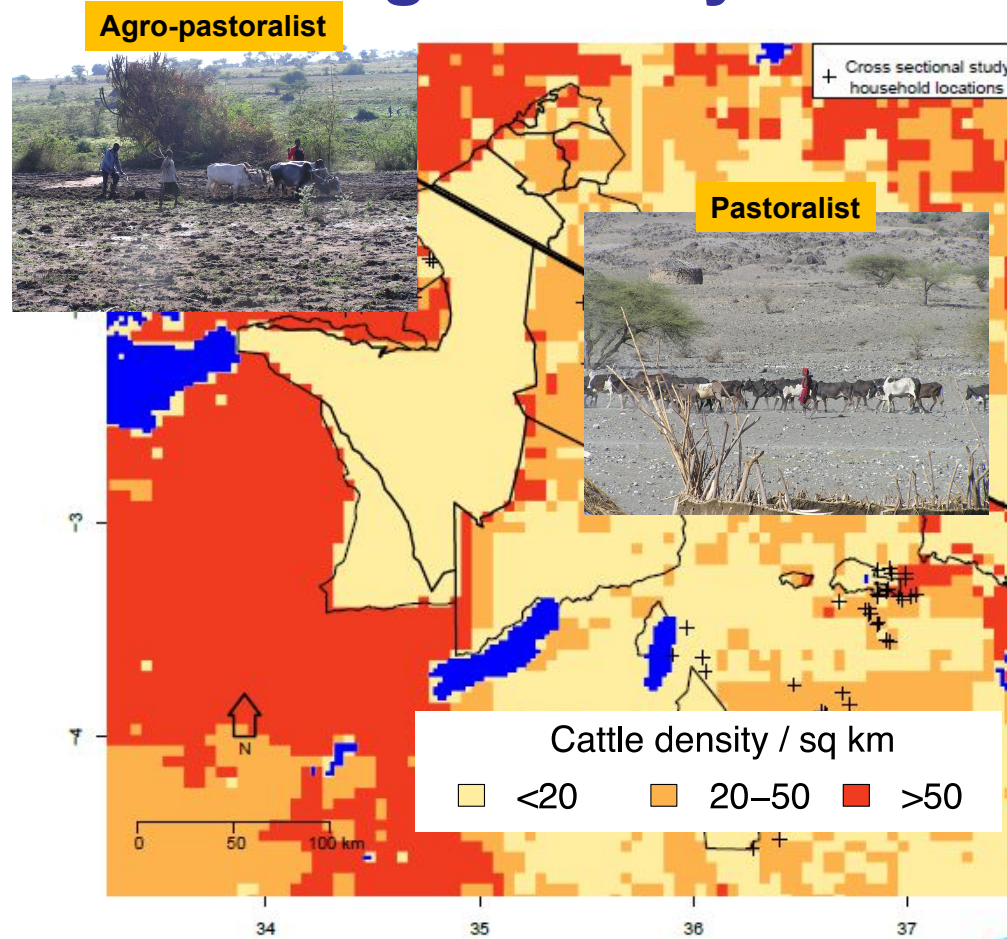
Mesosystem - Health and drug providers prescribing and supplying vaccines and drugs to manage the health of livestock for food production

Macrosystem - National level policy makers and regulatory bodies responsible for drug and vaccine production, supply, use, and control

Funders of initial field studies



Funders of current more intensive studies in the Serengeti ecosystem



BILL & MELINDA
GATES foundation





Funders of antimicrobial resistance research in northern Tanzania

Antimicrobial Resistance Cross-Council Initiative through a grant from the Medical Research Council, a Council of UK Research and Innovation, and the National Institute for Health Research

